

Mobilising Processes of Abstraction, Experiential Learning and Representation of Traditional Ecological Knowledge, in Participatory Monitoring of Mangroves and Fisheries

An approach towards enhancing social learning processes on the Eastern Coast of Tanzania

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Abstract

This study addresses a core problem that was uncovered in records from coastal management monitoring initiatives on the eastern coast of Tanzania associated with the application and use of coastal monitoring indicators developed by external development partners for the coastal zone. These records suggest that local communities, who are key actors in participatory monitoring of coastal and marine resources, face many challenges associated with adapting and applying the said frameworks of indicators and monitoring plans. These indicators tend to be scientifically abstracted and methodologically reified; given prevailing contextual and socio-cultural realities amongst them.

The research project addresses the following key research question: How can processes of *abstraction, conceptualisation, and representation* of TEK contribute to the development of coastal management indicators that are less reified, more contextually and culturally congruent, and which may potentially be used by resource users in the wider social learning process of detecting trends, threats, changes and conditions of mangrove and fisheries resources?

In response to the contextual problem and the research question, the study employs processes of abstraction and experiential learning techniques to unlock knowledge that local communities have, as an input for *underlabouring* existing *scientific indicators* on the Eastern coast of Tanzania.

The research is constituted as critical realist case study research, involving two communities on the eastern coast of Tanzania, namely the Moa and the Boma communities (in Mkinga coastal district). Overall, the study involved 37 participants in a series of interviews, focus group discussions, and experiential learning processes using visualised data, and an experiential learning intervention workshop, and follow-ups over a period of 3 years. The study worked with mangroves and fisheries to provide focus to the case study research and to allow for in-depth engagement with the assumptions and processes associated with indicators development and use.

Through the above mentioned data generation processes, critical realist analysis, and experiential learning processes involving abstraction and representation of traditional

ecological knowledge held by mangrove restorers and fishers in the study areas, the study uncovers possible challenges of adapting and applying scientific indicators in participatory monitoring of a mangrove ecosystem.

Using ampliative modes of inference for data analysis (induction, abduction and retrodiction) and a critical realist scientific explanatory framework known as DRRREI(C) (Resolution, Re-description, Retrodiction, Elimination, Identification, & Correction) the study suggests a new approach that may lead to the development of a framework of indicators that are less reified, more congruent to users (coastal communities), and likely to attract a wider context-based social learning which favours epistemological access between scientific institutions (universities inclusive), and local communities.

It attempts to establish an interface between knowledge that scientific institutions produce and the potential knowledge that exists in local contexts (traditional ecological knowledge), and seeks to widen and improve knowledge sharing and experiential learning practices that may potentially benefit coastal and marine resources in the study area. As mentioned above, the knowledge and abstraction processes related to the indicators development focussed on the mangrove ecosystem and associated fisheries, as engaged in the two participating communities in the eastern coast of Tanzania. The specific findings are therefore limited by the case boundaries, but the methodological process could be replicated and used elsewhere. The study's contributions are theoretical and methodological, but also social and practice-centred.

The study brings into view the need to consider the contextual relevance of adapted knowledge, the capacity or ability of beneficiaries to adapt and apply scientific models, frameworks or tools, and the potential of local knowledge as an input for enhancing or improving monitoring of mangroves and mangrove-based fisheries.

Finally, the study comes up with a framework of indicators which is regarded by the coastal communities involved in the study as being less reified, more contextually and culturally congruent, and which may potentially be used in detecting environmental trends, threats, changes and conditions of mangrove and fisheries resources, and attract wider social learning processes.

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Dedication

This thesis is dedicated to mangrove restorers and fishers in Mkinga District, and to my beloved wife Naomi, daughters Rhobi, Mary, and Rebekah (PhD baby), and son Joseph for their prayers, spirit of love, and perseverance throughout my study time.

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Acronyms and Abbreviations

DUCE	Dar es Salaam University College of Education
CIDA	Canadian International Development Agency
CHAT	Cultural Historical Activity Theory
CRT	Critical Realism Theory
ELT	Experiential Learning Theory
ELIW	Experiential Learning Intervention Workshop
ESD	Education for Sustainable Development
FAO	Food and Agriculture Organisation of the United Nations
FEA	Foundation for Environmental Awareness
ICM	Integrated Coastal Management
IK	Indigenous Knowledge
IKS	Indigenous Knowledge Systems
IUCN	International Union for Conservation of Nature
KICAMP	Kinondoni Integrated Coastal Area Management Programme
KIMP	KICAMP Integrated Monitoring Plan
TCZCDP	Tanga Coastal Zone Conservation and Development Programme
Sida	Swedish International Development Agency
NICEMS	National Integrated Coastal Environmental Management Strategy
TEK	Traditional Ecological Knowledge
TCMP	Tanzania Coastal Management Partnership
UNEP	United Nations Environment Programme
UNCED	United Nations Conference on Environment and Development
WCST	Wildlife Conservation Society of Tanzania
WIOMSA	Western Indian Ocean Marine Science Association
WWF	World Wide Fund for Nature

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 Conception of the study (motivation and personal background)

My love for nature revealed itself from my childhood when I spent at least half of my day observing birds' nests, forest patches, brooks, springs, creeping creatures, wild animals, and assisting my elder brothers to look after family cattle and goats. Sometimes, I would sneak from home duties to join hunters, wishing to see for myself how trapped or hunted wild animals looked. Back in the mid-seventies, I remember running after a neighbour's Peugeot car carrying some of my peers whose parents had granted them permission to visit Arusha National Park, but my efforts ended up in vain as they drove away before I secured a go-ahead from my parents.

My school life at Ordinary and Advanced Secondary levels hardly allowed me to keep up my passion of observing the wonders of nature. The only golden opportunity arrived in the mid-1990's when I registered for a degree that would lead me to practice the environmentally related activities which eventually shaped my understanding of the term 'nature', and provided me with a glimpse of the general overview of environment. I was further exposed to more environmental management excursions and theories at Master's level in the Netherlands, and little by little, I became a groomed environmental practitioner.

My journey to environmental education started with my appointment as an Assistant Environmental Education and Awareness Officer in the Wildlife Conservation Society of Tanzania (WCST) in November 1999. This gave me opportunities to visit junior and senior schools in the coastal area and collaborate with relevant administrative structures in establishing student environmental clubs and facilitating environmental events. My exposure to activities such as environmental competitions, debates and school-based greening projects painted my identity with a green colour and solidified my curiosity to advance in environment and sustainability education. In the following year (2000), I was attracted to the most appealing job which sought a candidate with an environment and journalism background, to act as the Information, Education, and Communication (IEC) Specialist for a Sida (Swedish International Development Agency)-supported Coastal Management Programme. Luckily enough, I secured the job and was thus able to employ all

my capacities in environmental education programmes. The nature of my new responsibilities drew my attention from terrestrial to coastal and marine ecosystems. I started spending most of my time with mangrove restorers and fishers in seminars, meetings, and conservation related activities. I was also still involved in facilitating the formation and operation of school environmental clubs as I had done while working with the Wildlife Conservation Society of Tanzania. This continued to raise useful insights for my colleagues and I, on how students and teachers could be supported to handle matters that evolve from environmental concerns in and around their school compounds. One of the key roles that the programme aimed to achieve, was to build the capacity of local communities to keep track of the health status of coastal and marine resources, namely mangroves, fisheries, sea grasses, corals, and coastal land. This practice is simply called 'monitoring' and was at that time being carried out in a specified period of time with the assistance of marine scientists from higher learning institutions in the country, and financial support from Sida and the Government of Tanzania.

After a few years, I was promoted to the rank of Team Leader (Programme Manager) to oversee all programme activities. This did not stop me from accompanying resource users in tracking (monitoring) the health status of coastal and marine resources as mentioned earlier. It is from these periodic monitoring sessions that my PhD study evolved. I learnt that while we were in the field observing the environmental conditions, changes, threats, and trends of mangroves, fisheries, sea-grass, and coral reefs; some members of the local community would hardly follow the framework of indicators and methodologies introduced to them by facilitators. This raised my curiosity to undertake further observations on the use of imposed scientific monitoring techniques, and whether the learning process amongst the involved participants was yielding better results or not.

It took me nearly four years to have a glimpse of an answer to the question 'Why would some resource users suggest alternative ways for carrying out monitoring practices?'. After thorough observations and repeated consultations, it was obvious that some key processes that would have encouraged 'learning through participatory praxis' had been overlooked. First, the imposed monitoring framework that was intended to guide monitoring practices on the Eastern Coast of Tanzania contained scientific indicators and methodologies that

proved to be difficult for resource users to follow, as the majority of them were either primary school leavers or did not get access to formal education at all. Secondly, the target group (resource users) who had lived and used coastal resources for many years, were not part of the team that developed the imposed indicators, and therefore their long term acquired knowledge was not considered as being a useful input to the scientific monitoring framework. My observation was that this would to a certain extent, affect their sense of 'belonging' to the community of practice in the coastal environment, and generate a form of non-accountability of individuals and social groups in the management of coastal and marine resources.

My next question that sought an immediate answer was 'How can scientific institutions, and institutions of higher learning (like universities) share research knowledge with local communities - particularly those in the coastal areas - and attract social learning at a wider scale?' It is from this focus that this PhD emerged and developed, with expectations that it would allow and facilitate the development of a monitoring framework h incorporating the local situation and allowing a wider social learning process between involved scientific institutions and communities. To achieve this, I opted for a research approach that would allow processes of abstraction, conceptualisation, and representation of Traditional Ecological Knowledge (TEK) to facilitate the generation of input for a new user- friendly framework of indicators which would first be introduced in the study area and later potentially be replicated to other parts of the Eastern Coast of Tanzania.

1.2 Research Focus

The study is situated within the field of environment and sustainability education, with a focus on social learning in a coastal and marine environment in Tanzania. It aims to contribute to an understanding of, and improvement of epistemological access between coastal communities (users of coastal and marine resources) and scientific institutions on the Eastern Coast of Tanzania, by seeking to stimulate social learning processes at the interface of scientific and indigenous knowledge. For nearly 20 years now, mangrove restorers and fishers in the study area have struggled to use imposed scientific indicators for learning purposes as an approach that would lead to wider social learning in the coastal environment (see sections 2.8 & 2.9). These indicators proved to be too reified, using the

language of description that favours scientific abstractions and representations, and thus leading to lack of *epistemological access* in the social learning processes; particularly in situations where communities have not been inducted into the same scientific discourses used in the indicators. This study seeks to bridge this gap, by identifying and analysing social learning processes and experiential learning methods that may potentially create avenues for coastal communities to generate and incorporate TEK in the existing scientific monitoring framework as ‘*underlabourer*’¹, for indicators that appear to be too reified to them. The study eventually comes up with a framework of indicators that is regarded by resource users as being less reified, more contextually and culturally congruent, and which can easily be used in detecting environmental trends, threats, changes and conditions of mangrove and fisheries resources, and attract wider social learning processes, referred to in this study as ‘periodic-monitoring of coastal and marine resources’.

1.3 Research Context

1.3.1 Background to the Study: coastal context and the need for monitoring

For over two decades now, the world has witnessed an increasing number of coastal management initiatives in areas that are endowed with coastal and marine resources such as mangroves, fisheries, coral reefs, sea grasses, and other coast- based biodiversity. Among the key coastal management processes that attract global, regional, and national (local) attention is the periodic detection of environmental trends, threats, conditions, and changes of coastal and marine resources more commonly known as *periodic-monitoring*. Such monitoring practices are carried out to safeguard the health status of the coastal environment, owing to increasing pressure due to the demand for coastal resources by surrounding local communities (Wagner, 2005; NICEMS, 2003).

At global level, the emphasis on conducting periodic monitoring practices of the coastal and marine environment is part of a wider initiative that has its origin in the decision reached by United Nations member states in Rio de Janeiro in 1992, and adopted as a component in chapter 17.6 of Agenda 21. Some of the key reasons stipulated in Agenda 21 for justifying the detection of environmental threats, trends, conditions, and changes of coastal based

¹ The term ‘underlabouring’ means to support or assist (see section 1.9 for further description).

ecosystems include the fact that coastal areas contain diverse and productive habitats necessary for the sustenance and subsistence of the world's poor who live around them. It is also recognised that local communities and indigenous people rely on coastal resources for food and income (UNCED, 1992; NICEMS, 2003).

At regional level, several management and conservation initiatives which allow ecological monitoring practices have been initiated along the Indian Ocean, through partnerships and conventions. The Western Indian Ocean Marine Science Association (WIOMSA), for example, was initiated in the early 1990s, to link knowledge that emerges from research, to the management and governance of coastal and marine resources in Kenya, South Africa, Tanzania, Mozambique, Mauritius, Madagascar, Comoros, Seychelles, and Reunion (France). Another notable regional initiative is the Nairobi Convention for the Protection, Management and Development of the Marine and Coastal Environment of the Eastern African Region, signed in 1985, came into effect in 1996, and was amended in early 2010. The Nairobi Convention provides a mechanism for regional cooperation, coordination and collaborative action in the Eastern and Southern African region. It enables the Contracting Parties to harness resources and expertise from a wide range of stakeholders and interest groups, towards solving interlinked problems of the coastal and marine environment - including critical national and trans-boundary issues (United Nations Environment Programme, 2010).

At national level, the United Republic of Tanzania, as a signatory to the Nairobi Convention and Agenda 21, initiated Integrated Coastal Management (ICM) projects and programmes in the country at both policy and implementation levels (TCMP, 1998). This witnessed the initiation of local integrated coastal management initiatives in the five regions of the Tanzanian mainland, namely Tanga, Dar es Salaam, Coast, Lindi, and Mtwara under donor support (Irish Aid, Sida, World Bank, World Wide Fund for Nature (WWF), and International Union for Conservation of Nature (IUCN)).

In the Tanga region, the Government and its donor partners (Irish Aid and IUCN) initiated a programme called Tanga Coastal Zone Conservation and Development Programme (TCZCDP) in 1994. This covered all coastal districts (TCZCDP 2004/2005; Samoilys & Kanyanga, 2008),

including Muheza which was later (in 2007) divided into two to form Mkinga District (the study area, see section 4.4). In the Dar es Salaam region, a new initiative called 'Kinondoni Integrated Coastal Area Management Programme (KICAMP)' was planned in the late 1990's, and launched in early 2001 under Sida support (KICAMP, 2001). This was later extended to include more coastal localities in the area. KICAMP drew most of its lessons from the TCZDP, including the adoption and application of scientific indicators in community-based monitoring practices (KICAMP, 2004).

1.3.2 The use of scientific indicators and methodologies in the Eastern Coast of Tanzania; emerging challenges

Through Integrated Coastal Management (ICM) programmes such as KICAMP and TCZCDP, coastal communities were involved in the periodic detection of environmental conditions, threats, changes and trends to coastal and marine resources as an approach for enhancing environmental awareness of involved communities. This motivated them to 'protect' coastal and marine resources (KIMP, 2005, p. 5), encouraging "knowledge sharing and learning as participants directly take part in the monitoring practice" (KICAMP, 2004, p. 26) or "learn through experiences in nature" (National Environmental Education and Communication Strategy (NEECS), 2005-2009, p. 9). This approach depicted a social learning typology which views learning as taking place "through deliberate experimentation and reflective practice involving joint actions such as monitoring" (Cundill & Rodela, 2012, p. 21).

The ICM programmes thus commissioned scientific institutions to develop monitoring programmes (KIMP, 2005, p.3) to guide what was said to be 'participatory monitoring' practices. The latter contained scientific indicators and methodologies adopted from the Survey Manual for Tropical Marine Resources developed by English, Wilkinson, & Baker (1994 & 1997 (see appendices 25 & 26), which are considered to be "in line with those put forward by the Science and Technical Working Group (STWG) of Tanzania Coastal Management Partnership" (KIMP, 2005, p. 3).

It was envisaged by ICM policy makers and participating actors that the use of scientific knowledge in community-based monitoring practices (TCMP, 1998, p. 9) would spread along the eastern coast of Tanzania and "influence learning and sustainable utilization of coastal

and marine resources” in the region. However, research carried out by Julius (2005, p. 2), indicated that there was “no effective monitoring programme” in place for the coastal environment and marine resources in the country. Moreover, the report released by KICAMP after its first phase of implementation indicated that local communities in the eastern coastal of Tanzania, struggled to “understand and apply the scientific indicators suggested in the monitoring programmes” (KICAMP, 2004, p. 26).

This implies that the ‘social learning typology’ embarked on by the ICM programmes and their partners had not played out as was envisaged. Reed et al. (2010) argue that for social learning to occur, three key criteria must be met. First, there has to be a demonstration that a change in understanding has taken place in the individuals involved; secondly, there must be a clear demonstration that this change goes beyond the individual and becomes situated within wider social units; and lastly, that the learning process must have occurred through social interactions and processes between involved actors. From this, it is possible to argue that the criteria which necessitate the occurrence of social learning were not met during the implementation of integrated coastal management, hence the process of social learning envisaged was not successful. Perhaps it is wise to examine possible reasons that are likely to have emerged as obstacles to successful learning.

Possible reasons for its failure include the fact that the introduction of scientific indicators and methodologies as key ingredients in the social learning process used a top-down approach, which ignored contextual realities on the ground such as the level of formal knowledge or education among target communities and local experiences (KICAMP, 2004).

In one of the studies carried out on the eastern coast of Tanzania by a team of marine scientists, a random sample of 145 individuals was taken for purposes of analysing their socio-economic status, including the level of education. The results indicated that the level of education among target communities “was very low” (Wagner, Mgaya, Akwilapo, Ngowo, Sekadende, Allen, Zollet, & Mackentley (2001, p. 475). About one-third of the population (31%) had no formal education at all, 26% had reached only up to standard IV, 3% had completed standard VII, and only 2% had received post-primary education. The study also revealed that women had generally “lower literacy and educational levels” than men (Ibid.).

In another coastal monitoring context, an assessment was carried out in the same area by one of the capacity building programmes through a two-day participatory workshop, to establish the capacity of coastal communities and local government staff to understand and apply the adapted monitoring plan. It was observed that the latter were more conversant with the indicators and methodologies used in the plan than the former (KICAMP, 2004, p. 26). The difference was ascribed to the varying "levels of formal education" between the two.

The imposed social learning typology also did not consider the potential of Traditional Ecological Knowledge (TEK) as a key input to the participatory monitoring programme. Responding to this kind of situation, Fraser, Dougill, Mabee, Reed, & McAlpine (2005, p. 115) insist that "local input" is required when developing community-based monitoring indicators, for the same to "accurately measure what is locally important". Kofinas, Lyver, Russels, White, Nelson, & Flanders (2003) also affirm that community-based monitoring practices can only be successful if the logic and methodology are derived from traditional ecological knowledge. This is because constant learning from lived experiences and daily observations set a platform for further learning (Berkes, 2008).

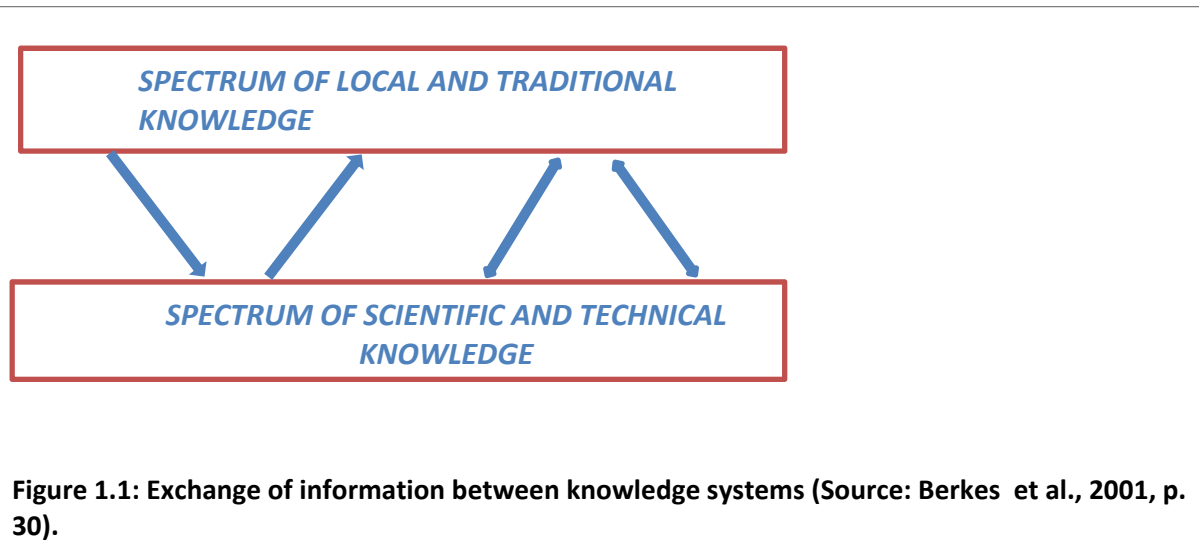
1.3.3 Bringing Traditional Ecological Knowledge (TEK) into view

Berkes (2008) affirms that insights from indigenous wisdom offer great potential for broadening epistemological access, given the difficulties and limitations of accessing and using scientific knowledge (western science) in addressing complex ecological challenges. Such difficulties emerge when scientific institutions favour the language of description and methodologies that are too hard for non-specialists at community level to follow, leading to lack of epistemological access between scientific institutions and local communities (Reed et al., 2006).

Campbell (2000) argues that problems are likely to emerge when facilitating firms and organisations prioritize natural scientific norms and approaches in community-based initiatives. Proceedings from the scientific forum on Integrated Coastal Management issues in Tanzania indicate that scientific knowledge was being "presented in a manner that was

too complicated” and a form that tended to limit understanding and access to information for management purposes (TCMP, 1998, p. 3)

Reid, Berkes, Wilbanks, & Capistrano, et al., 2006) advise that ways have to be explored in which scientific (western) and tradition knowledge can be used together, and conditions necessary for such integration need to be better understood. Berkes et al., 2001 affirms the integration idea as reflected in Figure 1.1 below:



1.3.4 The potential of TEK in developing indicators for detection of trends, changes, and threats in the coastal environment

There is evidence that indigenous groups in different geographical settings have developed their own traditional environmental monitoring mechanisms based on their own knowledge (Kofinas & McPherson, 2002; Heaslip, 2008; Castello, Viana, & Watkins, 2009).

Arguing in support of the existence of community based monitoring activities that are engineered by indigenous people, Berkes (2012) states:

As people with detailed understanding of the environment and accumulation of observations over generations, indigenous groups have a special place in community-based monitoring. As well, it is becoming clear that many indigenous groups have developed their own traditional monitoring based on their own ways of knowing... Most traditional monitoring methods used by indigenous people are rapid, low-cost, and easily comprehensible by harvesters themselves as they hunt, fish, and gather forest products ... (p. 186).

McDonald, Arragutainaq & Novaling (1997) argue that indigenous monitoring practices use traditional ecological knowledge as an input for monitoring not only local changes but also region-wide large scale environmental changes. As stated above by Berkes (ibid.), such monitoring is rapid, cost effective, and it employs methods that are comprehensible to local communities.

For communities to conduct environmental monitoring (detection of changes, threats, trends, and conditions of natural resources), there have to be indicators in place, and specified methods (see section 1.8 for meaning, types, and use of indicators).

Distinction is made between the indicators that indigenous people develop and those that are developed by scientific institutions such as universities, and conservation NGOs operating at different levels. Indicators developed by scientific institutions tend to be quantitative in nature and the language of description used is often abstract and reified (Hoppers, 2002; Berkes, 2012). In contrast, the indicators developed from indigenous sources are in most cases qualitative, as argued by Berkes (2008):

Indigenous observers do not gather quantitative data, but their ways of observing and assessing changes provide insights regarding the way indigenous holism is constructed... Indigenous knowledge seems to build holistic pictures of the environment by considering a large number of variables qualitatively, whereas science tends to concentrate on small number of variables quantitatively.....The indigenous solution is brilliant in building a holistic understanding by monitoring large number of variables over a period of time, accumulating and accessing a large amount of qualitative data, and building a collective mental model of health of animals and the environment (pp. 197, 201 and 202 respectively).

Parlee, Manseau, & Lutsel K'e Dene First Nation (2005b) affirm the role of traditional ecological indicators for the environment, by arguing that such 'qualitative' indicators are normally consistent with indigenous notions of health relations with the environment and biodiversity in general, and insist that their use in community-based monitoring practices (such as monitoring of mangroves and fisheries) has significant potential to enhance the health status of the environment that such communities live in. Reed et al. observe that indicators that are developed at local level (pursuing a bottom-up approach) have often

proved to be “accurate and easier to use than the indicators developed by experts” (2006, p. 414).

According to Berkes (2008), indigenous monitoring practices yield information on extreme changes (strange distributions, rare occurrences, breeding failure, unexpected behaviour etc.); presence or absence of desirable or undesirable species or assemblage; pre or post-harvest observation of species; harvest success; catch rate (usually per unit of time or time) and effort spent. Common methodologies used include feel, see, touch, smell, hear and taste (Ibid.).

1.4 Problem Statement

The process that guides participatory monitoring of coastal and marine resources on the eastern coast of Tanzania is mainly centred on the use of adopted scientific indicators, methods and techniques, which exclude contextual, social and cultural realities. Such monitoring tools fail to stimulate and mobilise learning among involved individuals and social groups, since their language of description favours scientific abstractions which limit the comprehension and capacity of involved non-specialists “to effectively adapt and apply them” (TCMP, 1998, p. 3). A report released by KICAMP after its first phase of implementation, indicated that local communities in the specified area struggled to “understand and apply” the scientific indicators suggested in the monitoring programmes (KICAMP, 2004, p. 26). Moreover, much emphasis was placed on participation of involved actors rather than on knowledge acquisition.

Reed et al. (2006) caution that indicators must be relevant to local people, and the methods used to collect, interpret and display data must be easily and effectively applied by non-specialists to allow full engagement of the local people. Aswan & Lauer (2006b), Chalmers & Fabricius (2007), and Goldman (2007) argue in favour of incorporating traditional ecological knowledge or indigenous logic and rules in community based monitoring practices for sustainability reasons.

Glahn, Specht, & Koper (2007, p. 2) insist that contextual realities should be incorporated in the indicators to help actors to organise, orient, and navigate through the learning process. They argue that contextual information has been proved to be important in supporting the learning processes as this stimulates learners' engagement in, increases their commitment to collaborating processes, helps them to reflect on acquired competences, and "supports thoughtful behaviour in navigation and learning paths". Campbell & Vainio-Mattila (2003, p. 425) raise the need for a process which will allow control over knowledge use and access to the information "to shift from experts and scientists to the people whose lives are being affected".

1.5 Research Goal

This study sought to understand the processes of abstraction, conceptualisation and representation of TEK and their potential contribution to the development of coastal monitoring indicators that may be less reified, more contextually and culturally congruent, and which can potentially more easily be used by resource users in the wider social learning process of detecting trends, threats, changes and conditions of mangrove and fisheries resources.

1.5.1 Research Question

How can processes of *abstraction, conceptualisation, and representation* of TEK contribute to the development of coastal management indicators that are less reified, more contextually and culturally congruent, and which may potentially be used by resource users in the wider social learning process of detecting trends, threats, changes and conditions of mangrove and fisheries resources?

1.5.2 Sub-Research Questions:

1. What is the potential contribution of abstraction, conceptualisation and representation in social learning processes within the coastal environment?
2. How can processes of abstraction and conceptualisation mobilise the representation of traditional ecological knowledge that is necessary in developing indicators for monitoring fisheries and mangrove resources?

3. How can abstracted TEK indicators be used as *underlabourer* for existing scientific indicators, and attract a wider social learning process of detecting trends, threats, changes and conditions of mangrove and fisheries resources?

1.6 Overview of study design, Study site, potential contribution of the study & study limitations

1.6.1 Study design

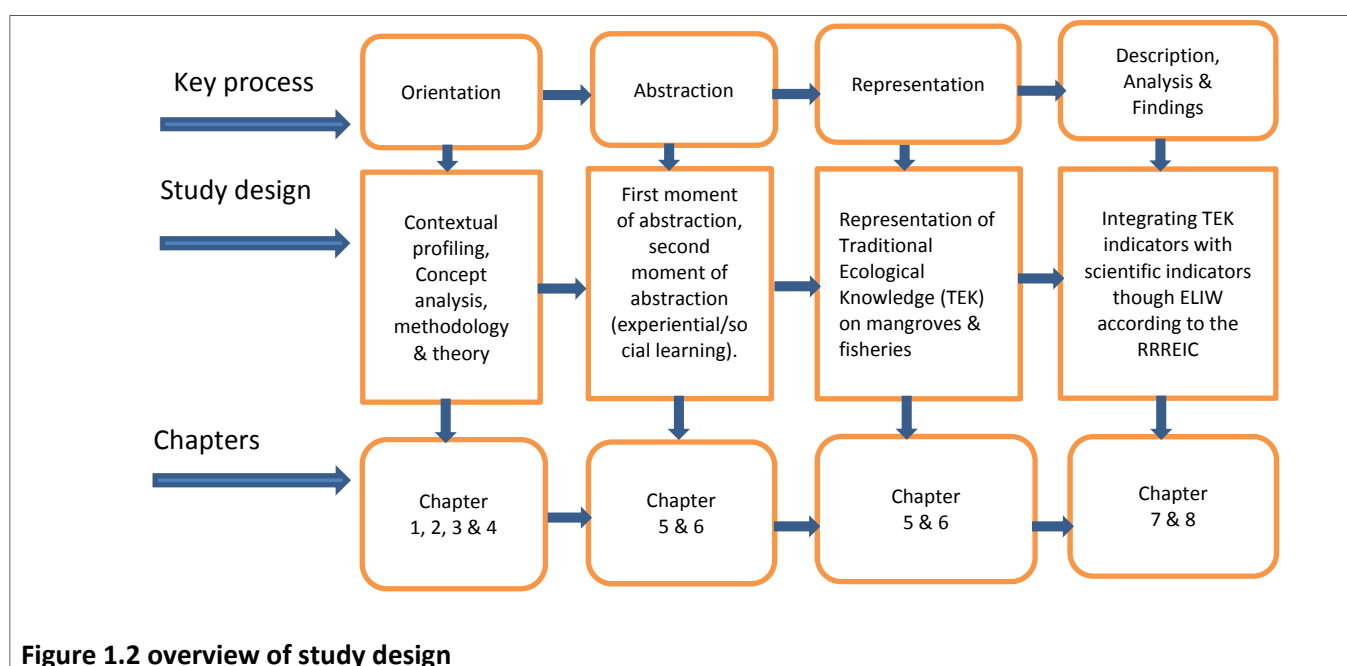


Figure 1.2 overview of study design

1.6.2 Study site

The study was carried out along a coastal mangrove strip that extends from Moa to Boma localities in the Mkinga District (see figures 4.1 & 4.2) on the eastern coastal area of Tanzania. The site is covered by over two thousand hectares of mangrove species and coastal and marine ecosystems that depict a potential context for experiential learning and social learning processes. Moreover, resource users in the study area (particularly fishers and mangrove restorers) are among coastal communities who had been involved in coastal monitoring practices from the early 1990's and are well versed with the challenges that are associated with adapting and applying scientific indicators - which this study seeks to address.

1.6.3 Potential contribution of the study:

1.6.3.1 Contribution to the field of environmental education

The study has the potential for understanding ways through which TEK can be represented by individuals, groups, and communities at large as an input for developing specific educational programmes, teaching materials, and training manuals on the Eastern Coast of Tanzania. The Tanzanian National Environmental Education and Communication Strategy (2005-2009) calls for integration of traditional ecological knowledge (TEK) into Education for Sustainable Development (ESD) and school curricula. For this to happen, ways through which TEK can be represented or appropriated have to be explored.

1.6.3.2 Contribution to wider social learning

The study also suggests social learning processes and experiential learning methods that may potentially create avenues for coastal communities to generate and incorporate TEK in the existing scientific monitoring framework as '*underlabourer*' to indicators that appear to be too reified for them. It eventually comes up with a framework of indicators that is regarded by resource users as being less reified, more contextually and culturally congruent, and which can easily be used by common resource users in detecting trends, threats, changes and conditions of mangrove and fisheries resources in a wider social learning process.

1.6.3.3 Contribution to epistemological access in social learning

The study has the potential for understanding the processes that favour epistemological access between scientific institutions and local communities for purposes of knowledge sharing. Most of higher learning institutions for example, profess to undertake community engagement responsibilities but there is evidence that knowledge flow between those institutions and local communities is limited. This study also contributes to addressing the above gap.

1.6.4 Study limitations

This study is regarded as case study research, designed to seek in-depth rather than wide-ranging information (see section 4.2). It employs processes of abstraction as a key to unlocking epistemological and ontological realities in the coastal environment. Limitations

are that employed processes have only been 'tested out' in the case contexts of this study. However, besides the actual indicators developed, which may be context dependent, the study also theorises and models a more inclusive, less eliminating process of indicator development and use, which may be tried in other contexts for learning purposes.

1.6.5 Anticipated contribution of the study

- The study seeks to inform and support the work of development experts and scientists in addressing challenges that emerge from adopting and applying knowledge frameworks, approaches, and models in local contexts.
- It also provides a case example of experiential learning practices and enhancing social learning in the coastal environment.
- It potentially also sheds light on how social learning can be stimulated, enhanced or impeded.
- I also anticipate that the indicators that emerge from this work (see tables 7.1 & 7.2) will attract active participation, accountability, and a sense of ownership in the coastal environment since they are based on contextual realities on the ground, and are themselves a result of the social learning process.
- The study has potential to create a knowledge sharing space between scientific institutions and coastal communities, for advancement of experiential learning practices, research activities, social learning, and improved praxis.

1.7 Key concepts in the study:

1.7.1 Abstraction and Conceptualisation

There is no consensus among researchers with regard to the unique meaning of abstraction (Hazzan, 1999). The term is widely used in different disciplines and philosophical perspectives such as Critical Realism, Hermeneutics and Marxism. Abstraction stems from the Latin words *abs* and *trahere*, meaning to draw away from. The Dictionary of Critical Realism (Hartwig, 2007, p. 71) considers abstraction to be the "mental process of isolating out, omitting, or absenting other aspects of the phenomenon being studied". It involves reducing the information content of a concept or an observable phenomenon, typically to

retain only information which is relevant for a particular purpose. Abstraction helps us to set boundaries within our perceptions by distinguishing what we see, hear, feel, experience, touch, and envision in different perspectives, and separating what is relevant from what is not (Ollman, 2003).

On the other hand, conceptualisation refers to a process through which “we specify what we mean, when we use particular terms in research language” (Babbie, 2007, p. 110). While both abstraction and conceptualisation may seem to be independent processes as their definitions stand, some authors agree that the two can hardly be separated (Danemark, Ekstrom, & Jacobsen, 2002). Ruane, (2005, p. 48) for example, argues that abstraction is reflected in the form of ‘concepts’, and she goes further by explaining that “concepts are essential tools for communication” and they enable us to give and receive information efficiently. As Puck & Stibbards (2012, p. 353) put it, concepts are not simply representations of the external world but rather “are active in the meaning-making process themselves”. Meaning making in this context implies ecology of the mind in which there is a union between perception and objects that are abstracted and conceptualised (Ibid.). Sayer (2000), for example, hardly separates abstraction from conceptualisation. He presents them as working together towards a common goal:

Much rests upon the nature of abstractions, that is, our conceptions of particular one-sided components of the concrete object...We therefore have to rely on abstraction and careful conceptualisation, in attempting to abstract out various components or influences in our heads, and only when we have done this and considered how they combine and interact can we expect to return to the concrete, many-sided object and make sense of it (p. 19).

Knowing what someone means when they use specific concepts provides a view of what is found in their thoughts (Puck & Stibbards, 2012). Some researchers have attempted to develop the so called ‘alternative conceptions’ models to allow the flow of experience-based explanations through which learners (coastal communities in this context) make a range of abstractions from natural phenomena as a path that leads to understanding and knowledge (ibid.). Sayer (2000, p. 36) argues that how we make sense of one concept or subject “depends on the concepts we use to interpret it”. Any description of the world is

“explanatory within a particular set of conceptual relations and potentially transformative of those relations.” (Scott, 2010, p. 6)

1.7.2 Representation as a process

Like abstraction, representation is a common term used in many different fields and domains (Webb, 2009). Due to its wide use, there are different meanings that are attached to it (Vieira & Runciman, 2008). In this study, I draw on the meaning that views representation as a process that leads to the description of an idea or concept based on knowledge of the external world (Ibid.), on grounds of its relevance to the research goal. Representation also refers to the use of signs that stand in for and take the place of something else (original object). It is through representation that people organize the world and reality through the act of naming its elements. This may involve representation of concepts that are abstracted in photographic images, video coverage, and general audio-visual work. A good example of the process of representation is given in chapter 6; when mangrove restorers and fishers take part in an experiential learning practice which exposes them to taking photographic images of their choice, and at a later stage, they take part in describing the images they have taken and how their participation in the practice stimulated learning amongst them.

Pole (2004) argues that there is a strong connection between the idea of memory and the photographic image which is always a representation of reality. However, the meaning of the images depends on the ways that participants interpret them, rather than on some inherent property of the images themselves (Herper, 2002 in Stanczak, 2007). Representations are therefore also dependent on abstractions and conceptualisations that are given meaning in the contexts of social practice. The same photograph of mangrove species could for example, represent significant TEK on the condition of the mangroves, or may be viewed by someone else more simply as a ‘nice image’ of the coastline or ecology of an area. The process shows how people make sense of the world and how they understand themselves and their environment (Webb, 2009).

Processes of abstraction and conceptualisation culminate when concepts, thoughts, ideas, or images are represented via used languages (Sayer, 2000). Through representation

processes, various kinds of knowledge can be represented, especially by social groups reflecting on what they have experienced in the social world. Traditional knowledge for example, provides insights on ecosystem dynamics, leading to important applications such as ecological restoration (Anderson & Barbour, 2003).

1.7.3 Indigenous Knowledge (IK) and Traditional Ecological Knowledge (TEK)

Terms such as Traditional Ecological Knowledge (TEK), Indigenous Knowledge (IK), Local Knowledge (LK), Traditional Knowledge (TK), Aboriginal Knowledge (AK), Native Knowledge (NK), Indigenous Knowledge Systems (IKS) and Indigenous Technical Knowledge (ITK), share a common meaning which refers to wisdom, experiences, lifestyles, know-how skills, practices, innovations, and beliefs that are unique to specific communities of people, and which are situated or embedded within broader cultural-historical traditions (Berkes, 2008; 2012).

In this study, I use the term 'Traditional Ecological Knowledge' (TEK) to represent other forms of indigenous knowledge (see 1.7.3) due to its inclusiveness, richness in accommodating key attributes that define indigenous knowledge systems (Berkes, 2008; 2012), and its specificity to ecological monitoring. TEK is defined

as a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 2012, p. 7).

Fabricius & Koch (2004) observe that TEK involves also knowledge of resource and ecosystem dynamics that local communities have accumulated over time.

1.7.4 Representation of Traditional Ecological Knowledge (TEK)

Through representation processes, abstracted and conceptualised traditional ecological knowledge has contributed to improved understanding of different kinds of ecosystems (Berkes, 2008; 2012). There is evidence that new scientific knowledge can be derived from perceptive investigations of TEK with respect to species identifications and species interrelations (Nabhan, 2000b; Laird, 2002; Nazarea, 2006). In Eastern Southern Africa for example, scientific wildlife institutions appropriated traditional ecological knowledge from

the Nguni people and used it in creating green nature reserves, and in developing notions of conservation and environmental education (O' Donoghue, 2003). There are also several cases where traditional knowledge has provided corrections to natural science with regard to fish spawning seasons and ecosystem dynamics (Johannes, Freeman, & Hamilton, 2000).

In some geographical settings, indigenous groups have developed their own traditional monitoring mechanisms that help them to establish the health status of ecosystems based on abstracted, conceptualised and represented TEK (Kofinas & McPherson, 2002). Such knowledge is not only useful in solving local situations but also for classroom activities (Ballantyne & Packer 2002; Fisher, 2001). Representation of TEK is a process that involves a change in understanding and reinterpreting knowledge through communication amongst involved social groups (Reed et al., 2006).

Abstraction, conceptualisation and representation processes are also reflected in Kolb's *experiential learning cycles* as "abstract conceptualization" or thinking processes through which learners conceptualise a model or plan of what is observed (Kolb, 1984, p. 38). According to Kolb, the learners consciously translate their own experience through a reflection of concepts while they are in the field or specific geographical settings; and try to use them in testing or planning a model.

Davies (2009) views abstraction, conceptualization and representation processes as an act of using a mix of picture-based materials, metaphors, and experiential dialogue in social learning processes. This outlook broadens the application of the above processes in social learning, and helps to set their scope and domain. The use of picture-based materials or images is supported by Stanczak (2007), who argues that images are not merely appendages to research but rather inseparable components which aid the learning process about social worlds.

While abstraction, conceptualisation and representation processes prove to be useful in experiential learning as reflected in Kolb's learning theory (ibid.), their role in facilitating social learning processes at community based level, especially in natural resources management has not been widely investigated. Sayer (2000, p. 19), for example, observes that "a bulk of literature" on social science completely "ignores abstraction". This calls for a

need for social scientists to bring into view the usefulness of the above processes and their potential contribution to social learning, particularly in the coastal environment (in the context of this study).

1.7.5 Social Learning

Recent descriptions of social learning describe it as a kind of learning that takes place at a wider scale or level (Reed et al., 2010), and a process that allows individuals and social groups to learn from each other. The early work of Bandura (1977) described social learning as mainly occurring at individual level and possibly in a linear manner. In this study, I work with a school of thought which believes that social learning is also emergent from the context within which it occurs (Pahl-Wostl, 2009; Reed et al., 2006; Mostert, Pahl-Wostl, Rees, Searle, Tabara, & Tippet, 2007; Pahl-Wostl et al., 2007) and that it is a process that leads to a change in understanding, and in perceiving and doing things in different ways that can potentially benefit social-ecological systems.

It is however, observed by Lotz-Sisitka (2012, p. 7) that though social learning serves as an “enabling condition”, little is documented on *how* such learning and change occur. This calls for a need to bring into view possible processes that are involved social learning information. O’Donoghue (2001) suggests a model which depicts situated and deliberative learning. The model encourages learners to consider what is already known (situated start-up stories), move to another level of where more information can be found (information seeking), deliberate on what should be reported (reporting ideas), agree on what should be done (trying out and experimenting/ taking action), and re-thinking of key needs that can benefit the social learning process. Wals (2007) argues that social learning is rooted in the life-worlds of people, and adds that there is a need to find out how people learn, what they want to know and learn, and how they will be able to recognize, assess and avoid challenges that result from social norms, personal biases, and group thinking. He further raises several key questions that pose challenges to social learning researchers:

How can social learning build upon people’s own knowledge, skills, and offer alternative ways of looking at the world? How can the dissonance created by introducing new knowledge, alternative values and ways of looking at the world become a stimulating force for learning, creativity and change? How can people

become more sensitive to alternative ways of knowing, valuing, and learning from what they are doing? How do we create spaces or environments that are conducive to the emergence of social learning? (p. 19).

Responding to descriptive challenges that resonate around social learning in the field of natural resource management, Cundill & Rodela (2012) mirror some typologies that emerge from a systematic review of social learning literature depicting possible processes that are necessary for occurrence of learning.

They argue that some literature represents social learning as a process that takes place through deliberative processes involving sustained interaction between individuals, and the sharing of knowledge and perspectives in a trusted environment, while others consider it to be occurring through deliberate experimentation and reflective practice, involving joint actions such as monitoring (Ibid.). In this case, social learning may involve experiential learning forms.

They also observe that some authors in the field of natural resources management describe social learning as a self-organising process of social-ecological interactions over long periods of time, and others regard it as a tool that has the potential to improve decision making by increasing human-environment interactions, building relationships, and encouraging problem solving capacity among stakeholders. Social learning is also depicted as a process that facilitates collective action around common environmental concerns and leads to behavioural change (see section 2.2).

1.7.6 Scientific knowledge

Distinction is made between the form of knowledge that is generated by formal scientific institutions (referred to in this study as scientific knowledge) and knowledge that is generated by indigenous communities (traditional ecological knowledge). The former is commonly referred to as “Modern science” (Hoppers, 2002, p. 24), “Global science (Sillitoe, 2007, p. 1), or “Western science” (Berkes, 2012, p. 31), and sometimes all four terms; ‘scientific’, ‘modern’, ‘western’ and ‘global’ are used interchangeably.

Hoppers believes that modern science is characterised by “one basic hypothesis; the idea that the structure of nature is mathematical” and therefore its description requires mathematical tools and approaches, “instead of a purely qualitative description of nature” (2002, p. 27). She argues that such a mathematical approach to nature dates back to the form of knowledge and methodologies inaugurated by the Italian philosopher Galileo, which started in Europe, and was later accepted in different parts of the world by formal institutions. Haverkort & Reijntjes (2010), consider modern science to be a form of knowledge which is produced through a thorough process of logical thinking, rational reasoning, measuring, empirical perception, quantification and experimenting.

The Alaska Native Science Commission in collaboration with the National Science Foundation (NSF) in the United States have, through a series of community workshops and forums involved native communities and scientists from the Arctic region to compare scientific knowledge and indigenous knowledge in terms of style and use. The two tables below give a clear comparative analysis of the two:

Table 1.1: Comparative in terms of style

Indigenous Knowledge	Scientific Knowledge
assumed to be the truth	assumed to be a best approximation
sacred and secular together	secular only
teaching through storytelling	didactic
learning by doing and experiencing	learning by formal education
oral or visual	written
integrated, based on a whole system	analytical, based on subsets of the whole
intuitive	model or hypothesis-based
holistic	reductionist
subjective	objective
experiential	positivist

Table 1.2: Comparative in terms of use

Indigenous Knowledge	Scientific Knowledge in use
lengthy acquisition	rapid acquisition
long-term wisdom	short-term prediction
powerful prediction in local areas	powerful predictability in natural principles
weak in predictive principles in distant areas	weak in local areas of knowledge
models based on cycles	linear modelling as first approximation
explanations based on examples, anecdotes, parables	explanations bases on hypothesis, theories, laws
Classification: • a mix of ecological and use • non-hierarchical differentiation • includes everything natural and supernatural	Classification: • based on phylogenic relationships • hierarchical differentiation • excludes the supernatural

Source: ANSC –www.nativescience.org, 2012.

1.7.7 Coastal and Marine Environment

The two terms ‘coastal’ and ‘marine’ are commonly used and reported in a conjoined form but may analytically be separated. The former is used to describe a geographical location where land meets the ocean or sea and where interactions between the land processes and the sea occur. Sometimes the term ‘coastal’ and ‘coast’ may be used interchangeably but they all have the same meaning. Coastal land harbours significant populations of local communities whose survival depend upon interactions that occur in adjacent oceans or seas (UNCED, 1992). Taking the example of Tanzania, it is estimated that about 15 per cent of the population live near the country’s Eastern Coast (NICEMS, 2003). The same is true of the Indian Ocean in countries such as South Africa, Mozambique, Mauritius, Madagascar, Comoros, Seychelles, Reunion, the Philippines, and some other Asian countries (Michel & Sticklor, 2012).

On the other hand, the term ‘marine’ is connected to life in the ocean or sea. Examples of marine life include fisheries, coral reefs, sea grasses, and mangrove forests (Wagner et al., 2001).

1.7.8 Mangrove species and fisheries that use them as key habitat

Mangroves are salt tolerant plant species that grow in tropical and subtropical areas along the land-ocean interface, estuaries², lagoons, rivers and backwaters (Kathiresan & Bingham, 2001). The term 'mangrove' is used to describe trees and shrubs that grow in a tidal environment and their ecosystem (Food and Agriculture Organisation of the United Nations (FAO), 2007). They appear evergreen throughout the year near sheltered coastlines. Their seeds germinate while still on the parent plant, which enables them to rapidly establish in soft sediments "without being washed away by the tide" (Scheltinga, Counihan, Moss, Cox, & Bennet, 2004, p.11). Mangrove forests cover approximately 20 million hectares worldwide (FAO, 2007), and they offer a variety of benefits ranging from socio-economic to cultural and ecological. They are found in 124 countries in sub-tropical and tropical areas (Ibid.), including Tanzania.

Mangroves are homes to a variety of invertebrate communities in and on sediments such as anemones, sponges, polychaetes (worms), bivalves (oysters and mussels), ascidians (sea-squirts) and barnacles and fish (Berjack, Campbell, Hockett, & Pammenter, 2011). They also host zooplankton (floating animals ranging from microscopic to large jellyfish), crustaceans (mud prawns, penaeid prawns, sesarmid crabs, ocyrodid crabs, portunid crabs, and pistol shrimps), molluscs (such as climbing whelks), fish (resident fish, marine migrants, marine stragglers, freshwater stragglers, and passage migrants), amphibians (normally categorized as rare in the mangroves, and reptiles (such as snakes, lizard, crocodiles, and ocean turtles) which are frequent foragers in the mangroves eating "mature fruits of *Avicennia marina* that drop from the tree at high tide" (Berjack et al, 2011, p. 71).

They stabilize coastal intertidal soils, reduce shoreline erosion, absorb and transfer nutrients, maintain water quality by trapping pollutants, and have a great capacity for recovering from natural disturbances (Ellison, 2000; Faunce & Serafy, 2006). Post tsunami studies have indicated that mangroves can significantly reduce the impact of coastal storms and thus protect adjacent communities from the devastating damages of tsunamis (Alongi, 2007; Scheltinga et al., 2005).

² An estuary is a part of the coastal area with blackish water where one or more rivers or streams flow into.

Mangroves (see Plate 1.1) are key habitats that support many species and their loss can affect both marine and terrestrial biodiversity (Kathiresan & Bingham, 2001). They serve as nursery grounds for a variety of fish and offer shelter to juveniles of a wide variety of marine organisms (Faunce & Serafy, 2006). Mangroves are also considered to be a good indicator of coastal change, especially sea level rise (Blasco, Saenger, & Janodet, 1996).



Plate 1.1 Mangrove area dominated by *Ceriops tagal* species (Mkandaa) in the eastern coast of Tanzania-source: field data, 2012.

The Tanzanian coastline is rich in mangrove ecosystems in all of the coastal districts (see figure 1.3). A variety of mangrove species are found in eleven coastal districts (see tables 1.2 & 1.3), although there is a decline in the Rufiji district.



Table 1.3: Mangrove coverage (in hectares) in the Eastern Coast of Tanzania between 1990 & 2000

Coastal districts	1990	2000
Tanga, Mkinga & Muheza	9,217	9,313
Pangani	3,799	3,879
Bagamoyo	5,039	5,051
Dar es Salaam	2,494	2,516
Kisarawe	4,159	4,092
Rufiji	49,799	48,030
Kilwa	21,826	21,755
Lindi	4,034	4,044
Mtwara	9,226	9,458
Total	109, 593	108,138

*Tanga region has 4 coastal districts (see row 1&2)

Table 1.4: Mangrove Tree Species in Tanzania

No.	Tree species	Local name
1	<i>Avicennia marina</i>	Mchu
2	<i>Bruguiera gymnorhiza</i>	Msinzi or muia
3	<i>Ceriops tagal</i>	Mkandaa
4	<i>Heritiera littoralis</i>	Msikundazi or mkungu
5	<i>Lumnitzera racemosa</i>	Kikandaa or mkandaa dume
6	<i>Rhizophora mucronata</i>	Mkoko
7	<i>Sonneratia alba</i>	Mpia
8	<i>Xylocarpus granatum</i>	Mkomafi
9	<i>Xylocarpus molluccensis</i>	Mkomafi dume
10	<i>Pemphis acidula</i>	Mkaa pwani

Figure 1.3 Coastline showing mangrove coverage in Tanzania (Source: FEA, ENVIROCARE & TACOECONT, 2010³)

Table 1.3 indicates the distribution of mangrove species by hectares on the Eastern Coast of Tanzania (excluding Zanzibar and Pemba Islands). The table reveals a general decline of mangrove forests from 109,593 hectares (1990) to 108,138 (2000). Rufiji coastal district (in Lindi Region) appears to be the most affected of all coastal districts, probably due to shifting

³ 'FEA' stands for Foundation for Environmental Awareness; 'TACOECONT' for Tanzania Coastal Environmental Conservation Network. ENVIROCARE is applied as a full term for a locally based environmental NGO in Tanzania.

rice cultivation which encouraged clearance of mangroves (Semesi, 1989). On the other hand, the four coastal districts in the Tanga Region, namely Tanga, Muheza and Mkinga (the study area; see figures 4.1 & 4.2) registered an increase in mangrove forest-cover which may be ascribed to on-going community-based restoration initiatives and the introduction of byelaws to restrict clearance of mangrove resources. Table 1.4 on the other hand, indicates the type of mangrove species present in Tanzania and shows their scientific names and local names (Swahili). Species no. 1, 3,6,7,8 and 9 are common in the study area.

1.7.9 Indicators

An indicator is a measure that is used to detect, indicate, or demonstrate change, results of, or progress of an activity or initiative (Canadian International Development Agency (CIDA), 1997). Indicators may be developed in qualitative or quantitative terms, depending on involved parameters or attributes, the purpose and the level of use. Qualitative indicators are expressions or concepts that are collected in the form of observations or descriptions, while quantitative indicators are based on measurable data in the form of numbers and ratios (Gallopín, 1997). Qualitative indicators carry on board “people's perceptions and judgements” about a phenomenon or subject rather than ratios, rate, percentage or share which are key in quantitative indicators (Patton, 1997, p. 220). For example, the number of fishers owning fishing boats in a coastal village is a quantitative indicator, and the confidence those people have in boats as reliable fishing equipment for income generation is a qualitative indicator. In other words, qualitative indicators use descriptive concepts as indicators while quantitative indicators use numbers and the other statistical attributes mentioned earlier.

There are different types of indicators that can be brought into view. These include: direct indicators, indirect indicators, and performance indicators. Direct indicators indicate a change, result, or an impact in a precise or lucid manner. They are called ‘direct’ because they indicate a situation or phenomena directly. Users of such indicators don’t need a related or closer term or measure to describe them. A good example of such indicators is an attempt to establish the extent of destruction of mangrove forests by ‘recording’ the number of ‘stumps’ in a cleared area. The latter (number of stumps) is a direct indicator which is precise.

On the other hand, indirect indicators are used to indicate or demonstrate the change where direct measures are not feasible. Some phenomena, like impact, are difficult to monitor. It is often necessary to select indirect or proxy indicators that may be easier for a monitoring team to measure. For example, the level of environmental awareness in the coastal area may be measured or determined by the extent to which mangrove restorers, fishers, and other social groups participate in organised programmes or practices. In this case, one may not have a direct measure that may determine the level of awareness, but rather use a proxy indicator like the 'extent of participation' to establish whether the level of awareness is high or low among the target groups.

Performance indicators show results relative to earlier plans at each level of intervention. They seek to measure impacts, outcome, outputs, and processes. They are normally used as tools for performance based interventions, and can also be used at the later stage of an intervention to evaluate its success.

Impact indicators measure the quality and quantity of programme or project output such as change in quality of life, reduced incidences of illegal fishing, increased level of environmental awareness, and reduced rate of forest degradation on a long-term basis, as opposed to outcome indicators which measure or indicate intermediate results (Patton, 1997).

Output indicators seek to measure the quality and quantity on a short-term basis yielding short-term results of an initiative, while Process indicators measure the progress of activities in an intervention, and how these are implemented. Input indicators indicate or measure the quality, quantity and timeliness of resource delivery in the interventions (Ibid.).

Indicators may be applied at local or global levels depending on the purpose or aim of their use. Monitoring practices that are carried out by indigenous communities for example, tend to be more solid at local level and scale than at global level, and make use of indicators that prioritize traditional ecological knowledge as key input (Berkes, 2008).

1.7.10 Underlabouring

Benton & Craib (2001) apply the concept of 'underlabouring' to show the kind of 'support' that philosophy may offer to the scientific world. They employ the term to indicate that the former should be there to provide 'help and support' to the work of scientists. Philosophy may guide them in using their expertise in the processes of logic making, argumentation, and in refining scientific methods of enquiry. The concept of 'underlaboring' in this study is applied to indicate the 'support or help' that indigenous knowledge (referred to in this study as Traditional Ecological Knowledge or TEK) may potentially offer to formal 'scientific knowledge' to make it easily accessible and applied by coastal communities; including people who have never had access to formal knowledge (common individuals and social groups).

Sillitoe (2007) observes that local knowledge can enrich scientific understanding and adds that this is not a revolutionary observation but rather a fact that evolves from historical scientific testimonies. This observation is supported by Bhaskar, Frank, Hoyer, Naess, & Packer (2010) in the following statement:

Many indigenous communities have detailed knowledge of human practices that are conducive to the flourishing of the biotic community as a whole... this indigenous knowledge is a valuable moral resource of practices embodying values (p. 211).

Turnbull (2000) acknowledges that from the era of the European global expansion, Western scientists had drawn on the knowledge of local populations to help them understand new plants and animals. In Southeast Asia for example, scientists drew heavily on native classifications and ecology, which continue to influence scientific biology to this day (Ellen, Parkes, & Bicker, 2000; Ellen, 2004).

Sillitoe (2007) argues further by uncovering the contribution of local knowledge as follows:

Local knowledge contributed to the emergence of the theory of evolution, one of the science's most grand theories, Galapagos inhabitants pointing out to Darwin (1845) that they could tell from which island tortoises came, and finches too, by their markings and shape, the result of micro-evolution (p.5).

Puri (2001) notes that from the vein of local or traditional knowledge, a number of pharmaceutical companies are currently active in using indigenous knowledge in their search for new drugs and cosmetics, and thus advancing a 'tradition' that has already contributed to over 25 percent of Western prescription drugs deriving from traditional or indigenous knowledge.

Bhaskar et al. (2010) recall the contribution of indigenous knowledge to modern science as following:

Remember that traditional knowledge informed the selection practices that bequeathed us the seeds that are indispensable for growing all crops today, and without which transgenics would be impossible (p. 201).

In this study, the process of 'underlabouring' starts with the adaption of processes of abstraction (see chapter 5) and experiential learning (see chapter 6) which allow research participants (mangrove restorers, fishers, and local elders) to represent traditional ecological knowledge and use it as an input for developing a congruent framework of indicators, which reflects contextual realities in the coastal environment (see chapter 7).

1.8 Thesis Outline (overview of thesis chapters)

Chapter 1: Sheds light on the motivation behind the development of this study and its link to the researcher's personal background. Other key aspects of this chapter are a descriptive summary of the research focus, problem statement, presentation of the research goal and questions, contribution of the study to new knowledge (significance of the study), limitations of the study, and an introductory discussion of the key study concepts. The chapter further discusses social learning at the interface of scientific and traditional ecological knowledge and proposes the possibility of using the latter as an input for underlabouring the former.

Chapter 2: Presents the contextual profile of the study in relation to what is already known (documented literature) and the real situation in the study area. Key to this chapter is a more in-depth overview of social learning, and the description, distinction, and link between abstraction, praxis, practice, monitoring indicators, and experiential learning. The kind of

abstraction that this chapter embraces is based on critical realism (a theory that guides the study).

Chapter 3: Introduces and discusses theories or lenses that are used in the study. Being a critical realist study, the key theory worked with is Bhaskar's Critical Realism. Given the background of the study which depicts practices of experiential learning in the eastern coast of Tanzania (that have been going on for over two decades), the study also employs Experiential Learning Theory commonly cited by education researchers as 'Kolb's Learning Cycles' to expand learning possibilities by incorporating the use of audio-visual methods. The chapter uncovers the potential of the identified theories as conceptual, explanatory, interpretive, analytical, epistemological, and methodological tools.

Chapter 4: Introduces the study area and presents in-depth methodological procedures that were employed in the processes of generating, processing, and analysing data. It also provides details about the study site, selection of research participants, scope of the study, and shows the selected research strategy. The chapter also presents and discusses the validity of data in relation to ethical considerations, uncovers the researcher's reflexivity, and suggests a critical realist approach for the generalisation of premises in the study.

Chapter 5: Discusses the potential of processes of abstraction, and how these may potentially create a platform for occurrences of social learning in the coastal environment. It reveals and discusses how conceptualised notions, concepts, and ideas may lead to knowledge production and understanding of social, ecological and economic roles of the mangrove ecosystem.

The chapter also uncovers how knowledge is transferred from experienced fishers to young fishers; how different species interact in the mangrove empirical space; and how power relations affect learning. Moreover, it also represents ecological concepts and processes that occur in the mangrove ecosystem; species relations (contingent and necessary relationships); metaphors that shape ecological descriptions; historical representations of the mangrove ecosystem; determinants of fish interactions and catch; and an understanding of attributes and indicators that define the health status of mangroves and fisheries.

Chapter 6: Analyses how abstraction and conceptualisation mobilises representation of traditional ecological knowledge as an input for developing indicators for monitoring mangroves and fisheries that use them as habitat. The chapter widens its scope from representation that takes place in the mangrove and fish-landing sites (covering a wide range of species) to representation of photographic images of specific mangrove species and fisheries that are taken by the research participants themselves as they take part in the experiential learning cycle.

Chapter 7: Presents the process and procedures adopted by mangrove restorers, mangrove fishers, local elders, and local marine scientists to discuss and analyse two different frameworks of monitoring indicators, namely the existing scientific framework, and the new framework of Traditional Ecological Indicators (TEK) for purposes of coming up with a set of indicators that are regarded by resource users as being potentially less reified, more contextually and culturally congruent, and which may easily guide community-based monitoring practices and attract a wider social learning process. The analysis of the two frameworks of indicators and the entire process that leads to their integration are guided by an Experiential Learning Intervention Workshop (ELIW), and presented using a realist scientific model of explanation commonly known as 'RRREI(C)' (i.e. Resolution, Re-description, Retrodiction, Elimination, Identification and Correction).

Chapter 8: Gives a summary of specific and general findings that this study yields, and also presents possible reflections, suggestions, and recommendations that are necessary to uncover realities. Specific findings in this context refer to knowledge that directly responds to the three key research questions while general findings are considered to be knowledge that results from an overall analysis of the study.

1.9 Conclusion

This chapter introduces the study background and articulates the research problem, goal, issue, focus, key study concepts, and provides an outline of thesis chapters. Most of the key study concepts that reflect theoretical processes in this chapter are further discussed as applied concepts and processes in the next chapter (see chapter 2), to reflect realities in the study context.

CHAPTER 2: CONTEXTUALIZING SOCIAL LEARNING, ABSTRACTION, PRAXIS, PRACTICE, AND EXPERIENTIAL LEARNING

2.1 Introduction

This chapter presents an overview of social learning, processes of abstraction, praxis, and practice; and how these are contextually lensed and linked to experiential learning in the study area. It attempts to uncover synchronic and diachronic processes of experiential learning based on an existing body of literature or documentaries of coastal management initiatives carried out from the 1990's up to the present. Some of the details that reveal the historical background of the study area which may closely be linked to this chapter are presented in the thesis introductory section (section 1.3.1). The chapter adopts a presentation style that necessitates a thorough description and practical implication of some key concepts that appear in section 1.7.

2.2 An overview of social learning

Recorded debates (at least in the Anglo-American literature) about how people learn, date back to the era of Greek philosophers (Socrates-469-399 B.C, Plato 427-347 B.C, and Aristotle 384-322 B.C) and have since then been filtered to reflect not only philosophical, psychological and biological views but also different dimensions and contexts such as social, cultural, economic, and ecological (Hammond, Austin, Orcutt, & Rosso., 2001; Reed et al., 2006; Mostert et al., 2007; Pahl-Wostl et al., 2007; Muro & Jeffrey, 2008). The purpose here is not to review all of these developments in detail, but rather to focus on those that have pertinence to an understanding of social learning.

The concept of 'social learning' can be understood by revisiting different paradigms of learning such as behaviouristic, cognitivist, constructivist, and humanistic. These paradigms created a space for the development of various theories of learning and thus expanded the meaning, concept, and the process of learning. In the 1960's and 1970's, learning was closely linked to behavioural change and was thus understood by observing an individual's behaviour (Hergenhahn & Olson, 2001). This view was subject to extensive critique including

claims of overgeneralisation, and the overlooking of confounding factors (other than change in behaviour) which might be responsible for stimulating or influencing the occurrence of learning (Ajzen & Fishbein, 1980).

Säljö (1979) observes that towards the mid and late 1970's, learning was eventually regarded as a multifaceted phenomenon which incorporated several social elements such as:

- Acquiring information and knowledge increase,
- Acquiring facts, methods, and skills,
- Memorising,
- Sense making or abstracting meaning, and
- Understanding and interpreting reality in various ways and re-interpreting knowledge.

In 1941, social learning was first defined through cognitive and psychological lenses by Miller and Dollard who suggested that individuals learn by observing the behaviour of others, transform what they have observed into 'cognitive representations' and execute the behaviours, if these were associated with certain rewards or benefits (Miller & Dollard, 1941). This understanding of social learning was expanded by Bandura (1977) when he introduced another outlook commonly known as 'social cognitive theory', which focused on observing and modelling cognitive behaviours and attitudes of individuals, as these interacted with their environment. The theory assumed that reality could be realised or perceived through interactions between one's cognitions and the environment. It placed an individual at the 'producer' level and also as a product of environment and social systems (Muro & Jeffrey, 2008).

Further approaches were suggested in the 1970's and 80's by social learning researchers to shape community practices and attract meaningful learning interactions. These included single, double, and triple loop theories; and experiential learning theories. Single loop learning was considered to be useful in correcting errors by changing the individual's routine behaviour, while double loop learning was considered to be useful in correcting errors by

examining existing structural factors, including policies (Argyris & Schön, 1978). Triple loop learning moved beyond structure and agency to incorporate institutional transformation or change; including the composition of learning itself (Pahl-Wostl, 2009). On the other hand, the experiential learning theory explained how social groups would be exposed to new concrete experiences, and increasingly learn as they reflected on these, to form abstract conceptualisations, test them in practice, develop other concrete situations, and again engage them in the learning cycle (Kolb, 1984).

In the 1990's, the concept of social learning was expanded further by researchers from the domains of knowledge management and human resources, to consider interactions that go beyond individual levels to a wider perspective. Falling into this category are theories of situated learning, for example, the theory of learning in communities of practice by Lave & Wenger (1991) & Wenger (1998), which emphasises learning through interactions with more experienced members of the community of practice, via processes of legitimate peripheral participation in which newer members of the community of practice are inducted into social practices by more experienced members of the community of practice, and active participation in social practices. Related to these situated and more sociological explanations of learning, is the social learning definition offered by Reed et al. (2010) who suggest that social learning occurs when it has been demonstrated that : (1) a change in understanding has taken place in the involved individuals; (2) that this change goes beyond the individual and becomes situated within wider social units; and (3) that the process must have occurred through social interactions (Ibid.).

Social learning as a concept and process was expanded in the 2000's to accommodate sustainability aspects. This was driven by an interest - that addressing sustainability in social practices could potentially lead to a more sustainable world (Wals, 2007, Jickling & Wals, 2008; Wals, 2010). It was during this historical period that more emphasis was placed on transformative interests and practices by proponents of social learning theories, for the purposes of attracting a kind of learning that provides a landscape for involved participants to mirror, understand, and address emerging dissonances and challenges in a different and more focused manner than how they would have approached them before the exposure.

It may be argued that central to the classical social learning theories produced in the Bandura era, was a focus on behavioural change at an individual level, while contemporary theories (e.g. situated, cognitive and more sociologically oriented learning) focus on the generation and sharing of knowledge in a practice context, with an interest in the distribution and uptake of knowledge within wider social units.

Further perspective on these shifts in understanding social learning from a broadly socio-cultural perspective can also be gained through the examination and analysis of learning via three metaphors of social learning, namely acquisition, participation and contribution (Sfard, 1998; Stetsenko, 2008). The acquisition metaphor deals with processes and procedures that facilitate knowledge acquisition as actors take part in social practices; the participation metaphor centres on active involvement of actors in the community of practice as explained above. The contribution metaphor places emphasis on active involvement of actors and their participation in change processes, rather than just 'being there' in social practices (Stetsenko, 2008).

The acquisition metaphor is believed to have dominated classical views of learning, whilst the participation metaphor rose to prominence in the 1990's (Sfard, 1998), following developments in post-Vygotskian socio-cultural learning theory, where learning was seen to be a process that 'leads development', and requires interaction between learners and significant others (peers or teachers). The contribution metaphor emerged from the participation metaphor as more efforts were made to encourage meaningful and active participation of actors in the changing of social practices (Stetsenko, 2008; Collis & Moonen, 2001). The contribution metaphor reflects the manner in which much social learning is conceptualised in environmental education and natural resources management, where a clearly articulated change oriented learning interest is manifest (Lotz-Sisitka, 2012; Cundill & Rodela, 2012; Wals, 2007; Wals, 2010; Glasser, 2007).

Hammond et al. (2001) argue that people learn in different social contexts and adds that the learning environment makes a difference. This argument is also put forward by socio-cultural learning theorists such as Sfard (1998) and Stetsenko (2008). This also seems to be the case in the field of natural resources where social learning is understood as an essential

element of participatory or collective initiatives (Muro & Jeffrey, 2008). Cundill & Rodela (2012) cite key 'typologies' that depict the occurrence of social learning in the context of natural resources:

- Social learning occurs when actors are engaged in interactions when there is a space for sharing different ideas, perspectives, and experiences, leading to an agreed manner of approaching or addressing challenges that emerge from their context.
- Social learning also occurs when actors are involved in social practices or interventions. Some of the practices may be in a form of experimentation or participatory monitoring. As people take part in joint actions or practices, they reflectively learn from what they experience and become acquainted with prevailing situations and more knowledgeable about processes that take place in their context. This form of learning is also referred to as experiential learning or learning by doing.
- Social learning is regarded as a process that favours not only learning among involved actors but also the transmission of knowledge from present contexts to future generations.
- Social learning is a process that improves decision making. This occurs when involved actors have been fully engaged in interactions and decisions that increase trust amongst them, and relationships that lead to enhanced-problem solving capacity.
- Social learning can facilitate joint action around common contextual concerns. In the natural resource management context, for example, where various environmental concerns tend to emerge, collective or joint actions are required. This is necessary since such concerns tend to affect socio-ecological systems rather than individual actors. This social learning typology considers collective action as an element of management success.
- Social learning is also linked to behavioural change in that the more actors learn through transformative praxis, the more they mirror and act differently from how they used to act before. Their options become filtered and weighed out against the consequences that are likely to happen should sustainable and reliable solutions be discarded.

With such understanding of what a social learning process constitutes, this study draws on the insight that processes of social learning are contextual and may sometimes be defined based on their landscapes; ranging from classroom to outdoor settings (Mostert et al., 2007). Craps (2003), Ridder et al. (2005) and Pahl-Wostl et al. (2007) also affirm that social learning is contextual. This does not mean that the knowledge engaged with in social learning is context bound, but rather that context provides an important referent for social learning processes.

Social learning therefore helps individuals and social groups to uncover the 'social world' and be potentially more able to address emerging needs or challenges in different contexts. However, in order to understand various phenomena that emerge or prevail in the external world, processes of abstraction are needed (see section 2.3) to help with close examination of the components that constitute emerging social phenomena in their concrete form (Sayer, 2000). Such processes, as mentioned in section 2.3 are necessary for learning.

2.3 Abstraction as a process

As indicated above, and as is also the case in this study, researchers in the field of environment and sustainability education seek to understand various attributes, aspects, and components of social learning and hopefully establish their relationships for better understanding and action. While this is the case, Lotz-Sisitka (2012) has indicated that not enough is known about the details of *how* social learning occurs in the environmental education / natural resource management context as much of the research to date has focussed on proposing models of social learning (e.g. Wals, 2007; Glasser, 2007); defining social learning (Reed et al., 2010); and/or documenting broad processes, and/or outcomes of social learning (Cundill & Rodela, 2012; Muro & Jeffrey, 2008). Developing an in-depth and detailed understanding of how social learning occurs, can hardly be achieved without prioritizing the process of abstraction (Sayer, 2000), but as yet no literature was found on studies that prioritise abstraction in their explanations of social learning in environmental education / natural resources management.

As reflected in the key concepts section of this study, (see 1.7.1) abstraction is considered to be a mental process of isolating out, omitting, or absencing other aspects of the

phenomenon being studied (Hartwig, 2007). It involves reducing the information content of a concept or an observable phenomenon, typically to retain only information which is relevant for a particular purpose.

The above meaning of abstraction clearly reveals that in the process of abstracting, certain aspects (objects) of the concrete or the phenomena being studied are left out or neglected momentarily (Bhaskar, 1998) to allow the researcher or learner to first analyse selected aspects and uncover what they are, what they contain, and how are they related to each other. It is after the analysis of selected aspects or items that the researcher or involved research participants who are also learners (as viewed in this study, see section 3.4.2 & 6.7), may come back to the *concrete* to select the remaining phenomena for the same, depending on the purpose of the study or an activity. As Sayer (2000) and Danemark et al., 2002 put it, processes of abstraction and conceptualisation are necessary and useful, not only in the research processes but also in learning and knowledge production.

Abstraction becomes a necessary process in research and learning because reality or information is often in a concrete form of knowledge (Bhaskar, 1998). Knowledge that is concrete usually constitutes a synthesis of aspects or phenomena which can only be understood better by isolating its constituents. Ignoring abstraction can therefore lead to a poor understanding of the *concrete*, since researchers or learners will have no knowledge of what it constitutes and how the elements contained in it relate to each other. Some critical realists call this kind of approach 'a bad abstraction' (Ibid.). On the contrary, a good abstraction would therefore involve individualising things that are constituted in the concrete so that we can understand them better before relating them to other aspects of the concrete and applying their knowledge. By so doing, we may thus be in a position to interpret and explain the concrete much better. Abstraction therefore, if carefully employed, may help us in defining our objects of study and in shedding light on how to interpret them in a more holistic or congruent manner (Sayer, 1992).

The use of abstraction and careful conceptualisation is imperative in qualitative research studies and also in participatory / experiential learning processes, especially those that are carried out in open systems given their nature of being characterised as being "complex and

messy” (Sayer, 2000, p. 19). It is unfortunate that some researchers act out of their own intuition to either employ or ignore such a process or methodological guidance (Ibid.). Critical realists discourage what they call ‘cookbook’ or prescriptions of method or process that allow researchers and learners to imagine that they can pursue their work without having a clear knowledge of the object that they are studying (Ibid.). As stated earlier, we may only avoid this by employing abstraction and conceptualisation.

If carefully employed, abstraction and conceptualisation processes can help researchers and learners to more accurately attribute *causes to their effects* in what they are studying and thus avoid the risk of misattributing causality (ibid.). Researchers or educators that ignore the use of abstraction can hardly distinguish between confounding and causal factors as there are multiple systems and causes that are likely to produce the same effects in their studies (ibid.). Sayer insists that a “common aspect of all critical realists” is the priority given to abstraction and conceptualisation, and that disregarding these may lead to a conflated or collapsed meaning of realities (Ibid:27).

Abstraction may be made at various levels of generality and /or geo-historical contexts, and arise from different perspectives in the social world, and at any social level (Ollman, 2003). Perhaps, the most important aspect that should be brought into view is who is involved in the process and how? Depending on the nature of the learning process and research design, and the need for understanding better the study object, if researchers and learners (for example in monitoring contexts) opt to work on studies that necessitate interactions between themselves and members of communities, then the process may entail involvement of both sides. It may thus involve local people or various communities of practice involved in either a basic form of research or applied research and learning, and may take different forms depending on the nature of the study - whether intensive or extensive (Sayer, 2000). The aim is to seek “substantial connections” among phenomena rather than establishing formal associations or regularities of events (Sayer, 2000, p. 27). As Sayer puts it, much depends on the manner of abstraction that we opt for, and the way we shape and define our study objects (Sayer, 1992).

2.4 The form of abstraction experienced in the study area

There is no evidence that links coastal communities with processes that might have created platforms for them to take part in the processes of abstraction, but rather records of their involvement in ‘periodic monitoring’ of coastal and marine resources as a form of experiential learning. As discussed earlier in the research context (see section 1.3), this was introduced as a top-down approach which encouraged the adoption and/or adaption and use of indicators developed by scientific institutions, supported by the central government and donor communities, and engineered by Integrated Coastal Management projects and programmes operating at local levels in the coastal environment.

Scientific indicators in this context were the abstraction of the ‘concrete’. These were meant to be understood by coastal communities through the process of abstraction undertaken by scientific researchers prior to applying them in contexts with local communities. Available records (KICAMP, 2004; KIMP, 2005; Samoilys & Kanyanga, 2008) reveal that efforts and resources were employed to encourage target communities to adapt the represented and already abstracted ‘concrete object’ (scientific indicators) rather than developing their own, based on reality in the local context (bottom-up approach) in which they (community members) could engage in processes of abstraction to produce indicators.

Since the process of ‘abstraction’ as discussed earlier, aims at making involved participants understand better what they are intending to work on (Sayer, 2000), it may only be useful and relevant to particular contexts and backgrounds. This emerges as a challenge when the indicators that contain scientific abstractions are imposed into contexts where people do not share the same scientific background and discourses used in the abstraction process as reported on in sections 1.3.2 and 1.4. In this kind of situation, understanding (which is key in abstraction) is not guaranteed. This seemingly third party adapting game affects social learning, as the occurrence of the latter also considers understanding as key (Reed et al., 2010), although few social learning theorists explain *how* such understanding is to be gained (Lotz-Sisitka, 2012). In my literature review work I found no reference to research that explains *how* such understanding is gained via abstraction processes.

2.5 Abstracting praxis and linking it to experiential learning

For one to establish a link between *praxis* and experiential learning, there is a need to understand thoroughly what the former means and the kind of situations that allow the two to merge or work together in the social world. The meaning of the term *praxis* varies across languages, cultures, disciplines, theoretical traditions, and geographical settings, but a common view places it as a particular kind of ‘*action*’ (Kemmis & Smith, 2008, p. 4).

In order to understand the term ‘*praxis*’ there is a need to abstract it further by isolating out some of its key features and possibly components that differentiate it from a mere action or social practice. It is a kind of action that takes into account not only individual interests but also long term interests of the society or a particular community (ibid.), and a *morally*-committed and oriented action that is informed by traditions in the field and expectations of bringing about some kind of transformation in the social world. Like abstraction, *praxis* accommodates reflections and reflexivity on the manner that the objects of the social world may be better approached and understood.

Developing *praxis* requires opportunities for experiential learning and an environment that favours field and traditions of practice (Kemmis & Smith, 2008, p. 29). It requires that learners identify themselves as people who try to develop their knowledge and practices within their social context through action, experience, and reflection (ibid.). Kolb (1984) believes that knowledge is gained through both personal and environmental experiences. He further argues that for knowledge to be gained, four conditions must be fulfilled; firstly, the learner must be willing to be actively involved in an experience; secondly, he or she must be able to reflect on the experience; thirdly, she or he must be able to conceptualize that particular experience; and finally, he or she should possess decision making and problem solving skills in order to apply ideas gained from experience (ibid.). The second and third conditions that Kolb brings into consideration can hardly be reached without the process of *abstraction* and careful conceptualisation. The last condition in the process of ‘experiential learning’ which requires the learner’s ability and skills to internalize gained knowledge or experience can be referred as “*Praxis*”. It is at this point that *praxis* and *abstraction* potentially meet in the facilitation of social learning.

2.6 Differentiating praxis from practice

While both praxis and practice involve actions, the former as discussed earlier (see section 2.5) has some special attributes that differentiate it from the latter. It is a moral action which follows a logical nature of intervention (Kemmis & Smith, 2008). On the other hand, the latter may also be morally carried out but not necessarily for the intention that aims at safeguarding or benefiting the community at large. From this description, it may be argued that ‘praxis’ is in most cases acceptable since it is preceded by logical plans that involve more than one individual as may be the case in ‘practice’. The latter may also be seen as a social activity.

Coastal documentaries produced by different coastal actors on the eastern coast of Tanzania, indicate that both praxis and practice have occurred all over the Tanzanian coastal belt (NICEMS, 2003; TCMP, 1998; KICAMP, 2004; Wagner et al., 2001; Julius 2005). Most of these are encouraged by the social, cultural, ecological, and economical values of mangroves and associated ecosystems (see table 2.1). Some practices were environmentally friendly while others were destructive and unsustainable. Reported unsustainable practices include destructive fishing such as the use of dynamite, poison, and small-meshed nets.

Table 2.1: Social, cultural, ecological, and economical values of mangrove ecosystems:

Provisioning	Regulating	Cultural
Food (fish, crabs, shrimps)	Atmosphere and climate regulating	Recreation
Timber for fuel (charcoal, firewood)	Hydrological balance	Spiritual and religious
Building material (boats, houses, furniture)	Disease control	Aesthetic
Curios	Waste assimilation	Inspirational
Fibre	Erosion control	Educational heritage
Medicines	Storm/ flood protection	Research
Genetic resources		
Supporting Nutrient cycling, Primary production, Providing habitat, supporting life cycles		

Source: Berjack et al., 2011, p. 115

Other cases include cutting down of mangroves for the creation of salt-pans, charcoal-making using mangrove plants, lime-making using mangrove plants as fuel energy, and commercial logging of mangrove species. These do not qualify to be called praxis, but may fit into the 'practice' category. Other practices which are commonly accepted by coastal communities but which may be carried out at an individual level include fishing by using traditional equipment such as fish traps, commonly known as *malema* or *madema*, *mishipi*, fishing hooks, spears, and accepted locally made nets (large sized to allow catching of mature fish and protect juvenile fish). However, the use of *madema* or *malema* among artisanal traditional fishers is presented by some studies as contributing to the damage of corals in the reef (Wagner et al., 2001), since the equipment concerned requires heavy materials like a stone placed on top to make it settle steadily to the ocean floor and thus avoid being easily swayed by waves to other locations. As many local fishers set their traps far from the landing site, they prefer using live or dead corals (found in the ocean) to carrying stones from offshore (ibid.). This kind of behaviour is believed to be destructive to the corals; thus affecting nursery grounds in-shore (Wagner et al., 2001). However, such claims are disputed and ignored by local fishers as being untrue (KICAMP, 2003).



Plate 2.1: Participant7FMNII describing the use of traditional fish traps (*madema*) in the study area.

It may be argued that most of the reported practices that appeared to be environmentally friendly (see sections 5.2.2, 5.2.5 & 5.2.9) had a moral 'attachment' and were being carried out by groups for community interests guided by logical plans, hence they may be discussed as 'praxis'. These include:

- Preparation of nursery grounds for mangroves species
- Transplanting of selected mangrove species
- Beekeeping in the mangrove ecosystem
- Seaweed farming
- Crab fattening/farming
- Oyster farming

Learning is presented in this section as an outcome of engaging or taking part in the preparation of nursery grounds, selecting seeds that are suitable for transplanting, and taking part in the actual transplanting or other practices such as beekeeping, seaweed, crab fattening, and oyster farming (discussed briefly below in sections 2.6. – 2.6; see also sections 5.2.2, 5.2.2.1, and chapter 6).

2.6.1 Preparation of nursery grounds for mangroves species

Mangrove restorers know the flowering seasons for different mangrove species. When mangrove seeds mature, special nurseries are prepared for different seeds, followed by seed harvesting and selection (sorting). The latter is done to increase the chances of seed growth at the nursery level.

The demand for seedlings that are required for transplanting in a particular time of the year depends on the size of bare sites observed in the mangrove forest and the type of species that are affected. The number and type of nursery grounds are thus dependent on the need on the ground. Seeds from *Avicennia marina* (locally called *mchu*) grow faster and adapt more easily to the nursery environment than other mangrove species such as *Bruguiera gymnorhiza* (msinzi or muia), *Ceriops tagal* (mkandaa), *Rhizophora mucronata* (mkoko), *Sonneratia alba* (mpia), and *Xylocarpus granatum* (mkomafi). See table 5.2 (chapter 5) for characteristics of mangrove species.

Preparation of nursery grounds as a practice that is morally embarked on, for social-ecological reasons, encourages not only learning by doing among mangrove restorers, but also knowledge transfer from individual levels to a wider levels of the social unit (i.e. social learning).

Each nursery plot serves a purpose for specific mangrove species depending on identified needs. In other words, a nursery that is aimed for raising *Ceriops tagal* (mkandaa) is restricted for this particular seedling production and 'labelled' to simplify identification.

2.6.2 Transplanting of selected mangrove species

Transplanting of mangrove species is carried out by mangrove restorers in bare spaces in Moa (North and South), Boma Kichakamiba, and Boma Subutuni. Caring for the nursery requires sufficient knowledge and experience as it involves the need to understand different needs or requirements for particular mangrove species.

New members, who have never been inducted to the practice before, learn from others as they observe how seeds are picked from mature plants, sorted, soaked for at least 24 hours to quicken germination, and later planted in rows in the nurseries. When the new members are familiar with the practice, they also pass the knowledge they have acquired to others up to a level that attracts more active participation and learning (see section 5.2.2.1). *Avicennia marina* (mchu) and *Xylocarpus granatum* (mkomafi) produce round fruits. The former produces small to medium round fruits which can be collected for nursery purposes while the latter tend to bear much bigger fruits which contain several seeds (Berjack et al., 2011). These are released when the outer skin of mature fruit tears due to falling or decaying. On the other hand, other mangrove species such as *Ceriops tagal* (mkandaa), *Rhizophora mucronata* (mkoko), and *Sonneratia alba* (mpia) tend to produce seeds which germinate while still on the parent plant which enables them to rapidly establish in soft sediments "without being washed away by the tide" (Scheltinga et al., 2004, p. 11). These hang headlong facing the ground, and have sharp endings which stick to the soft muddy ground after falling, and germinate. These seeds can also be harvested and planted in nursery

grounds or directly pinned to the ground by mangrove restorers (see a mangrove nursery in plate 2.2).



Plate 2.2: Mangrove nursery (source; this study 2012)

2.6.3 Beekeeping in the mangrove ecosystem

Beekeeping is emerging as a viable economic practice which has many benefits, not only to coastal communities as an income generating activity, but also to the mangrove ecosystem. Mangrove restorers select certain mature mangrove plants which can support the installation of modern beehives. Areas that are covered by beehives remain undisturbed throughout the year in fear of the *African honey bees* which are aggressive by nature (Hodgson, Stanley, Roe, & Downey, 2010) and can attack people who disturb the surrounding environment or who cut trees near the beehives. Honey and bee products from the mangrove area are considered to have medicinal benefits, and are thus widely preferred by coastal dwellers to honey from terrestrial forests.

Prior to the introduction of beekeeping and other economic practices like crab fattening in the mangroves, there were debates around the coastal area, over the justification of involving poor communities in projects such as mangrove restoration which were believed

to have no direct and tangible benefits to the people (KICAMP, 2003). Such debates no longer exist and more people, especially women, are attracted to beekeeping projects in the mangrove sites.



Plate: 2.3 Beehives in the mangroves (source: this study; 2012)

2.6.4 Seaweed farming

Seaweed farming is a common economic and ecological practice in the study area. There are two main species that are farmed in the study area specifically in areas that border mangroves. These are *cotonii* and *spinosum*.

Seaweed farming is practiced at a medium scale in the study area where selected species are tied in specified ropes (preferably manila or plastic) and placed in either shallow or deep water to grow and multiply. Harvesting time may range from few weeks to three months, depending on location of the farm and absence of predators such as rabbit fish (*Siganus spp*) and other fish (Talbot & Wilkinson, 2001).

Rafts such as plastic bottles or other light materials are also tied to the rope(s) to help seaweed farmers identify farm demarcations, as these float and can be seen or detected from a distance (see plate 2.4 below).



Plate 2.4: harvesting of seaweed (photo taken by TCZCDP-2008)

Some studies have associated seaweed farming with increased fish catches of particular species. It is said that fishing traps or gear set near seaweed farms caught three times more fish than those placed elsewhere (Eklöf, Torre-Castro, Nilsson & Rönnbäck, 2006). The fact that seaweed farming may occur near mangrove areas raises the possibility of mangrove based fish species feeding on seaweed.

2.6.5 Crab fattening/farming

Crab fattening is simply an act of catching or fishing mud crabs (*Scylla serrata*) and keeping them in locally made cages in the mangrove areas and feeding them until their weight increases relatively.

Mud crabs are caught at juvenile stage and are fed fish offal⁴, oyster meat, and gastropods (Samoilys & Kanyanga, 2008) to encourage quick growth to market size. This process seems to be viable economically since crab weight determines the price. The more the weight the

⁴ Internal organs of animals such as livers, hearts, intestines etc.

higher the income. Locally made cages require traditional skills and knowledge, and this can be carried out by people who understand the biological and natural behaviour of the crabs.



Plate: 2.5: Wood enclosure (cages) for raising/fattening juvenile mud-crabs in Tanga (photo source: TCZCDP-2008)

2.6.6 Oyster farming

Oyster farming is a kind of *mariculture* practice which allows involved actors to raise oysters either for commercial purposes or home consumption (Rice, Mmochi, Zubieri, & Savoie, 2006). It is believed that this form of practice is not widely carried out, due to a limited market and the abundance of wild oysters (TCZCDP-2008).

The study area also has the potential for oyster farming but this does not involve local creativity as in other parts of the coastal area. Unlike crabs, oysters are directly harvested from their natural environment and consumed. Mangrove oysters (*saccostrea cucullat*) are common and abundant on the eastern coast of Tanzania as a potential *culture* species (Rice et al., 2006).

2.7 Abstraction of indicators as a learning process which affirm praxis

Different authors have made contributions on processes that lead to developing and applying environmental indicators at local level (see section 1.8 for meaning, types, and use of indicators). The emphasis is placed on strategies, criteria, and the process itself. Reed et al. (2006) present two paradigms that determine the development of indicators in the local context as being top-down and bottom-up. The process that leads to development of indicators under the former paradigm excludes contextual aspects, and does not encourage consultation of local communities like the later (bottom-up). They argue that indicators that result from the bottom-up approach “provide a more contextualised understanding of local issues” (Reed et al. p. 409). Arguing in favour of prioritizing contextual information, Glahn et al. (2007) provide the following description:

Actors depend on indicators in order to organise, orientate and navigate through complex environments by utilising contextual information. Contextual information on the learning processes has been proven as important to support the learning processes. It stimulates the learners’ engagement in and commitment to collaborating processes; it helps to raise awareness of, and stimulates reflection about acquired competences; and it supports thoughtful behaviour in navigation and learning paths (p. 2).

The above description not only favours developing indicators that are relevant to the context within which they will be applied, but also bringing into view the fact that the process that leads to development of indicators is closely linked to learning. In other words, it implies that involving local actors such as coastal communities in such a process or a practice creates opportunities for them to learn from each other, and therefore understand better both the context and the indicators they have developed. This may also suggest that imposing or causing actors to adapt indicators from other contexts denies them opportunities to incorporate local knowledge in the learning process, and compels them to apply tools that they are not familiar with.

Rydin, Holman, & Wolf (2003) note a wave of change in indicator development, from a ‘technical’ process which involves experts (at global level) to a participatory process which focuses on understanding the local context within which the indicators are being developed, and as a process which focuses on the relationship between lay people and experts. They

argue that if indicator development is no longer a technical issue, then it should not be left to experts but rather to people who are directly affected by the situation. The role of experts therefore, is to facilitate the learning process as they also learn from local participants and share knowledge. Indicator development should thus be centred on the learner's situation or context, and not on 'static' approaches which, according to Glahn et al. (2007), follow a fixed set of rules in the process of collecting, aggregating and indicating information to learners.

In the process of learning, understanding is a criterion (Reed et al., 2010). Without understanding, social learning of whatever kind can hardly be attained or attract a wider learning context (ibid.). Reed et al. (2006) identify two key criteria for 'sustainability' indicators as being the ability of users (learners) to apply them, and their relevance to local level as discussed earlier. For users of the indicators to meet the first criterion (ability to apply them), they must first understand them. Understanding them depends on the language and discourse used. If for example, the development of the said indicators pursued a formal natural science route, common people who have never had access to participate in 'formal learning' would be hard pressed to understand them (Rydin et al., 2003). But if the abstractions favour the local context, and the learners or users are part of the process that leads to development of such indicators, they are likely not only to understand the indicators but also to meet the second criterion (local relevance).

Jackson (1997) argues that the measures that the indicators suggest must be contextually appropriate, clear and acceptable - to target communities to avoid an misrepresentation of information, over reporting or underreporting of events. It is suggested further that indicators should also be cost-effective, relevant to the context, and easy to apply or use (ibid.). Scheltinga et al. (2004) also insist on the need to avoid complexity by avoiding technical abstractions and embarking on simple processes that can easily be measured, analysed, and interpreted by involved communities.

2.8 Monitoring as a specified kind of praxis which leads to wider social learning

Monitoring is defined as a process that involves repeated surveys in which “qualitative or quantitative” observations are made (Hill, Fasham, Tucker, Shewry, & Shaw 2005, p. 4). It involves detecting of changes, trends, threats, and the condition of specified parameters of the environment (KIMP, 2005), and is carried out for different purposes depending on what it is aimed at (Hill et al., 2005). Monitoring is a good ground for experiential learning, and as discussed in section 2.4, it potentially allows actors (local communities) to learn from each other to the level that may enhance their praxis and attract a wider participation of learners.

Hill et al. (2005) insist that a monitoring programme needs to have a defined or formulated standard; which should specify the kinds of *features* that will be monitored, for example mangroves, and fisheries; it should also specify *attributes* for selected features’ (e.g. soil, vegetation cover etc.) target state, and the methods that will be employed in the process of monitoring. Monitoring, according to Hill et al. (2005) should therefore:

- establish whether standards are being met;
- detect change and trigger responses if any of the changes are undesirable;
- contribute to the diagnosis of the causes of change; and
- assess the success of actions taken to maintain standards or to reverse undesirable changes, and where necessary, contribute to their improvement. (p. 4)

Formulating ‘standards’ implies choosing a preferred monitoring-route that is based on actors’ priorities or preferences. The ‘standard’ therefore, serves as a guideline of inclusion and exclusion of monitoring parameters and adherence. Emerging questions from this context are: ‘Who are the actors?’ and ‘Who decides what should be included or excluded?’ To answer these two questions it is necessary to briefly historicise the changing role of social learning in different contexts, especially in the field of natural resource management where monitoring practices are used for management, conservation, and protection, and for social learning purposes.

Cundill & Rodela (2012,p.18) observe that learning approaches have been changing over time and space from “command and control” (where the focus was on nature) to “adaptive management” (which focuses on ecosystem change through experimentation), and from the latter to “collaborative management” (where every stakeholder in a particular resource like coastal resources such as mangroves, fisheries, coral reefs, and coastal land) is encouraged to work together with other members, building relationships in often highly conflicting environments, and taking part in the deliberation process which encourages exposure of values and knowledge sharing.

If monitoring standards are developed as a result of collaborative learning where actions are morally justified, and logical plans are developed to guide practices that serve collective interests, according to Kemmis & Smith (2008) they may qualify to be categorized as ‘praxis’ rather than mere ‘practices’.

It is after historicising the context as reflected earlier, that the answer to the questions ‘Who are the actors?’ and ‘Who decides what should be included or excluded?’ may be clear. In the command and control approach, for example; the learning process was (and still is in many cases) traditionally controlled by park wardens. Local communities that take part in the learning are told what to do, how to do it, when to do it and where to practice. Campbell & Vainio-Mattila (2003, p. 430) however, argue that communities are not “passive bystanders” in the on-going or introduced initiatives, but have to be actively engaged in the negotiations that determine what and how those initiatives will look.

In the adaptive approach, learners are involved in the experiential practices but these are not their own creation. They are made to adapt them on grounds that they are based on scientific principles, and therefore are reliable and applicable to the learners’ situation or context. Aspects of learners’ experiences, contextual realities, relevance, learners’ ability to cope with introduced practices and experimentation methods are in most cases, ignored (Reed et al., 2006). Reed et al. (2006) and Glahn et al. (2007) insist that aspects of contextual realities are key in the process of monitoring and should not be ignored since they affect the sustainability of implemented learning processes.

In the collaborative approach, everyone who has a stake, is involved in the deliberative learning process. Learners participate in deciding and formulating the kind of parameters or features that should be incorporated in a plan; and may therefore be in a good position to understand the plan better and take part in the implementation process, since they took part in its creation and thus belong to it as much as it belongs to them (Wenger, 1998). This depicts a sense of learning as belonging, doing, and sharing experience, which causes actors to engage in meaning making and to identify themselves as ‘a community of practice’. Hence learning becomes part of *identity formation* or *becoming* as reflected in figure 2.1 below:



Figure 2.1 Components of a social learning theory: adapted from Wenger (1998).

In this kind of situation, there are high chances or possibilities of knowledge transfer from one individual to another, in a manner which can be regarded as ‘wider social learning’. This, however, can only be attained when involved actors have clearly understood what they are working on, and interacted with each other through practice (Reed et al., 2010). A study which was conducted in Ethiopia by Belay (2012), found that as social groups engage themselves in practices such as participatory mapping, there is knowledge transfer from the experienced members (elders) to the less experienced (youth). The latter learn about historical, cultural, and ecological concepts from the former, and pass knowledge to other members of the local community in the same manner (ibid.). Belay’s research also shows that such learning takes place as communities engage in the unfamiliar and matters of concern (i.e. when dissonance is present), and as they make sense of their shared

experiences, issues, context and realities. In the case of his research, the participatory mapping processes provided a means of abstraction, but this aspect was not explained as such. His research also shows how such social learning processes can lead to agency and a willingness to engage in collective action amongst communities (demonstrating the confluence of the acquisition, participation and contribution metaphors discussed in section 2.2 above).

2.9 Experiential learning, practice, and praxis

As revealed from the study background (see section 1.3.1), the learning interests of this study are linked to praxis and practice. Most of the learning that is found in the study area is experiential, in that it creates room for people to learn as they get involved in practice and praxis. In some cases, certain individuals who, for a long time, have embarked on illegal harvesting of mangrove resources, came to a point where they reflected upon their past experiences and decided to abandon their previous unsustainable activities by joining environmentally friendly initiatives. At this point it is obvious that some kind of a new ‘knowledge’ was attained after some moments of reflection, and the weighing up of different situations. A good example of people who fall under this category are those who were previously making salt and charcoal by cutting or clearing mangrove forests, but are currently restoring mangroves and installing some beehives in mature trees as their new source of income. This situation affirms the premise that social learning may lead to new knowledge, shared understanding, trust, and collective action (Lotz-Sisitka, 2012).

Experiential learning is also reflected in the carrying out of periodic detection of changes, conditions, threats, and trends of coastal resources initiated by the scientific institutions, development projects, and both the local and central Government. As explained in chapter 1, this was being carried out on the eastern coast of Tanzania from the 1990’s involving specified coastal communities. In spite of its failure to secure a wider social learning due to overlooking contextual, social, and cultural factors (see sections 1.2, 1.3 & 1.4), the initiative had attributes that would have qualified it to be categorized as ‘praxis’ rather than a mere practice.

2.10 Culture as an ‘enabler’ or ‘constrainer’ of praxis and learning

While contextual elements are covered in this chapter (see 2.7, and 2.8), cultural aspects also need to be lensed since they too influence the process of social learning. Wals (2010) observes that learning is influenced by values, beliefs, and perspectives, and the language used (also a component of culture) is a conduit or medium that facilitates the process of learning. It is argued that traditional ecological knowledge is handed down from one generation to another through “cultural transmission” (Berkes, 1993; Gradil et al., 1993; Berkes, 1995); with ‘culture’, in this context, being inseparable from community practices and beliefs. Brumann (1999) defines culture as shared values, knowledge, beliefs, and practices among a group of people living in a specified geographical area, who share a language, a history and cultural identity. Medin & Atran (2008) also describe culture in terms of values, practices, and attitudes, but argue that sometimes these attributes may not be shared. Though this study does not seek to analyse whether ‘culture’ is a shared attribute or not; the influence of culture on practices is obvious and cannot be ignored.

Culture in most societies is closely linked or related to moral aspects (Medin & Atran , 2008). When it is regarded as a moral duty, it may create a binding situation which compels a defined community to abide by what is believed to be morally acceptable. In this manner, culture may either act as an enabler or a constraining factor. For example, if most forest sites are regarded or designated by a particular local community as being sacred, visiting such areas may be restricted to specified individuals, mostly those who may perform rituals on behalf of the entire community. Opportunities for other members of the community, especially women and youth, to undertake conservation or management activities may be limited.

In such a situation, culture may become a constraining factor for community-based monitoring practices. On the other hand, if particular communities regard caring for the environment as a moral obligation, most social groups, if enabled to, may strive to take part in whatever kind of socio-ecological and economic initiatives are associated. In this case, culture may enable praxis and learning rather than constrain them.

Development of indicators should thus consider what may be acceptable in a particular culture and what may not. This can potentially be reached by consulting, enabling, and involving participating social groups in processes which will allow them to take part in the development of a monitoring plan, and the indicators that are meant to guide such experiential learning practices.

Human interaction with nature, particularly plants and animals, is part of human history and because of this, Medin & Atran (2008) argues that it is difficult to imagine that cognition (mental processes involved in knowing, learning, and understanding things) would not be moulded by these interactions. Berkes (2012, p. 31) also observes that “knowledge of the biophysical environment is embedded in the social environment”; but he notes that ecological knowledge that a particular traditional group may hold may still be identified as an aspect of their overall culture, as opposed to western science which tends to separate knowledge from other cultural spheres. He affirms however, that traditional ecological knowledge can be analysed independently regardless of it being embedded in a particular culture. Bhaskar et al. (2010, p. 113) argues that traditional or indigenous knowledge should be articulated not only with school knowledge but also “cultural understandings”.

Berkes however, warns that carrying out research that attracts ‘cultural preservation⁵’ may encourage *in situ* conservation approaches and obscure opportunities for traditional ecological knowledge to be seen as an “integrated package” which depicts classification systems of the local groups (e.g. coastal communities), group practices and management systems, their social institutions that set rules for management systems, and their world views that constitute the ethical or ideological foundation of local systems (p. 31). Arguing in a similar way to Berkes, Medin & Atran (2008) explain further that ‘culture’ has positive properties such as transmissibility, high variability, value standards, and cumulativeness, which may seem not to have significant value, but which are potentially useful especially

⁵ Cultural preservation research or activities tend to encourage restrictions from responsible authorities to keep cultural sites unchanged or modified. Sometimes preservation is accompanied by conservation measures. This is likely to interfere with indigenous practices or their way of dealing with the natural environment (Berkes, 2012).

in the classification or categorization of taxonomical knowledge in different parts of the world.

In a nutshell, it is possible to argue that ‘culture’ offers both an enabling and constraining environment for community-based experiential learning practices and praxis, and it is perhaps important to uncover opportunities that favour enabling conditions and employ them as opportunities for social learning and a platform upon which wider social learning (especially in natural resource management contexts) may be attained. Sayer (2000) argues that for ‘agency’ to emerge, or for people to exercise their innate powers to act, enabling conditions must be put in place. Identification of the enabling conditions that culture may offer is therefore an important element of praxis.

2.11 Abstraction of knowledge forms and their impact on Praxis and Learning

Based on its core interest, this study seeks to uncover and examine two main forms of knowledge namely ‘Traditional Ecological Knowledge (TEK) and ‘Scientific knowledge’ (see sections 1.7.3 and 1.7.6 respectively). Different authors have attempted to describe these forms of knowledge by attaching terms that may sound easier to readers and knowledge users at different levels in different parts of the world. Hoppers (2002) for example, calls TEK ‘endogenous’ (internal) and ‘scientific /Western knowledge’ ‘exogenous’ (external). This kind of description simply communicates the message to users of knowledge that knowledge may be created in a specified setting, but may also be adapted to different contexts depending on emerging or existing needs.

Though this study employs the term ‘Scientific knowledge’ to represent Modern, Western, and Global forms of knowledge (see section 1.7.6), which are different from indigenous forms (see section 1.7.3), it is also imperative to note that TEK is believed to have qualities that qualify it to be called a form of ‘science’ by itself (Sillitoe 2007; Berkes, 2012). However, the focus here, is not to address the ‘scientificity’ of TEK, but rather to clarify the use of the term ‘scientific knowledge’ or scientific abstractions, in this particular research context.

One notable key element which distinguishes 'scientific' knowledge from TEK is the language of description that each of them use. As discussed earlier, language is a component of culture which plays a vital role in communication; and can be regarded as a medium for the occurrence of social learning (Wals, 2010). For this reason, Hoppers (2002) argues that there is a strong relationship between language, knowledge, and power:

Knowledge, language, and power have an interdetermining relationship. The main door into a knowledge system is through its language. The words and their meanings are the vehicle for the conceptual ordering of categories and relationships that constitute the world-view of the speakers of that language and you control the way in which people see and relate to the world around them, including themselves and each other. (p. 227).

The metaphor "main door" which is assigned to language by Hoppers (ibid.), suggests that successful knowledge transfer can mainly or largely be attained if the language of description used is able to make its users view the social world more clearly, to the level that they are able to understand various processes and make possible decisions as they interact with the world. The said metaphor also leaves the possibility for 'the door' to be closed or opened. This simply implies that language may be 'described' either in a manner that allows common people to understand (Reed et al., 2006), or in a form that may only give access to those that share the discourse as in educated communities of scientists.

Traditional ecological knowledge, for example, has proved to contain the language of description that accommodates qualitative abstractions that are common and familiar to indigenous communities (Berkes, 2008); while scientific institutions favour the language of description that prioritizes scientific or quantitative abstractions (Hoppers, 2002). From these examples, a premise may be drawn that indigenous communities may not freely use 'scientific language' to the level that will make them view the world in the manner that they would have viewed it in their familiar language of description. If this is the case, then to them language becomes a closed door to knowledge rather than an access tool. Efforts should thus be made to ensure that plans such as community-based monitoring of natural resources like mangrove forests, prioritize contextual relevance (see 2.6 and 2.7) and the language of description that leads to an understanding of the social world.

As mentioned in sections 1.3.2 and 2.7, Reed et al. (2010) argue that understanding is a criterion for the occurrence of social learning or acquiring knowledge. Failure to understand the language of description may lead to a misunderstanding of what is going on and may thus limit wider social learning (Ibid.). This was found to be the case in the social learning study of Masara (2011) where he found that the language of learning was not the language of use, leading to misunderstanding and poor communications of key concepts and ideas associated with the commercialisation of beekeeping practices in rural communities in South Africa and Zimbabwe.

Different studies indicate that both TEK and scientific knowledge can be applied or used together, or support each other in the process of social learning. Sillitoe (2007) calls this process 'hybridization of knowledge', and Berkes (2008) calls it 'knowledge integration'. The call for creating an environment that will allow each of those knowledge forms to support each other is paramount, since both have potentials to complement each other and none of them is 'infallible' (Berkes, 2012). Arguing in support of this, Hoppers states:

We must find ways to reformulate traditional knowledge in terms of the imported knowledge and vice versa, we must integrate the traditional into the modern in a way that allows the development of new forms of rationality, enlarged and more comprehensive than the forms prevailing today. (p. 37).

How this is to be done in ecological monitoring is the focus of this study as indicated in section 1.3.3. Berkes argues further that traditional ecological knowledge "is complementary to Western scientific knowledge and not a replacement of it" (2012, p. 144). He observes that the two knowledge forms have many similarities in terms of the information-base used, though fundamentally, they differ in that Western Science or 'scientific knowledge' gives priority to quantitative measures, and employs population models for management decisions, as opposed to TEK which favours qualitative approaches or measures. In other words, both forms of knowledge need to complement each other and none of them can successfully operate fully on its own (ibid.).

Prior to inviting the possibility for integrating the two forms of knowledge, it is important to examine the kind of contribution that each of the two may offer to praxis or experiential learning processes. Wavey (1993), testifies that indigenous communities retain a record of ecological changes for generations more so than any other social institutions, and argues that their time-tested in-depth local knowledge can be used in monitoring ecological systems. They also have what Berkes (2012, p. 47) calls “constructed mental models” of the health status of the ecosystems, which according to Kofinas & McPherson, (2002) and Eamer (2006), can give rich information for monitoring environmental change.

Castello et al. (2009), Sullivan, Sullivan, Wood, & Iliff (2009), and Goffredo, Pensa, Neri, & Orlandi (2010) all indicate that indigenous or traditional ecological knowledge has been used for environmental monitoring in many cases; including monitoring of salmon aquaculture waste (Heaslip, 2008).

Apart from environmental monitoring, there is evidence that traditional ecological knowledge can also be used in assessing the environment, or in evaluating environmental impacts (Ericksen & Woodley, 2005). Moller, Berkes, Lyver, & Kislalioglu (2004) list common traditional methods that are used by indigenous communities in the process of monitoring the health status of animals and plant species (see table 2.2).

Table 2.2 Traditional methods for monitoring plant and animal species and their health

Method	Description
Catch per unit of effort	Harvest success, or catch rate, usually per unit of time, or time and effort spent.
Body condition index	Pre - or post-harvest observation of fat in body parts of many kinds of animals.
Breeding success	Number of young per adult or per nest, or the ratio of young to adults in a population.
Population density sensing	Qualitative assessment using “feel, see, touch, smell, hear, and taste.
Noting unusual patterns	Detecting change by noting extreme (strange distributions, rare occurrences, breeding failure, unexpected behaviour, etc.)
Observation of species mixes	Presence or absence of desirable or undesirable species or assemblages.
Communal hunts	Collective information gathering by sweeping a large area with participation of many harvesters.

Source: Adapted from Moller et al. (2004)

In some cases, traditional methods and indicators go beyond biophysical systems and assess human–environment relationships (ibid.).

Developed indicators are in most cases believed to be consistent with the notions that indigenous people have on the healthy relations with the environment and other living things (Parlee et al. 2005b). Berkes (2012) argues that TEK addresses three main clusters, namely unity and diversity of indigenous systems, ethics of sacred ecology, and the importance of community-based and participatory resource management.

Berkes views indigenous knowledge as providing reliable opportunities necessary for development. Presenting his views on this, he argues that the use of traditional ecological knowledge may benefit involved communities since indigenous ways of dealing with the environment encourage “realistic evaluations of local needs, environmental constraints, and natural resource production systems” (Berkes 2012, p. 48). He also observes that TEK is used as a major tool among practitioners who believe that development must carry on board local concerns and should also be relevant to target communities.

Preston, Berkes, & George (1995) and Berkes (2012) note that the use of TEK has great potential not only in designing strategies for culturally sustainable development but also for protecting humans from natural disasters like tsunami and modern crises. This is possible since indigenous groups have a social memory of past events and predictive abilities for natural disasters and weather conditions (Berkes, 2012).

In situations where scientific information proves to be not available, some scientists tend to opt for traditional knowledge for help. A good example of this, is when Robertson & McGee (2003) used TEK and social memory to assess events that are associated with flood frequency in a wetland project in Australia. Schlacher, Lloyd, & Wiegand (2010) also used traditional knowledge of ‘noxious algal blooming’ to develop a management plan for tourist beaches. Cited cases affirm that the two forms of knowledge can complement each other. Affirming the idea of integrating the two forms of knowledge, Berkes (2012) argues as follows:

Traditional knowledge and Western Science need not to be thought of as opposites. Rather, it is useful to emphasize the potential complementarities of the two, and to look for points of agreement rather than disagreement. The use of traditional knowledge contributes to conceptual pluralism, and expands the range of approaches and information sources needed for problem solving' (p. 174).

The same plea is given by Bhaskar et al. (2010, p. 196) that indigenous knowledge should "not stand opposed to scientific knowledge" but rather work together. For this to happen, indigenous knowledge needs to be "fostered, re-contextualized, and appropriated" (Bhaskar et al., 2010. p. 113). In contexts where such knowledge has been marginalised, it can also be re-appropriated (O'Donoghue & Neluvhalani, 2002).

2.12 Parameters, attributes, and methods/ techniques used in the two forms of knowledge as components of monitoring/praxis

Monitoring of mangrove and fisheries resources requires an agreed set of parameters, attributes, and methods or techniques (KIMP, 2005). General monitored parameters include trends, condition, threats, and changes (ibid.).

Monitored attributes vary across prioritized natural resources; and their selection will normally depend on the purpose of monitoring and the resource condition (Hill et al., 2005). Scientific monitoring of mangroves, for example, would identify soil as one of the selected attributes, seek to analyse the structure and nutrient status as associated properties, and advance further by analysing soil cores, chemical composition, water retention capacity, and soil chemistry (Ibid.). Traditional or indigenous monitoring may also use soil or land as an attribute (Kofinas & McPherson, 2002), and observe its quality and nutrient level, but will instead employ indigenous techniques. In this case, emerging challenges between the two forms of knowledge will not be on attribute selection but rather on choosing preferred monitoring techniques or methods.

One of the criteria for effective monitoring of selected attributes is having a cost-effective programme, and making it sustainable (Jackson, 1997). In deciding whether to employ Scientific or Traditional techniques in analysing or observing a particular attribute such as

soil, it is wise to choose a solution which is both sustainable and manageable in terms of cost implications. Laboratory soil analysis may require not only sufficient funds but also technical knowledge. Monitoring programmes that are undertaken at a community level are supposed to be participatory and carried out in a manner that allows interactions and knowledge sharing - including how to test and analyse selected attributes (Reid et al., 2006). The use of in-situ and ex-situ scientific techniques in the analysis of soil in the mangrove ecosystem may raise challenges. Firstly, due to its requirement of laboratory knowledge that common indigenous people may not have, and secondly, local communities may not afford and maintain involved costs since community-based monitoring of coastal resources is normally carried out after short periods of time (Wagner et al., 2001; KIMP, 2005) and it is thus a continuous experiential learning activity.

Other attributes that can be analysed by both forms of knowledge include size and shape of the mangrove forest, forest composition like the extent of old, mid and young growth, the extent of felling patches and gaps, dominant species, thinning extent, species composition, richness, and biodiversity (Hill et al., 2005). Scientific knowledge may allow capturing of canopy gaps through the use of aerial photos (Ibid.), which may seem expensive for indigenous communities to undertake. Indigenous participants may still have alternative ways of doing this, for example, observing the general forest canopy from a distance and sharing what they have seen. In community-based monitoring, the purpose is to ensure that the health status of monitored resources are maintained through sustainable processes and that social learning is enhanced, rather than seeking to compare the scientificity of used techniques or methods.

2.13 Conclusion

The chapter provides an overview of social learning across history and relates contexts that favour its occurrence, including natural resource practice and praxis. It suggests that there is always a connection between practice, praxis, and social learning. The chapter also highlights the significance of employing literature and other theoretical concepts to unlock contextual aspects that underpin various phenomena in the study area. From this chapter, it is possible to draw learning examples that are necessary in social learning contexts oriented

towards natural resources management, especially the coastal environment. These include the necessity to address cultural concerns along with contextual concerns when involving coastal communities in experiential learning actions (praxis), such as the monitoring of mangrove and fisheries resources or the restoration of mangroves. It is important also to note that abstraction of indicators is part of the social learning process and a key stage that requires involvement or participation of target communities. The chapter also highlights a link between experiential learning and praxis.

The next chapter provides an overview of the study methodology and approach.

CHAPTER 3: THEORETICAL FRAMEWORK

3.1 Introduction

This chapter introduces theories which were employed in this study to serve as explanatory, descriptive, interpretive and analytical tools. **Critical realism** was used as the main lens to support the conceptualisation of events, mechanisms, and existing internal relations in the studied phenomena. It offered a language of description for understanding, describing, and categorizing notions, concepts, ideas, processes, and interactions in the first *moment* of processes of abstraction (see sections 4.8.3 and 6.1); where participants represented or described mangroves and fish species while seeing, touching, and feeling them. The second *moment* (see section 6.1) focused on the representation of photographic images as a ‘type’ of the first *moment* (antitype) or means of verifying descriptions that were made in the latter *moment*; where **Experiential Learning Theory** was applied to explain learning events and mechanisms across learning stages in the experiential learning cycle. Critical realism, as underlabouring philosophical theory for this study, also offered a methodology or model of scientific explanation (RRREI(C))⁶ to help in explaining how research participants used the Experiential Learning Intervention Workshop (ELIW) as space for analysing two frameworks of indicators (see section 7.1), and how they arrived at an ‘integrated’ set of indicators for monitoring mangroves and fisheries in the study area. Some of the emerging concepts (e.g. power relations and knowledge transfer) necessitated re-contextualisation through drawing on explanatory support from Foucault, Vygotsky and Archer (Vygotsky and Archer’s work are social realist in orientation with some perspectives that are commensurate with those of critical realism; and some would say that Foucault’s work - especially his genealogical work - has social realist dimensions; although his work has been more widely typified as being post-structuralist).

⁶ Resolution, Re-description, Retrodiction, Elimination, and Correction are components of the RRREI(C) applied scientific model of explanation. The model helps critical realist researchers to approach systemic and complex phenomena or systems in the social world and it also serves as an explanatory tool on how various processes are carried out (see section 7.3).

3.2 Conceptualising theories and their application in research

The Compact Oxford English Dictionary for College and University students (2006) defines a theory as a reasoned set of ideas that is intended to explain why something happens or exists. Theories are abstract conceptualisations of how thoughts and external objects relate to each other in a consistent manner (Beard & Wilson, 2002). Bryman (2012) argues that theories provide a framework within which social phenomena can be understood and research findings interpreted.

Danemark et al. (2002, p. 116) elaborate that researchers “can never understand, analyse or categorize reality without using a theoretical language of concepts”, and insist that theories help us to see and understand the world by serving as interpretive frameworks. Their application is inevitable since they help researchers to explain relations and conceptualise causal mechanisms (ibid.). Theories are also perceived as lenses that help researchers to clearly see or view what they are seeking to understand (Howell, 2013); and how best they should approach various study phenomena (Maxwell, 2012).

This particular study was not exceptional; it also required suitable lenses that would lead the researcher to a focused direction and provide him with reliable explanatory, interpretive, and analytical support. As explained earlier (see section 3.1), the study used Critical Realism and Experiential Learning theories.

3.3 Critical Realism

Critical Realism stems from the work of Roy Bhaskar (1975, 1986, and 1989). Critical realism is a complex body of philosophical work led by Roy Bhaskar over a forty year period of research. The work was initially developed as a response to the loss of an ontological engagement in research. Bhaskar’s PhD was focussed on economic philosophy and history and he was puzzled as to why there was no real engagement between economic theory and the world; i.e. that economic theory had to be pursued for its own sake; and his project developed into a long and substantive critique of empiricism and idealism (now known as Basic Critical Realism, in which he argues for ontological depth and emergence in open systems (Bhaskar 1975; 1986; 1989). This work was later also extended to a critique of the Hegelian dialectic which was said to be ideational, and from this Bhaskar proposed an

associated onto-axiological theory of transformative praxis (now known as Dialectical Critical Realism (Bhaskar 1993); and meta-Reality. His most recent work which is a “philosophy of identity- or unity-in-difference” (Hartwig, 2007: 304) which complements and extends the dialectical critical realist work, is said to be more spiritual in orientation. In this study I draw mainly from Basic Critical Realism.

One of main claims of basic critical realism, is its capacity to provide *under-labour* for metatheoretical philosophical positions, including empiricism, social constructionism, neo-Kantianism, and hermeneutics (Bhaskar & Danemark, 2006), which according to Bhaskar et.al (2010), reduce reality to either the empirical domain (observable part of the world that shows experiences) or actual domain (events that occur in the world) by ignoring structures and mechanisms that generate the events and experiences (Creaven, 2010; Byrne & Ragin, 2009), and eventually reducing the ‘being’ (ontology) to ‘knowledge’(epistemology). The theory appears to be therefore an alternative to philosophies that embrace closed research systems; epistemic fallacies (the analysis or reduction of being to knowledge), judgmental realism (the view that one cannot judge between different discourses and decide that some accounts are better than others), and ontological monovalence; which generally involves a tendency to ignore emergent properties or phenomena by judging from what is only known to exist (Bhaskar 1975; Sayer 2000; Dean, Joseph, Roberts & Wight, 2006).

Critical Realism was helpful in this study context because it is a theory which seeks to identify ‘potentials, possibilities, and necessities in the world’ (Sayer, 2000, p. 11); this study too sought to analyse certain potentials within processes of abstraction, conceptualisation, and representation that may contribute to social learning in the coastal environment.

Drawing on basic critical realism as it is used in this study, was driven by the contextually complex nature of interactions between social-cultural, ecological, and economic phenomena in the mangrove ecosystem which could better be approached and discussed through the lenses of stratified ontology and thus avoid conflation of different layers of

reality (flat ontologies or ontological monovalence) which tend to be reductionist by nature (Sayer, 2000).

Epistemologically, basic critical realism indicates how one might manifest phenomena, and mechanisms that produce them, in their complex situations (Bhaskar & Danemark, 2006). As advised by Sayer (2000), choosing a particular theoretical tool depends on the “nature of the object of study” and what one wants to learn about it (Sayer, p. 19).

Critical realism theory promotes the search for reality beyond the world that we don’t experience empirically, and proposes that there are three main domains of reality namely the real, the empirical, and the actual (Sayer, 2000). The identified stratified “domains” are all relevant in the context of case-study research (Carter & Sealey, 2009, p. 73). Through these domains, researchers can investigate observable and non-observable experiences, events, and the mechanisms that generate the events in the social world (see figure 3.1).

	<i>Domain of Real</i>	<i>Domain of Actual</i>	<i>Domain of Empirical</i>
Mechanisms	√		
Events	√	√	
Experiences	√	√	√

Figure 3.1: Domains of the Real, Actual and Empirical: Source: Bhaskar (2008).

The domain of the *real* refers to the structures and mechanisms that generate events and experiences in the social world (ibid). Some of these events and experiences are reflected in chapters 5, 6, and 7 and are connected to experiences that either directly or indirectly affect social, ecological and economic interactions in the study. The *real* constitutes objects that may be seen or not; we may have adequate understanding of their nature or not. Much of what we see happening in other domains is believed to be influenced or generated by the structures and powers that emanate from the real.

Structures and powers that populate the *real* represent abilities or capacities to behave in certain manners (particular ways), or to cause things to happen in certain ways (Sayer, 2000). Some critical realists simply call such capacities tendencies or ‘mechanisms’ that

generate the events and experiences in the social world (Carter & Sealey, 2009). The kind of power that exists in the *real* can be passive or may by nature be susceptible to change. Such powers may be vested in bureaucracies by virtue of existing structures, but may also be present in individuals or social groups by virtue of their physical make up regardless of their social status (Sayer, 2000). Such powers may also reside in natural systems or objects such as marine coastal ecosystems or climatic conditions.

Emergent from the *real* is the *actual* domain. This is dominated by 'events' that are influenced by existing powers, structures, and mechanisms. According to Sayer, when the powers of mechanisms are activated, they tend to cause or lead to activities or events (ibid). The effects of these events are sometimes observable. In a coastal setting for example, communities may observe some natural or human induced effects that pose threats to the health status of mangrove and fisheries. The events that are associated with the experiences or effects occur in the 'actual domain'. When a prevalence of the identified events lead to a decline in the status of a mangrove forest or a decline of particular kinds of mangrove-based fisheries, such effects become apparent to people since they depend upon fishes for survival. On the other hand, decline in the health status of mangrove forests may lead to an absence of some social, economic and ecological advantages that mangrove resources can offer in a given coastal area. Events that occur in the domain of the *actual* may also depict a positive scenario. For example, conserved, monitored, and managed mangrove resources (in the actual domain), may yield positive experiences in another domain (empirical), or simply cause involved communities to directly or indirectly experience some social, ecological, and economical benefits that the mangrove ecology offers.

Another distinguished domain which is closely linked to and emergent from the real and the *actual*, is the *empirical*. This is dominated by experiences. Here, reality may be investigated through enquiries of the past and present experiences of the phenomena under study. Experiences that occur in the *empirical* domain are "apparent to us" and from these, our senses may inform us about what is going on in the social world (Gerring, 2007, p. 41, Byrne & Ragin 2009, p. 75).

It is from such experiences that traditional ecological knowledge may be abstracted, conceptualised and represented by social groups and individuals who come into contact with the physical world on a daily basis and are either positively or negatively affected by prevailing socio-ecological interactions. While some structures or powers may not be directly observable in the experienced world (*ibid.*), existence of unobservable entities can be made by making reference to observable effects (Collier, 1994a, Carter & Sealey, 2009). In this particular layer of ontology, Sayer cautions critical realist researchers to recognise the possibility that powers may exist that are unexercised, and therefore existing experiences of what has happened or what is known, does not exhaust what happened or is likely to happen (Sayer, 2000).

In the coastal scenario, experiences may refer to prevailing situations such as people's experiences of abundance or decline of fisheries resources, their observations and reports of an increased or decreased number of fishers in the study area, improved health status of mangrove species, or experiences, perceptions and views of situations that result from various praxes and practices in the coastal environment. Critical realist researchers argue that if one only focuses on these experiences as in hermeneutic research, the research can be characterised by methodological individualism or rely too heavily on what people say (Sayer, 2000), hence the need to consider interacting layers of the domains of reality as described by basic critical realism, and how such experiences can be shaped.

3.3.1 Application of critical realism in the study

The use of basic critical realism as the main theory underlabouring this study was evident in the following theoretical support:

- Critical realism helped me to conceptualise and explain concepts of abstraction and conceptualisation (see section 1.7.1), and how these (as processes) may lead to representation and understanding of social, ecological, economic and cultural values of the mangrove ecosystem in the study area; and steer social learning (see sections 2.3, 2.4, and 2.5). Critical realist descriptions from Bhaskar (1998), Sayer (2000), Danemark et. al. (2002), and Hartwig, (2007) served as key explanatory tools.
- It also helped me to lens processes of ‘knowledge transfer’ at the empirical level; and identify mechanisms that generate transmission of knowledge from the most experienced fishers/mangrove restorers to the less experienced (sections 5.2.2. & 5.2.2.1). Critical realism helps to explain that knowledge transfer may be apparent to us at the empirical level, our senses may inform us about its occurrence, and our language allows us to provide descriptions that allow for knowledge transfer (Byrne & Ragin, 2009). Here, due to my interest in abstraction and learning, I also drew on the complementary concept of ‘internalisation’ from Vygotsky (Wertsch, 1985; Daniels, 2001) to explain how individuals, for example inexperienced mangrove restorers, begin to appropriate the procedures, actions, and routines that are involved in the mangrove transplanting practice via knowledge exchange with others in the domain of the empirical, and they eventually ‘internalize’ those routines and begin to practice transplanting as independent mangrove restorers.
- Critical realism also helped me to conceptualise causal mechanisms for fish interactions in the mangrove ecosystem (see section 5.2.3); such as food, shelter, and seasonal variations (northerly and southerly monsoons). It also helped me to conceptualise fish behaviours that were being generated by unknown drivers or determinants such as the immersion of cuttlefish (locally called *dome*) during low water tide, and raised the need for scientific investigation of the same to identify generative mechanisms that drive such behaviour. Critical realism helped me to

conceptualise and interpret the power relations depicted in the notions, concepts, and ideas of mangrove restorers and fishers in the study area (see section 5.2.5). Sayer (2000), drawing on Bhaskar (1975, 2008) helped me to describe two types of power that may be operating in the study area and how these may potentially interact to produce particular kinds of effects or outcomes. These include potential powers that individuals (coastal communities) hold which may be actualised, triggered, or activated to cause the said communities to act in particular ways (Bhaskar describes these as Power 1); and hierarchical powers such as institutional, government, etc., which may either act at the higher level or the same level and influence the experiences and practices of the coastal communities, either in enabling or constraining ways (Bhaskar describes this as Power 2). The latter is applied to reflect the role of existing government structures, which may for example restrict the unsightly clearance of mangroves in the country and encourage their protection via the establishment of patrol systems and environmental committees at village/ward level in the study area. Individual powers (Power 1) could be suppressed for a while by Government power (Power 2), but could also at a later stage be activated and triggered to generate either negative or positive effects in the mangrove ecosystem for example. Scott's (2010) and Sayer's (2000) interpretations of Bhaskar's work on power, are also used in this study to explain how powers may 'act against' each other and how sometimes a combination of different powers may give rise to observable phenomena in the mangrove ecosystem. Additional insight into power relations and their operation in social settings are borrowed from Foucault (1983) to interpret the tendency of individuals to resist powers that act against them. Additionally, insights were drawn from Archer's concept of '**reflexivity**' to explain causal mechanisms that encourage individuals (like those in the coastal environment) to refrain from destructive practices, and therefore comply with what 'Power 2' is seeking to achieve (protect the mangrove ecosystem). This social realist lens also shows how 'reflexivity' can potentially raise the need to introduce sustainable practices such as mangrove transplanting.

- Critical realism also helped me to distinguish, interpret, and explain species relations in the mangrove ecosystem, where some relations are presented as depicting a kind

of necessary relations and others contingent relations (see section 5.2.4). For example, the relationship between mangroves and fish species that use them as permanent habitats is considered to be depicting the former characteristics rather than the latter. Some species are shown as depicting formal or external relations (not real) but they have connections and may share some common characteristics such as feeding, spawning, and movements. On the other hand, relations that are considered to be necessary and internal or substantial, suggest that one species cannot exist without the support of the other in that particular ecosystem. For example, some biotic organisms such as earthworms live in the mangrove soil, and they help in mixing up the said soil to facilitate nutrient absorption for mangroves. Cuttlefish (*dome*) may also yield some benefits to the mangrove species through their act of 'immersing' in and up muddy mangrove soil during low and high water tides respectively. Some form of transfactual explanation is made to adopt the same interpretation in order to explain the relationship between the mangrove ecosystem (which is naturally governed by natural laws) and coastal communities (who are governed by social systems). Danemark et al. (2002, p. 117) suggest "switching between different levels of abstraction" and relating those levels to discover further explanations.

- Epistemologically, critical realism helped me to consider different 'meanings' that people assign to language during abstraction, conceptualisation and the representation of ecological processes and events. Danemark et al. (2002) argue that 'meaning' forces us to seek knowledge rather than experiences and facts. They argue that sometimes particular terms and words, gestures, actions, etc. have specific meanings that carry important messages or knowledge. For this reason, this study also considered the use of metaphors in the participants' representations. Critical realism was later used to help analyse specific metaphors (see section 5.2.7), identify their domain of reality, and interpret them to reflect represented contexts.
- Methodologically, critical realism indicated the domain of reality that I was meant to start with in the process of enquiry, i.e. *empirical* (domain of experiences) which is "apparent to us" and where our senses may inform us about what is going on in the

social world (Gerring, 2007, p. 41, Byrne & Ragin 2009, p. 75). Processes of abstraction drew heavily on experiences that were apparent to fishers, mangrove restorers, and local elders.

- Critical realism also offered a realist scientific model/framework of explanation commonly known as RRREI(C) for analysing the processes in the Experiential Learning Intervention Workshop (ELIW) (see chapter 7 and appendix 14) where mangrove fishers, mangrove restorers, local elders, and representatives from the local marine scientific community discussed and analysed two different frameworks of monitoring indicators; namely the existing scientific framework - see sections 1.3.2, 1.41, and 1.6, and the new framework of Traditional Ecological Indicators (TEK) - see section 5.2.10, 1-4) for purposes of coming up with a set of indicators that are regarded by resource users as being potentially less reified, more contextually and culturally congruent, and which may easily guide community-based monitoring practices and attract a wider social learning process (see sections 7.1-7.10). The RRREI(C) model focussing on processes of resolution, re-description, retrodiction, elimination, identification and correction, helped me to show: 1) how research participants with my support, named, described, and analysed various component parts and relations of the two frameworks of indicators (resolution); 2) how they re-described the components in a way that made them relevant or theoretically significant (re-description); 3) how they explained the events by making inferences back to mechanisms that were capable of producing them (retrodiction); 4) how they eliminated alternative expressions and explanations that suggested the existence of confounding mechanisms (elimination); 5) how they identified generative mechanisms from those considered (identification); and ultimately 6) how they made corrections (C) that were necessary for producing one framework of indicators (see tables 7.1 and 7.2). The RREI(C) is a mode of scientific explanation used by critical realists, also referred to as “applied (or practical or concrete) explanation ... a form of explanation that is essential when conditions are fundamentally open” (Hartwig, 2007, p. 196) as in the open social-ecological systems of mangroves.

3.4 Experiential Learning Theory

As explained earlier (see section 3.1), this study also drew on Experiential Learning Theory (ELT) to indicate how learning occurs across different stages of the learning cycle. This theory was developed by David Kolb in 1984, as a tool that could facilitate ‘learning by doing’; and is widely applied in both formal and informal learning situations across disciplines. Reed et al. (2010) describes experiential learning theory as a theoretical framework which helps us to understanding how people learn, and the processes that lead to occurrence of social learning.

Experiential Learning Theory expands Dewey’s earlier cognitive learning perspective which focused on integrating learners’ actions with thinking (Dewey, 1938). According to him, learning is a lifelong process which the learner experiences not only in a classroom environment, but also in outdoor contexts (ibid.).

Kolb’s work goes beyond ‘integration of actions and thinking’ by devising the means through which learners may develop different abilities and learning styles, which are necessary for addressing emerging contextual challenges or help them make necessary decisions. He does this by introducing a learning cycle called ‘Kolb’s Experiential Learning Cycle’ and describes it as follows:

Learners, if they are to be effective, need four different kinds of abilities – concrete experience abilities, reflective observation abilities, abstract conceptualisation abilities and active implementation abilities. That is, they must be able to involve themselves fully, openly, and without bias in new experiences. They must be able to reflect on and observe their experiences from many perspectives. They must be able to create concepts that integrate their observations into logically sound theories, and they must be able to use their theories to make decisions and solve problems (Kolb, 1984, p. 30).

Four learning stages may be cited from the above quotation. These are presented in Table 3.2 (learning cycle) and described thereafter:

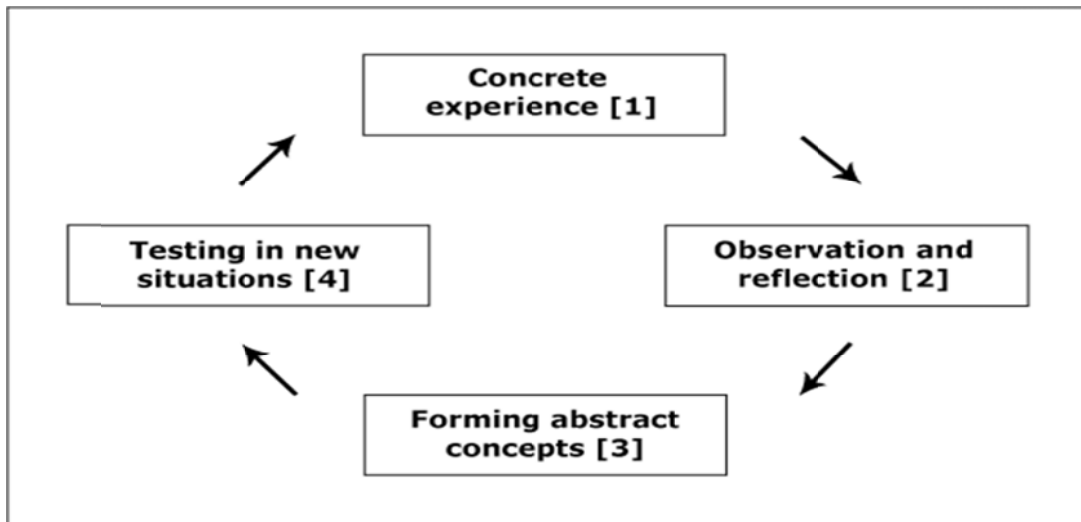


Figure 3.2 Experiential learning cycle: Source Kolb (1984, p. 21)

3.4.1 Concrete experience (first stage)

This is the first stage in the learning cycle where learners are facilitated to engage themselves in a new experience like an action or practice, and they focus on what is experienced rather than what is reflected, conceptualised, or tested. This gives them opportunity to immerse themselves in their task of choice and observe it, feel it, and react to it in different ways.

3.4.2 Observation and reflection (second stage)

The second stage indicates how learners step back from the on-going task and review what has been carried out and experienced. They add or adjust their perceptions based on what they have learnt before (previous knowledge). They are then able to notice any differences and apply terms that help in identifying even hidden events, and communicate them to other learners. It should however, be noted that values, beliefs, and attitudes of learners will still influence their manner of differentiating certain events. In a nutshell, the second stage of the cycle focuses on 'observation and reflection'.

3.4.3 Forming abstract concepts (third stage)

This learning stage involves abstract conceptualisation or concept formation to define a particular situation. It exposes learners to interpretations of noticed events, understanding

the relationships between them, and making generalizations. It is a stage that creates avenues for learners to discuss emerging concepts as they reflect on experiences that invariably raise questions that need answers. In this stage, guidance is extremely helpful to the learners to help them in the process of abstract conceptualisation or concept formation.

3.4.4 Testing in the new situations (fourth stage)

The fourth stage of the experiential learning cycle helps learners to realise the input that emerges from the third stage and use it in formulating new situations to be tested. According to Kolb (1984), this level will only be meaningful if learners are involved in the planning of the learning experience. The facilitator therefore, helps learners to develop their own objectives for a preferred intervention. This is necessary in the process of social learning since learners are engaged in the development of knowledge that is held collectively, and which is likely to influence the behaviour of other group members (Keen, Brown, & Dyball, 2005b).

3.4.5 Learners' depictions of different learning styles

Kolb (1984) argues further that as learners take part across the learning cycles, they begin to reveal different learning styles not as a group but as individuals. Some depict a form of ***diverging*** behaviours or characteristics when they are being exposed to the new practice or action (at concrete experiences level). These tend to have broad views about what they have experienced; and are interested about what people do, and how people do those things.

The second category of learners in the experiential learning cycle involves those who depict the ***assimilation*** style (assimilating). These are less focused on people, and they tend to focus more on abstract concepts and ideas. In other words, they draw attention to theoretical insights rather than practical implications of what they have been exposed to. They thus prefer exploring new ideas that underpin the new practice.

The third learning style that may be identified as learners engage themselves in the practice is called ***converging***. Learners who display this kind of style are very active in making abstract concepts and engaging themselves in active experimentation (testing new

situations). They reveal certain capabilities or abilities to react to emerging problems or challenges and are therefore good at making practical decisions. They prefer finding solutions to questions rather than raising more questions in the learning exposure.

The last learning style that Kolb (1984) brings to attention involves ***accommodating***. Learners that fall under this group have abilities to learn from 'hands-on experience' and they enjoy being part of the active implementation process (or executing or experimenting plans). These tend to be driven by 'feelings' than logic, and are reliant on information from other learners. They therefore prefer engaging in collective or team work to have their assignments done. As explained earlier in this section, *accommodators* tend to rely heavily on other people for information than on their own.

3.4.6 Application of the theory in the study:

- Experiential learning theory offered a methodological tool (Kolb's experiential learning cycle) to guide the learning process and events across the four stages. This also helped me to explain how research participants as learners experienced the new practice (taking photographic images of mangroves and fisheries), and how they reacted to it in different ways. It made it possible for me to track learners' advancement from one stage to another and describe their experiences in the learning process.
- Epistemologically, the theory helped me to *explain* how learners conceptualised the images they had taken; and to *interpret* conditions, processes, and events that enabled or constrained their involvement in the new practice. This also helped me to explain different learning styles depicted by learners (see section 3.4.5).
- Kolb's experiential learning cycle also served as an 'analytical tool' for participants' representations, in that it helped me to interpret represented accounts and reason whether these indicated a shift from one stage of the cycle to another or not.

- It gave me a language of description since the process of explaining, interpreting, analysing, and describing events in the learning cycle was presented using the same terms that are applied in the cycle, such as concrete experience (first stage), observation and reflection (second stage), forming abstract concepts (third stage), and testing in the new situations (fourth stage).
- Experiential learning theory also helped me to distinguish how learners contrasted or compared two different experiences they had gone through (i.e. representation of real and visible mangrove and fisheries images versus the representation of photographic images of the same).
- It also helped me to explain how experiential learning or 'learning by doing' takes place in the mangrove ecosystem. For example, photograph taking practices and indicator testing exercises (see sections 6.1-8) engaged the participants in learning as they took part directly in practice(s).

3.5 Link between Critical Realism and the Experiential Learning in the study

- The two theories have a close link, in that they both provided opportunities for explaining how processes of abstraction and representation of traditional ecological knowledge occur in the coastal environment.
- Critical realism served as an explanatory and descriptive tool for learners' representations in the first *moment* of processes of abstraction (see chapter 5), and it also compelled me to identify drivers or mechanisms which generated learners' events and experiences across the Kolb's learning cycles (see chapter 6).
- The fourth stage of the experiential learning cycle (active implementation or testing new situations) was facilitated by the input that had been 'perfected' through processes of *resolution*, *re-description*, *retrodiction*, *elimination*, *identification*, and *correction*, which are all components of the realist scientific model of explanation commonly called the RRREI(C) (see section 7.3.1).

3.6 Criticism of used theories (critical realism and experiential learning)

The process of ‘underlabouring’ that critical realism claims to do is widely represented at a grand theoretical level rather than at contextual application levels. In particular, while it is said that critical realism is a “*critical* philosophy of and for science and cognate practices, aspiring in the case of the social sciences to supply the general conceptual schema [e.g. the stratified ontology and RRREI(C) explanatory methodology] that they currently lack to obtain ontological depth and emancipatory explanations that work in open systems” (Hartwig, 2007, p. 490), it was not easy to find examples of how this is done in social science research. This entails some creativity when applying the said theory, especially in new areas where there are limited research examples. I was able to obtain some examples from southern African environmental education researchers e.g. Price (2007); Pesanayi (2008), Davies (2009); and Mukute (2010); but most had only worked with the stratified ontology, and had not used these tools to engage with processes of abstraction and the RREI(C) explanatory methodology. Besides the direct application challenges I have specified above, as I was reading through various literature, I noted that critical realism as a theory was being criticised for not recognising the contribution made by other philosophical positions. Mingers (2011), for example, argues that some concepts that critical realism as a philosophy advocates such as open systems, causality, emergence, totality, and stratification have already been developed in systems theory; and adds that the latter (critical realism) may benefit more from the former (system theory) and that the two can build each other. In spite of the criticism raised against critical realism, its potential to serve as an explanatory, interpretive, analytical, methodological, and epistemological tool seems to be explicit, especially in examples that are reflected in this particular study, and as I found in some other studies where critical realist tools were being applied in educational research contexts (ibid.). It is possible that more application of this theory in social learning and other related contexts may foster its usefulness at contextual or disciplinary levels.

As for experiential learning theory, in spite of its usefulness in clearly indicating ‘learning’ across the experiential cycle, it suggests some kind of a routine process which pursues a *linear* form of learning. It also ignores the fact that some events, for example observation and reflection (see stage 2 in figure 3.2) may happen concurrently with those happening in the 3rd stage of the cycle (forming abstract concepts). It is also claimed that experiential

learning theory as a perspective fails to explain appropriately the concrete experience stage (Miettinen, 2000). Other cited weaknesses include ill-definition of used concepts which encourages open interpretations, learning phases being separate (not connecting to each other), failure of the theory to adequately discuss the role of non-reflective experiences, and over emphasis on experience as a strong point of acquiring knowledge while disregarding subjective observations of the learner (Ibid). Nevertheless, the theory serves as a useful experiential learning tool which encourages interactions and knowledge sharing; which are all necessary elements of social learning (Cundill & Rodela, 2012), and it suggests a kind of learning that leads to new thinking and creative solutions as advocated by Wals (2010:23). The use of the critical realist DREIC approach also helped to address some of the said problems with experiential learning, as it enabled synthesis and reflection on the whole process, and also engaged subjective observations of the learners.

3.7 Conclusion

Critical realism and experiential learning theories are, as shown in this chapter, potentially helpful lenses that can work together in guiding the analysis of processes of abstraction, conceptualisation and representation in social learning contexts among indigenous or traditional communities like those in the coastal areas that are the focus of this study. Both - as indicated in section 3.5 - prioritize processes of abstraction and conceptualisation in the same focus. They show how thoughts are related to external objects (such as fish and mangrove species) and how these create a platform for reflective learning, new thinking, and creative solutions through interactions, knowledge sharing, and experiential space. They also serve as the explanatory, interpretive, epistemological, conceptual, methodological, and analytical tools necessary in conceptualising and realising social learning processes in the coastal environment. Details on how some of the theoretical tools were employed in the study are presented in the methodology chapter (see chapter 4).

CHAPTER 4: RESEARCH METHODOLOGY, METHODS AND STUDY DESIGN

4.1 Introduction

This chapter presents the procedures, methods, and techniques that were employed in the study to ensure the credibility, trustworthiness and dependability of the research process and its outcome. The first section of the chapter provides an overview of the research approach; namely case study research. It then provides further detail on the research sites, selection of research participants and details on the data generation processes. The chapter also shares details of how data generation took place over a series of phases, which overall make up the study design. Furthermore, the chapter discusses how I sought to maintain trustworthiness throughout the study, and how I sought to ensure that ethical protocols were observed. I also discuss the processes of data management and the analytical processes, through sharing insight into the modes of inference that were applied to the analysis of data.

4.2 Research approach

The study was constituted as a critical realist, qualitative single case study as it sought to access in-depth information about the significance of abstraction, conceptualization and representation of TEK in social learning processes, that might potentially contribute to the development of a user-friendly and less reified framework of coastal monitoring indicators which may be used by coastal communities in detecting changes, threats, trends, and conditions of fisheries and mangrove resources on the Eastern Coast of Tanzania, as discussed in Chapter 1. The case study approach was useful in this coastal context because it allows investigators to “retain holistic and meaningful characteristics of real-life events” (Yin, 2003, p. 2). Opting for this strategy also implied choosing to have a deeper understanding of the phenomena under study (depth), rather than breadth of perspective. Sayer (1992), who is a critical realist researcher, explains that intensive study designs (normally using case studies) are appropriate for critical realist research as they allow for in-depth probing of complex phenomena in open systems. He differentiates between intensive

methods associated with concrete research, and the extensive techniques used for generalisation research. Intensive research, according to Sayer (ibid.) is concerned with causal processes and how it works out in a number of cases. Extensive research, on the other hand, concerns itself with finding out common properties and patterns of a population as a whole. Extensive research designs tend to use descriptive and inferential statistics along with numerical analysis, while intensive research designs tend to work more with qualitative analysis and small groups of participants bounded by case boundaries. Intensive research designs do not seek to generalise to whole populations, but there are possibilities, especially in critical realist research, to develop generalised views at the level of underlying generative mechanisms that may shape and influence different case contexts in similar ways (e.g. poverty can influence a wide range of people or communities in similar ways, but the exact way in which individuals and communities are influenced may differ from context to context / case to case). This study is designed as a critical realist case study that follows an intensive research design, as described by Sayer (1992). According to Babbie (2001, 2007), case study research yields either 'descriptive' or 'explanatory' knowledge. This study pursued a 'descriptive case', which according to Yin (2012, p. 49) offers "rich and revealing insights into the social world of a particular case" (i.e. descriptions that depict indigenous representations of the mangrove ecosystem and associated experiential and social learning processes). Danemark et al. (2002) emphasise that a case should be studied in its natural setting since it is signified by the context within which it occurs. Through the use of the RRREI(C) explanatory process, the study also offered an explanatory case of how TEK and Western Scientific coastal monitoring indicators can be engaged.

Verschuren & Doorewaard (1999, p. 64) list key characteristics of case study research as having "a small number of research units, labour intensive data generation processes, more depth than breadth, a selective, i.e. a strategic sample, qualitative data and research methods, and an open observation on site". It is also argued that open questions should guide individual and group interviews in a face to face manner, coupled with observations and audio-visual methods in order to attain in-depth reality of the case (Verschuren & Doorewaard, 1999, p. 64). This study applied most of the suggested methods and approaches, depending on contextual and social realities.

Flyvberg (2006) observes that the case study approach is criticised for seemingly generating knowledge that cannot be generalized. He corrects this misunderstanding by arguing that produced knowledge is determined by used designs (i.e. extensive or intensive) within a particular case and not the case itself; and adds that the focus should be more on understanding the study phenomena in particular contexts and generating knowledge that benefits people. Stake (1995) also insists on the need for case study research to benefit people rather than archives. He believes that this may be attained by understanding the 'knowledge about the particular' in full (which he also argues can be recognised in new and external contexts). Nevertheless, ways through which such knowledge may be inferred or generalised to other contexts may vary across approaches and perspectives.

Generalization and inference making in this study (as stated earlier in this section) are not based on sample size as might be the case in other research approaches, but rather on the critical realist perspective which focuses on generalised views at the level of underlying generative mechanisms, that may shape and influence the study phenomena (Danemark et al., 2002, see also section 4.6.3).

4.3 Scope of the study and research sites

As indicated in sections 1.5 and 1.5.1, and implicated in sections 1.2 and 1.3, this study was confined to the mangrove ecosystem, and fisheries that use mangroves as key habitats in the Mkinga coastal district (Tanga administrative region), on the eastern coast of Tanzania (see figures 4.1 & 4.2). As reflected in section 4.4 below, it involved selected fishers, mangrove restorers and local elders, who contributed to the study. Nevertheless, the output of this study may be useful not only to the study area (Mkinga district), but also to adjacent coastal communities residing in the Tanzanian coastal strip, as there is evidence of shared culture, increased socio-cultural and economic-interactions, and shared ecological characteristics (NICEMS 2003), which suggest the possibility of shared traditional ecological knowledge. The study also sought, through the critical realist stratified ontology analysis, the experiential learning process and the RRREI(C) process, explanations to 'model' or show how it could be possible to reconcile Western Scientific indicators with contextualised forms

of TEK. While the exact TEK cannot be replicated outside of the specific contexts that were studied here, beyond the potential described above where shared culture may exist, the *process methodology* can be applied to different contexts where similar *process outcomes* may be possible. This is discussed in more detail in Chapter 8 of the study.

A coastal mangrove strip that extends from the Moa to Boma localities in Mkinga District (see figures 4.1 & 4.2) was selected as the main study site, on grounds that it would provide opportunities for selected research participants to work from the environment that they are familiar with, rather than being moved to one specific location (except for some combined research activities). Working from this familiar environment was necessary, especially for retired fishers and mangrove restorers who could not manage to walk to other parts of the extended coastal strip.

Sub-sites that served as meeting points in the main study site (the coastal mangrove strip of Mkinga district) included Moa South, Moa North (Kijiru), Boma-Kichakamiba, and Boma-Subutuni. All these are located in a shared mangrove coastal strip (TCZCDP, 2005). 'Moa' is the main locality which is presented in this study as having two sub-sites (North & South). Moa-South is where most of combined activities such as the Experiential Learning Intervention Workshop (ELIW) and the elders' focus group discussion were held, due to its central location. Moa-North is commonly known as 'Kijiru' but this study employs the former term for inclusiveness as the latter is sometimes used to imply a sub-locality, excluding some parts of the entire locality. On the other hand, 'Boma' locality, which is also made up of two sub-sites (Kichakamiba and Subutuni,) lies within a shared coastal strip in the eastern border of Mkinga District (see figures 4.1 & 4.2).

Selection of the study site was based on the following criteria:

1. It contained over two thousand hectares of mangrove species with unique ecological characteristics (good for experiential learning);
2. Resource users in the study area had been involved in coastal monitoring practices from the early 1990's, and were thus versed with challenges that are associated with adapting and applying the framework of scientific indicators.

3. I, as researcher, had participated in various community-based natural resource management activities in the study area for over 2 years, and in other coastal sites for over 10 years, and therefore had the potential to access useful information for the intended study (as reported in section 1.1).

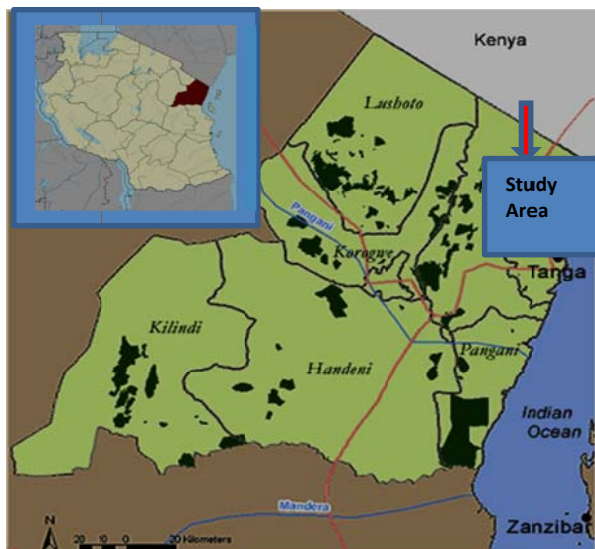


Figure 4.1: Map of Tanzania (top-left).

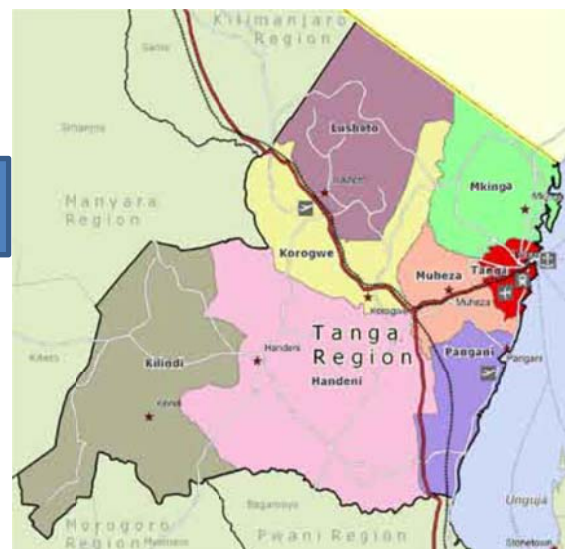


Figure 4.2: Mkinga District (far-right)

4.4 Selection of research participants

Maxwell (2012) notes that some qualitative researchers may prefer using the term 'selection' of research participants instead of 'sampling', since the goal of qualitative studies is not to raise and generalize scientific claims, but rather 'to understand the processes, meanings, and local contextual influences involved in the phenomena of interest, for specific settings and / or individuals studied' (Maxwell, 2012, p. 94).

The selection of study participants in this study was guided by Verschuren & Doorewaard, who recommend the use of a "strategic" or purposive sample in case studies (1999, p. 164; 2010) to allow in-depth analysis of the phenomenon under study. I initially proposed a purposive (strategic) sample of 40 research participants, targeting 16 fishers, 16 mangrove restorers, and 8 local elders. The selection of research participants was based on their involvement in mangrove and fisheries praxis and practice in the study area. Using this criterion, I selected fishers who had participated in fishing activities for at least 15 years, mangrove restorers with at least 10 years of experience, and local elders who had witnessed

trends, threats, changes, and conditions of fisheries and mangrove resources for at least 20 years.

Fishers: Fishers that are involved in this study are conducting artisanal fishing; using limited gear, mostly traditional fishing nets, hooks, spears, traps and other locally based techniques (Wagner et al. 2001, Wagner 2005, also see plate 2.1). These are normally operating on a small scale; yielding low to medium incomes to enable them meet their family needs such as food, school fees, travelling, health costs, and emergencies (NICEMS, 2003). Fishing is the main economic activity in the study area and it involves the majority of medium aged fishers, collectors, and middlemen and women (Ibid). The practice of fishing is traditionally carried out by male fishers, but collection of sea cucumber and curios involves female participants (KICAMP, 2003). Some fishers practice 'gypsy fishing' (locally called '*malago*'). This is mainly practiced by fishers from Pemba and Unguja Islands (Zanzibar), who move to the Tanzanian mainland (the study area inclusive, see figures 4.1 & 4.2), when seasons change due to lack of fish in their area.

Mangrove restorers: These are groups of coastal community members largely made up of female participants, carrying out mangrove restoration activities after exposure to the significance of mangrove species to the coastal ecology. Mangrove restorers raise mangrove seeds in prepared nurseries after carrying out some kind of needs assessment (see section 2.6.1 & plate 2.3), and they afterwards transplant the same to affected areas (see section 2.6.2). This activity was initially not motivated by income generation but recently, they have realised that mangrove forests can support beekeeping and eco-tourism as income based initiatives (see section 2.6.3 & plate 2.3). As indicated earlier, mangrove restoration groups are dominated by female participants because most of the males are involved in fishing.

Elders: These are mostly retired fishers who have practiced fishing for a long time, and are well versed with past historical trends, changes, threats, and conditions of both mangrove species and fishing activities in the study area. Traditionally, this group is made up of male participants some of whom are religious leaders; and like fishers and restorers, the group yielded significant contribution for understating TEK in the study area (see chapter 5).

To ensure credibility, accountability, and trustworthiness, I used previous contacts as is reflected in criterion 3 (see section 4.3), to form a team of 5 experienced mangrove restorers and fishers (3 females and 2 males) which assisted me in identifying potential research participants as per set criteria, and adjusting the proposed participants from 40 to 26 (i.e. 8 elders, 6 fishers and 12⁷ mangrove restorers, whom they believed that had clear knowledge as per criterion 2 (see 4.3).

The number of research participants was thus narrowed down from the originally anticipated 40 to 26, though the latter figure would sometimes increase during Focus Group Discussions (FGD's), as there was a need to allow village administrators and other experienced fishers to participate in some discussions, depending on the locations of such meetings. Working with such a strategic sample (less than 40) was useful for accessing in-depth data given the intensity of the study. In total, following the focus group interviews where additional participants joined the process, and the experiential learning intervention workshop; a total of 37 people participated in the study, as shown in summary in Table 4.1 below. See also Table 4.4 where the data indexing codes allocated to these participants is indicated.

Table 4.1: Research Participants involved in the study (summary per sub-site)

Research activity	Moa (South) ⁸	Moa (North)	Boma -Subutuni	Boma-Kichakamiba
In-depth interviews: Mangroves	5 restorers (3 males, 2 females)	4 restorers (3 females, 1 male)	1 restorer (male)	2 restorers (males)
In-depth interviews: fishers ⁹	3 (males)	3 (males)	-	-
In-depth interviews: Elders	4 (males)	2 (males)	2 (males)	-

⁷ The actual number of mangrove restorers and fishers was 10 and 4 respectively, but there were two participants who had specialised in both fishing and mangrove restoration. These were interviewed twice hence bringing the total responses to 12 mangrove restorers and 6 fishers (see description of table 8.8.1)

⁸ Moa South & North have a wider coverage of coastal mangrove strip than other sub-sites, besides the set participant selection criteria, the two sub-sites required more representations in the research process.

⁹ Selection of research participants was based on the criteria specified in section 4.4.

Focus group discussions (in addition to those included above) ¹⁰	4 (3 males,1 female)	1 (male)	3 (males)	3 (2males,1 female)
Experiential Learning Cycle-mangroves ¹¹	5 learners (3 males, 2 females)	3 learners (2 males, 1 female)	-	-
Experiential Learning Cycle-fishers ¹²	2 learners (males)	1 learner (male)	-	-
Experiential Learning Intervention workshop ¹³	12	10	6	4

4.5 Data generation and research methods

4.5.1 Process of data generation

The process of data generation was divided into four main phases (see further description of these in section 4.5.2 below), each aiming at collecting specific kinds of data that would eventually contribute to the research goal. In a critical realist perspective, data are not simply seen as texts to be interpreted, or as mere constructions of research participants, but “as evidence for real phenomena and processes (including mental phenomena and processes) that are not available for direct observation” (Maxwell, 2012, p. 103). The collection or generation of data started at the *empirical* domain; this stratified layer of ontology provided a starting point to approach the domains of the *actual* and the *real* (see section 3.3). Justification for starting at the empirical level is given by Byrne & Ragin (2009, p.75) and Gerring (2007, p. 41) as “being the most apparent domain to us and the one where our senses inform us about what is going on”.

¹⁰ The study used focus group discussions as a means of verification hence all those who were involved at individual in-depth interview level participated in the focus groups also (see section 4.5.3.2)

¹¹ This involved some participants who had participated earlier in in-depth interviews (most of them from Moa south & north (see more details in section 4.5.2.2 and chapter 6).

¹² Fishing activities in the study area are carried out by male fishers.

¹³ 2 local marine scientists and 2 local leaders joined the facilitator (researcher) making a total number of workshop participants to 37.

The study was carried out in a typical open mangrove and fisheries environment which allowed research participants to abstract, conceptualise, and represent traditional ecological knowledge at agreed times, sites, and platforms or mediums. ‘Representation’ as presented in the first chapter (see sections 1.7.2 and 1.7.4), refers to giving ‘descriptions’ of ideas, knowledge, or experiences about the research phenomena. Bhaskar affirms that “descriptions” help critical realist researchers to understand the social world (1986, p. 72), and are therefore an “integral part” of critical realism.

4.5.2 A phased approach to data generation

The study was designed in four phases; in each phase there were processes of data generation. Preliminary analysis was also necessary between phases. The overall study design and the data generation processes are provided below, with a more detailed discussion on the actual use of the data generation methods and analytical processes following.

4.5.2.1 Phase 1: Capturing of ecological knowledge and experiences using abstraction, conceptualisation and representation

This phase focused on capturing data that resulted from processes of abstraction, conceptualisation, and representation among selected mangrove restorers and fishers. In this phase, two open-ended interview questionnaires, one for fishers and another for mangrove restorers (see section 4.5.3) were prepared and employed in guiding individual abstractions and conceptualisations, and eventually leading the research participants in representing what they knew about the mangrove ecosystem and fisheries that use mangroves as key habitat, shelter, and feeding ground. Open-ended interview questionnaires were preferred in this particular phase because they are useful in probing people’s experiences (Wilkinson, 2000). The interviews for mangrove restorers (see Appendix 4) captured representations on:

- Condition of mangrove resources (health status as physically perceived)
- Trends of mangrove resources (over a specified period of time)
- Threats to mangrove resources (synchronic and diachronic experience)

- Changes observed in the mangrove resources (observable and unobservable and mechanisms that generate them)

The interview for mangrove-fishers (see Appendix 5) captured representations on:

- Condition of fisheries that use mangroves as habitat (as physically perceived)
- Dynamics of mangrove based-fisheries (over a specified period of time)
- Threats to mangrove based fisheries (synchronic and diachronic experiences)
- Changes in quantity and quality of mangrove-based fisheries (observable and unobservable and mechanisms that generate them)

Captured representations are reflected in appendices 3, 9, 10 and 11, and discussed in chapters 5, and 7. As stated in section 4.5.3 below, individual interviews for fishers and mangrove restorers culminated in focus group discussions on grounds that are given in the same section.

4.5.2.2 Phase 2: Verification of ecological experiences using Experiential Learning

The second phase of the study was primarily aimed at yielding experiential learning insights from photographic pictures that contained images of mangrove and fisheries species, taken by research participants themselves in the same environment where previous in-depth interviews had been carried out with them. The purpose here, was to first analyse the manner in which the processes of *abstraction* and *conceptualisation* mobilised representation of TEK, and secondly, to verify whether the descriptions that were made earlier using real physical objects of mangroves and fisheries (antitype) varied from those that were made using photographic images (type). Details of the verification and comparative processes are presented in chapter 6 of this study.

4.5.2.3 Phase 3: Investigating historical background of the mangrove and fisheries ecosystems

Investigation of the historical background of the mangrove and fisheries ecosystem as originally planned, sought to involve 8 local elders - 2 from Moa North, 2 from Moa South, 2 from Boma-Kichakamiba, and 2 from Boma-Subutuni. The real situation on the ground favoured 2 elders per sub-site as previously envisaged; with the exception of Boma-

Subutuni which did not have elders who could meet the study criteria (see Table 4.1). Given the availability of more knowledgeable elders in Moa South, and dwelling in the physical reality that all the above ecological sites lie in a single coastal strip with no significant varying ecological nature and characteristics, the team that assisted the researcher to identify potential research participants (see section 4.4) recommended that 2 more elders from Moa South should be added to the research participants.

Formal *individual* in-depth interviews with the selected elders were carried out using an open-ended interview questionnaire to allow capturing of in-depth historical ecological data from the identified sources. The interviews for local elders captured in-depth historical representations of fisheries and mangrove parameters that are presented in section 5.2.9, and also in sections 5.6, 5.2.6.1, and 5.2.6.2). These helped me (as a facilitator and researcher) and other research participants, to understand the trends, condition, threats, and changes that had occurred in the mangrove ecosystem, which are necessary parameters in participatory monitoring of coastal and marine resources (see Wagner et al., 2001), particularly mangroves and fisheries. Moreover, input from the elders also helped me to compile a list of attributes / indicators from different representations (see section 5.2.10), which served as an input for phase (see 4.5.2.4 below).

Data that reflect the investigation of the historical background of the mangrove and fisheries ecosystems are reflected in the all three field-based chapters (5, 6, and 7), since local elders who are a key source of the said data have knowledge and experiences that expands beyond that of other research participants from an historical experiential perspective, as most of these had witnessed and experienced the conditions, threats, trends, and changes of the mangroves ecosystem for more than 30 years.

4.5.2.4 Phase 4: Integrating TEK indicators with scientific indicators

This stage brought together representatives from the three research groups (mangrove restorers, fishers, and elders) from the study area. An arrangement was also made to secure the attendance of scientists from the mangrove regional and local offices, since the event aimed at integrating a new set of TEK indicators with the existing framework of scientific indicators (see section 1.2).

The integration process was preceded by verification of the draft TEK- framework by the research participants (at the end of phase 3), which allowed them to interact with the researcher and confirm that the information contained in the new framework was accurately derived from the data and not from researcher's own perspectives. Both the new and old frameworks of indicators were discussed further in a two day Experiential Learning Intervention Workshop (see section 4.5.3.8), and mirrored thoroughly to retain only meaningful attributes or indicators. In other words, this workshop was regarded as an important 'filter' where mangrove restorers, fishers, elders, and local scientists would resolve, re-describe, retroduce, eliminate, identify, and correct both frameworks (beginning with the scientific framework). As explained earlier in sections 3.3 and applied in chapter 7 the RRREI(C) process was used to produce an integrated set of indicators that may potentially be less reified, congruent to users, and addressing social-cultural challenges (see section 1.5).

The scientific framework was analysed first in the Experiential Learning Intervention Workshop because it contained more contextual, social, and cultural challenges than the latter (see section 1.4.1). It should also be noted that the latter (TEK framework) had already been verified as explained earlier in this section, and it only required input from invited local scientists and additional input from other participants who were participating in the experiential learning intervention workshop for the first time. Lastly, the new TEK framework was to be used as 'underlabourer' for the existing scientific framework (see section 1.6.1). Therefore, it was necessary to first revisit the existing framework for gaps that would require input from the latter (TEK). This process was based on a critical realist principle which states that knowledge at a "new level" may lead to a revision, correction or modification of knowledge at a "previous level" (Bhaskar, 2008, p. 181). At the end of the session, a new set of less reified indicators was suggested and tested in the field, followed by discussions on the usefulness of the 'new integrated framework'. Feedback from the indicator testing exercise necessitated incorporation of some equipment such as tape measures and weighing scales to assist in establishing the exact size and weight of monitored objects (see section 7.4.6).

Further details on how data was generated in this process framework are provided below.

4.5.3 Research Instruments and methods

4.5.3.1 Interviews

As explained earlier in sections 4.2, 4.4, and 4.5.2.1, processes of abstraction, conceptualisation and representation of TEK occurred through the medium of in-depth interviews with individual fishers, mangrove restorers and elders. These interviews were carried out using three (3) open-ended interview questionnaires (one per each group of participants; namely mangrove restorers, fishers, and local elders). Two of these interview questionnaires were employed in Phase 1 (see section 4.5.2.1) and the remaining questionnaire was used in Phase 3 (see 4.5.2.3). The interview questionnaire for mangrove restorers captured representations that depicted traditional ecological experiences in mangrove ecosystems; the interview questionnaire for fishers captured representations that reflected traditional fishing knowledge or experiences; and the interview questionnaire for elders captured representations that depicted both traditional understandings of mangrove ecosystems and mangrove-based fishing.

Open-ended interview questionnaires are very useful when conducting in-depth interviews since they allow capturing of in-depth information (Boyce & Neale, 2006). Interviews with individual fishers were carried out near fish landing sites (when fishers are back from fishing, that is, between 10 am and 1.00 pm, and when there are enough fish in the landing sites) to allow them to choose at least three kinds of mangrove-based fisheries as visible objects for abstraction, conceptualisation, and representation.

Interviews with individual mangrove restorers were held near or in the open mangrove ecosystem depending on the tide level and the ability of individual participants (elderly inclusive) to cross muddy areas to the desired positions where they could clearly see or touch mangrove species while they continued to describe them. Participants were thus free to choose forest patches, species, and any other features in the mangrove ecosystem which they believed could assist them in describing what they intended to communicate to the researcher.

Interviews with the local elders were held in their home-compounds or near mangrove areas depending on age advancement, physical well-being, and preferences. Having confirmed their participation in in-depth interviews at agreed times and within the agreed topic, some elders would arrange for mangrove leaves to be brought to them from nearby mangrove sites; and would use these in describing mangrove ecology.



Plate 4.1: Participant 8EBKII representing TEK on mangrove species (*Mpia-Sonneratia alba* and *Mkomafi - Xylocarpus granatum*) at Boma-Kichakamiba in January 2012.

In-depth interviews with individual research participants in all three groups (6 fishers, 12 mangrove restorers, and 8 elders) culminated in 4 focus group discussions held at Boma and Moa respectively. Details about the focus group meetings are presented below in section 4.5.3.2.

4.5.3.2 Focus group interviews

Focus groups were employed in this study as a verification method, since Berkes (2008, p. 207) argues that individual knowledge or experience tends to be distinct, but “is enriched by the “knowledge of the group”, and is “shaped by the ways of knowing of the group”. Wilkinson (2000) recommends that a group of 7 to 10 individuals should sit in a guided focus group discussion, and cautions that beyond 12 participants the group tends to fragment. Focus group inquiry was also considered useful in this context since it allows researchers to probe, it places research participants in natural or real situations, it can be easily

understood and has useful results (high face validity), it provides speedy results, and it follows socially oriented procedures (Krueger, 2000). Moreover, the method allows the researcher to gain information on how people think, perceive, give ideas, and share experiences (Wilkinson, 2000).

The focus group interviews were guided by a set of questions which sought to verify representations that had been made at the individual interview stage. Questionnaires for the focus groups contained questions that were directly connected to what had been probed earlier during in-depth interviews for the purposes of enriching individual representations, on grounds that are presented in the beginning of this section.

A total of four focus groups meetings were held in the study area between phase 1 and phase 3. The first focus group was arranged for mangrove restorers in early January, 2012 at Moa (see plate 4.2 below). As stated above, this was intended to enrich representations that had been made at an earlier stage (i.e. individual in-depth interviews), and was attended by 13 participants (see appendix 17; see also appendix 7 for questions that guided the session). This expanded and enriched the understanding of mangrove ecosystem in terms of trends, conditions, threats, and changes, and ecological attributes or indicators (see appendix 3, section A).

The second focus group was held in mid-January 2012 at Boma-Subutuni, bringing together 9 mangrove restorers from the area and in the nearby sub-site (Boma-Kichakamiba). This also yielded a shared understanding of the mangrove ecosystem and socio-ecological and economic interactions that are necessary for experiential learning (see appendix 3, section A, and was also guided by appendix 7).



Plate 4.2: Mangrove restorers' focus group session at Moa in January, 2012. Participant 5MMNFG is seen in the middle making a contribution while gesturing.



Plate 4.3: Mangrove restorers' focus group session at Boma-Subutuni in January 2012.

The third focus group was held at Moa in early March, 2012 (see plate 4.3 below). This brought together fishers from the study area plus a few retired fishers (also referred to in

this study as elders). This focus group yielded, expanded, and enriched knowledge about fish dynamics, interactions, species relations, knowledge transmission, trends, threats and causal mechanisms that generate such events in the mangrove ecosystem. (See appendix 3, section B, chapter 5 and appendix 8).



Plate 4.4: On-going fishers' focus group session at Moa in March 2012 .

The fourth and last focus group was held at Moa at the end of March 2012, and was attended by 8 elders, most of whom took part in in-depth interviews. This session verified representations that reflected historical events and processes that occur in the mangrove ecosystem involving fisheries and mangrove species. It was also used as a space for verification of traditional ecological attributes / indicators that appear in chapter 5, and appendix 3, sections A and B.



Plate 4.5: Elders' focus group session at Moa in March, 2012 (source: field data).

4.5.3.3 The use of audio-visual methods to complement interviews and focus groups

The process of data collection in both interviews and focus group discussions was audio and video recorded, and supplemented by photographs of research events (using a still camera). Audio-visual methods (video-recording, photograph taking, and audio recording) were employed in the study to compliment individual in-depth interviews and focus group discussions. Informed consent was secured from research participants to use the said audio-visual methods, and I explained to fishers, mangrove restorers, and elders that recording would also capture sound and images of participants. This procedure was done to avoid ethical tensions (Mitchell, 2011) and maintain the trust that had been established from the beginning of the study. I explained to the participants several advantages of using such methods - including record keeping of the traditional ecological knowledge that would emerge from the study, assisting me as a facilitator to observe recorded research events and avoid mistakes, errors, and unnecessary repetitions as the study would be proceeding, help me to identify details that required more clarification, and allow me to integrate data with associated participants' thoughts (Henry & Feters, 2012). A research assistant was commissioned to assist me in video-recording activities, taking photographs, and assisting in meetings and transport logistics.

4.5.3.4 Using audio-visual methods in experiential learning in Phase 2

As explained earlier in section 4.5.2.2 (see also section 6.1), and as indicated in Table 4.1, this study engaged 5 mangrove restorers and 3 fishers (identified as learners) in photograph taking as a new practice in the experiential learning cycle (see learning stages in chapter 6). This was carried out to understand how processes of *abstraction* and *conceptualisation* mobilised the representation of traditional ecological knowledge, and also to verify whether learning experiences in the first moment of abstraction (in-depth interviews and focus groups) varied from those in the second moment of abstraction (participatory photograph taking).

Crawford (2012) for example, observes that using visual methods like photographic images can enhance qualitative research by providing different ways of accessing participants' experiences. A photograph offers a "self-evident relationship" between itself and what it shows (Kuhn, 1996, p. 474), and its meaning depends on the ways that participants interpret it rather than some inherent property of the image itself (Mitchell, 2011). The method involves fewer 'ethical tensions' as compared to other methods, especially when the focus is on photographing objects like mangroves and fisheries, (as is the case in this study) as opposed to 'people' in issues surrounding informed consent (Mitchell, 2011).

4.5.3.5 Image taking basics

Packard (2008) observes that with widespread access to cameras amongst the general public there may not be a need for the researcher to conduct basic training on how to operate the device. Nevertheless, Mitchell (2011) clarifies that access to use of a camera is wide in the developed world which may not be the case in developing countries. Based on the latter advice, a brief session was organised with eight participants on how to operate and handle digital cameras. Five participants were specialized in mangrove restoration, two were practicing both mangrove restoration and fisheries¹⁴ (their representations cover both

¹⁴ The term 'fisheries' is more inclusive than 'fish' or fishes. It includes oysters, mussels, sea-squirts, floating animals ranging from microscopic to large fish jelly, crustaceans, amphibians, and many other species.

areas), and one was involved in mangrove-based fishing. Details about the types of images captured in the new practice are presented in section 4.5.3.5 below.

4.5.3.6 Selecting 'objects' for representation and setting image taking time

Mangrove restorers were free to choose any mangrove species of their choice (out of the eight species that grow in the study area), and fishers were also advised to opt for any mangrove-based fish species as 'objects' for representation, without being influenced by colleagues, the researcher, any individual, or social groups who happened to be on the scene during image taking. Mangrove restorers opted to take photographic images at low tides (when they could freely walk in the mangrove forest), while fishers opted for times that most fishers return from fishing; when fish-landing sites or local storage stations have a variety of fish species which are good for experiential learning purposes (see section 6.5). Mitchel (2011), describes participatory photograph taking as the first stage of analysis (which precedes a debriefing session), and it may involve asking questions like which photos are the most visually interesting, which ones depict the real situation, and any other questions depending on the research theme and focus.

In this study, five main questions were put forward:

1. What image (s) did the participant take?
2. Where was the image taken from?
3. Why did the participant opt for particular image(s)?
4. What physical condition or health status did the images depict?
5. How did they experience the new practice?

4.5.3.7 Actual image taking

The actual process began with mangrove restorers taking still images of mangrove species one after another, using a digital camera, in a guided group workshop, followed by fishers. As explained in section 4.5.3.5, each of the involved learners were free to walk around the forest or a fish-landing site and take an image of any species (which they thought had some significance, or any status that they would wish to share with other learners as per the guiding questions specified in section 4.5.3.5 above). All captured images (5 for mangroves

species and 3 for fish species) were printed in a 5 x 7 size and used the following day to facilitate individual representations.

Learners were thus asked to meet in the general group session and report what they had captured, and how each one experienced the new practice (beginning with mangrove restorers in the morning session). The afternoon session was spent for fishers (also taking the same process). Different reactions or emotions that emerged from this stage (concrete experience) and other stages of the learning cycle are presented in chapter 6, sections 6.4 to 6.7). Learners' representations were audio and video-recorded. These recordings were useful in capturing specific events that the researcher might have missed or not seen as the enquiry process went on (Crawford, 2012; Henry & Feters, 2012). These were afterwards transcribed and coded descriptively (describing emerging themes to the level that would allow them to be further analysed); topically (assigning emerging themes under specific topics or sub-topics) and analytically (recontextualising initial analyses of captured representations, to make them useful for sub-subsequent levels or layers of analysis). Transcribed Individual representations and photographs taken during the practice were comparatively analysed (see each learning stage of the cycle in chapter 6), to capture emerging links or contrasts based on the meanings that learners had attached to them (Mitchell, 2011). These were later used as input(s) for different stages of the cycle.

4.5.3.8 Field-based observations and visitations

The research also involved a number of field visits in which I observed the participation of the fishers and mangrove restorers in coastal monitoring and management activities. Observation, according to Fox (1998) and Kawulich (2005) is a useful research method which helps researchers to capture events, processes, and understand what is going on in the study settings. It also helps them to observe what they might not have observed in other phases of the study and know immediate needs or requirements that may seek ethical attention, reflexivity, or realisation of data that have the potential to complement what has already been covered.

As a researcher, I made an arrangement to live close to the study area (see figures 4.1 & 4.2 and also section 4.3) from December, 2011 to May, 2012. This helped me to visit the study site and sub-sites four to five times per week - meeting mangrove restorers, fishers, elders, and sometimes locality leaders in both adhoc and planned sessions. Initial dates were spent for contextual profiling, identification of study participants, and testing of questionnaires (see Table 4.2 below). The actual data generation stage began in January 2012, and at this level I organised and facilitated in-depth interviews and focus group meetings to verify what had been captured at the former level.

I returned to the study area for two more months (November and December 2012) for purposes of discussing and improving a framework of traditional ecological knowledge that had been developed through processes of abstraction (see sections 5.2.10.1-4 and 7.1) and facilitating the Experiential Learning Intervention Workshop (see sections 4.5.3.8 above).

It is important to note that some research activities which were primarily arranged to take place in particular phases were moved to other times across phases depending on the availability of research participants. This was either caused by religious ceremonial activities, deaths (as was the case in Boma-Subutuni and Boma-Kichakamiba), or illness. From this situation, this study does not provide ending dates for each of the study phases as this may suggest irregularity across research phases.

Table 4.2 Observations and field visits undertaken in this research

Study Phase	Number of visits and timing of observations	Purpose of visitation/observations
Phase 1: Capturing of ecological knowledge and experiences using processes of abstraction, conceptualisation and representation	30 visits to the study site and sub-sites as per details given in section 4.5.3.7.	Contextual profiling, Identification of research participants, questionnaire testing, In-depth interviews, focus group discussions for mangrove restorers and fishers
Phase 2: Verification of ecological experiences using Experiential Learning.	20 visits to the study area, specifically Moa-South & North; (see Table 4.1 for number of involved individuals)	To provide orientation to the experiential learning participants as per sections 4.5.3.4, 4.5.3.5, and 4.5.3.6. To work with participants to reflect on captured photographic images and to engage them in various stages of the experiential learning cycle.
Phase 3: Investigating historical background of mangroves and fisheries	22 visits to 3 sub-sites (Moa north, Moa south and Boma Subutuni were made. Boma- Kichakamiba was not visited for the same as there were no elders who met the set criteria see section 4.5.2.3 and also section 4.4)	To organise and facilitate in-depth interviews with selected elders and one focus group meeting held at Moa-South as a central meeting point (see sections 4.5.3.1 and 4.5.3.2 respectively).
Phase 4: Integrating Traditional Ecological Indicators with scientific indicators.	20 visits; most of these to Moa-South (where preparations for the ELIW were being made (see section 4.5.3.8), followed by the actual 2 day workshop which included indicator testing.	Discussing and improving TEK framework (see sections 5.2.10.1-4 and 7.1) & facilitating the ELIW (see sections 4.5.3.8)

4.5.3.9 Experiential Learning Intervention Workshop

Workshops are often used as an opportunity to generate data in research (Krishnaswamy 2004). They differ from focus group discussions in that they are more interactive, over a longer period of time; and they often follow a structured or semi-structured programme of interaction. In expansive learning research for example, Engeström (2001) and others such as Virkkunen & Ahonen (2011) have developed a sophisticated workshop methodology

called the 'Change Laboratory Workshop' which engages participants in a mutual learning process in order to expand their learning and practice. In this research I did not use the exact procedures that Engeström (2001) uses in Change Laboratory Workshops, but I drew on the manner in which he proposes that data generated from previous fieldwork, can be 'shared back' or mirrored back to research participants and made available for further dialogue and discussion.

Another aspect of the Engeström Change Laboratory Workshop methodology that I adopted was the concept of an 'intervention' workshop i.e. the workshop was established with the specific purpose of furthering collective learning via the sharing and discussion of research data previously generated in and through a field-based research process with research participants and other stakeholders. In such workshops, the researcher acts as an 'intervention researcher' (Mukute, 2010), and through sharing the data generated earlier in the research process, helps to structure the workshop engagement through a carefully structured workshop programme, as was the case in this research. Instead of using the processes of 'modelling solutions' that Engeström uses in his Change Laboratory Workshops, however, I worked with the RRREI(C) scientific explanatory framework from critical realism; (see section 3.3) to explore the relationships between the western scientific indicators that already existed in the study area (as explained in section 1.3) and the TEK-based indicators that had emerged in and through the abstractions and representations and the experiential learning process in Phases 1, 2 and 3 of the research. The experiential learning intervention workshop however, was also needed to consolidate and refine these emergent TEK indicators.

As indicated in section 4.5.3.8 above, the Experiential Learning Intervention Workshop (ELIW) was used in Phase 4 of the research as a platform for discussing and analysing the two frameworks of indicators according to the order of the RRREI(C) (see section 7.1 & appendix 14), in order to reduce 'complexity' that surrounds their systemic nature and pave the way towards knowledge integration (see Tables 7.1 & 7.2). Having a framework of indicators that is congruent to users, and which addresses contextual, socio-cultural, and ecological realities would steer comprehension among mangrove restorers and fishers and

stimulate experiential learning practices, rather than using adopted scientific frameworks of indicators which have previously indicated limitations in stimulating and mobilising social learning in the eastern coastal area of Tanzania (see sections 1.3.3 and 1.4; also KICAMP, 2004).

The two frameworks of indicators were used as ‘mirror data’ in the workshop, whereby the attributes or indicators that form them were to be analysed to reduce tensions and contradictions or challenges that might limit their potential to stimulate experiential learning practices and praxis in the eastern coast of Tanzania, as discussed earlier in sections 1.3 and 1.4. The desired criteria or rules for this particular activity system was to ensure that the components that form the two frameworks were clear to research participants and could be applied by non-specialists in the process of detecting changes, trends, threats, and conditions of mangroves and fisheries resources.

As a researcher and facilitator, I convened and facilitated a two day experiential Learning Intervention Workshop as indicated in Table 4.2, for a total of 37 participants (32 mangrove restorers and fishers, 2 local scientists, 2 local leaders, and myself). The workshop was held at Moa-South (in the last phase of the study) for reasons that are specified in section 4.3 (i.e. being in a central position and having a wider coverage of the coastal strip).

The Experiential Learning Intervention Workshop was planned to incorporate four main sessions. The first session (8.00 am – 9.00 am) focussed on assessing the level of familiarity and comprehension of attributes that constituted the framework of scientific indicators for monitoring mangrove species and mangrove-based fisheries respectively. As a facilitator, I listed on a board the attributes / indicators that constituted the scientific framework (see section 7.4.3.1); and thereafter I asked the participants (especially those who had been involved in participatory monitoring from the early 1990’s i.e. 20 people) to raise their hands if they were familiar with any of the attributes that I pointed at. Those who raised their hands were noted and asked to share their experiences, followed by those who did not. This created a space for workshop participants to explain how the scientific framework

of indicators which had been in use from the early 1990's was familiar to them or not familiar.

Two participants out of the 20¹⁵ reported that they understood the attributes / components of the scientific framework for monitoring mangroves; 5 said they partially understood them, and 13 said they did not understand the components. In terms of capacity to apply the framework, 2 participants reported that they were able to apply it, 8 said they could partially apply it, and 10 said they could not apply the framework. As for the scientific framework for monitoring fisheries, 9 participants out of 20 reported that they understood it and could apply the framework; 3 said they could partially apply it, and 8 reported that they could not apply the framework. These responses suggested that the scientific framework for monitoring fisheries was more familiar and useable by its intended users compared to the mangrove framework. By identifying the attributes or indicators that constituted the scientific framework; workshop participants had basically engaged themselves in the 'resolution' stage of the RRREI(C) model (see appendix 14). According to Bhaskar (2010), this stage involves identification or resolution of the component parts that form a systemic phenomenon which the participants seek to uncover in a particular context.

The second session (9.00 am – 10.30 am) was spent in identifying and linking the methods and techniques that are proposed in the scientific monitoring plan, with the attributes or indicators identified during the first session. This session was intended to make the participants understand the connection between the indicators / attributes and methods, so that they could afterwards be able to make contributions to the new monitoring framework. This level covered the second component of the RRREI(C) model i.e. re-description stage (discussing or analysing the attributes by either contrasting them or relating them at a deeper level to discover emergences or outcomes- Bhaskar, 2010); see sections 7.4.3.1 and 7.4.3.3.

¹⁵ Total participants were 37 but individuals who had participated earlier in the monitoring practices using the scientific framework of indicators were 20.

The third session (10.45 am – 1 .00 pm) was an extension of the second session but this time with a focus on in-depth discussions and descriptions of the attributes / indicators and methods that constituted the scientific framework, with explanatory and descriptive support from invited local marine scientists. This also paved the way for the remaining processes of the RRREI(C) - retroduction, elimination, and corrections to be made (see sections 7.6,7.7,7.8 and 7.9).

This was followed by a discussion of the traditional ecological knowledge framework (2.00 pm – 3.00 pm), which contained attributes/indicators that had previously been discussed in the focus group sessions, but which had to be further refined through the experiential learning intervention workshop. Input from this session is reflected in sections 7.4.3.2 and 7.4.3.4.

The afternoon session (3.15 pm - 5.00 pm) was used to integrate the two frameworks based on the needs and requirements identified during the second and third sessions. The next day was spent testing of the new framework, and having a feedback session on the testing exercise (which affirmed that the integrated framework was congruent to the research participants). As indicated in chapter 6, this latter session was also the culmination of the experiential learning process described in chapter 6. It was from the above workshop sessions that the details that are presented in sections 7.5 - 7.9 were analytically discussed, leading to the congruent framework of indicators which appear in Tables 7.1 and 7.2.



Plate 4.6: Some of the invited participants waiting for the Experiential Learning Intervention Workshop to start (at Moa) as per section 4.5.3.8 above.

4.5.3.10 Summary of data generated

As can be seen from the above descriptions the study generated a corpus of data; most of which was qualitative, within a phased process of data generation. For ease of reference, I summarise the full data corpus below in Table 4.1, whereafter I discuss the data processing and analysis in section 4.6 below.

Table 4.3: Summary of data generated across the phases of the study; also showing the main moments of data analysis.

Phase of Study	Data generated	Purpose of generated data
Phase 1: Capturing of ecological knowledge and experiences using processes of abstraction, conceptualisation and representation	Social, ecological and economic roles of the mangrove ecosystem; knowledge transfer from experienced fishers to young fishers and from experienced mangrove restorers to the inexperienced; different species and how these interact in the mangrove empirical space; species relations (contingent and necessary relationships); power relations among different actors and how this affects learning; ecological concepts and processes that occur in the mangrove ecosystem; metaphors that shape ecological descriptions; how weather	To analyse the extent to which processes of abstraction, conceptualisation and representation may potentially yield necessary input for stimulating or steering social learning in the coastal environment.

	influences fish catch and interactions; historical representations of the mangrove ecosystem; and attributes and indicators that define the health status of mangroves and fisheries.	
Phase 2: Verification of ecological experiences using Experiential Learning	Naming and description of mangrove and fish species; identification of attributes that indicate the health status of mangrove-based fish species; description of species relations in the mangrove ecosystem; identification of threats (human induced and natural) that face mangrove and fish species; ecological role of mangroves; knowledge transfer across the learning stages of the experiential learning cycle; naming of ecological concepts; physical descriptions of fish and mangrove species; and descriptions of fish behaviour in the mangrove ecosystem.	To understand how processes of <i>abstraction</i> and <i>conceptualisation</i> mobilised representation of traditional ecological knowledge, and also to verify whether learning experiences in the first moment of abstraction (in-depth interviews and focus groups) varied from those in the second moment of abstraction (participatory photograph taking).
Phase 3: Investigating historical background of mangroves and fisheries.	In-depth historical data about trends, conditions, threats, and changes that had occurred in the past 30 years; descriptions of social-ecological and economic roles of mangroves; power relations over time; knowledge transfer over time, descriptions of attributes that depict the health status of fish species and mangroves; naming and description of species; and fish behaviour and dynamics.	To capture traditional ecological knowledge from the elders as a potential input for informing current experiential learning praxis in the study area.
DATA FROM PHASE 1-3 ANALYSED AND CONSOLIDATED INTO 'MIRROR DATA' FOR USE IN PHASE 4 WORKSHOP AND RRREI(C) EXPLANATORY PROCESS		
Phase 4: Integrating TEK Indicators with Scientific Indicators	Data generated from four workshop sessions: Session 1: Notes and video-data about the challenges of applying the scientific framework of indicators. Session 2: Notes and video data about the resolution stage. Session 3: Notes and video data about the re-description stage, identification, elimination and correction processes. Session 4: Notes about the congruent attributes or indicators of the two frameworks.	To ensure that the components that form the scientific and TEK frameworks are clear to research participants and can be applied by non-specialists in the process of detecting changes, trends, threats, and condition of mangroves and fisheries resources. To reduce tensions and contradictions that may limit their potential to stimulate experiential learning practices and praxis in the eastern coast of Tanzania.

4.6 Data processing and analysis

4.6.1 Index coding of data sources

4.6.1.1 Index coding of interview and focus group interview data

Data processing began with the indexing of participants to allow for systematic representation of collected data (see Table 4.4 below). Appearance of the participants' names and locations in this section was ethically consented to by all participants (see two sample copies of consent forms i.e. appendices 15 & 16; and section 4.8 below on the ethics procedures followed in the study); and it thus carries no sensitive personal details that may interfere with their socio-economic and cultural affairs. Nevertheless, the study employs participant indexing described hereafter to communicate participants' representations or accounts rather than their actual names.

The process of assigning index codes to research participants involved the inclusion of key aspects in the 'code' such as the reference number, locality of participants (village), specialisation, and the level of involvement (e.g. in-depth interview or focus group). If for example, a participant is assigned number 1, and is an elder from Boma-Kichakamiba sub-site who took part in In-depth interview, the index code will be **1EBKII**. Description of this index code is given below:

- **1**- stands for a reference number
- **E**- Elder
- **BK**-Boma- Kichakamiba.
- **II**- In-depth interviews.

If participant no.2 is a fisher from Moa (North) and was involved in focus group discussion; the code will be **2FMNFG**:

- **2**- reference number
- **F**- fisher
- **MN**- Moa (North)
- **FG**- Focus group

If a participant is practicing both fishing and mangrove restoration (see serial number 13 and 24 in Table 4.3 below), mangrove specialisation (M) is indicated first, followed by fishing (F) and the two are separated by a stroke sign as it appears in the bracket (M/F).

Table 4.4: Index Coding of research participants involved in interviews and focus group interviews

SN	Name of the participant	Locality/Site	Sex	Specialisation	Index Code	Level of involvement
1.	Nyundo O. Shime	Boma-Kichakamiba	M	Elder	1EBKII***	In-depth Interview
2.	Kijoli K. Barua	Boma-Kichakamiba	F	Mangrove restorer	2MBKII*	In-depth Interview
3.	Hassan S.Hassan	Boma-Kichakamiba	M	Fisher	3FBKFG	Focus Group Discussion
4.	Mwapondera Saidi	Boma-Subutuni	M	Fisher	4FBSFG	Focus Group Discussion
5.	Mohamedi Iddi	Boma-Subutuni	M	Mangrove restorer	5MBSFG	Focus Group Discussion
6.	Foleni Mafanya	Boma-Kichakamiba	F	Mangrove restorer	6MBKFG	Focus Group Discussion
7.	Kipitu Mussa	Boma-Kichakamiba	M	Mangrove restorer	7MBKII*	In-depth Interview
8.	Mafanya Mbaruku	Boma-Kichakamiba	M	Elder	8EBKII***	In-depth Interview
9.	Hassan I.Kitojo	Boma-Subutuni	M	Mangrove restorer	9MBSII*	In-depth Interview
10	Ali Hamdu	Boma-Subutuni	M	Fisher	10FBSFG	Focus Group Discussion
11	Sendeu Rashidi	Boma-Kichakamiba	M	Fisher	11FBKFG	Focus Group Discussion
12	Rehema Juma	Kijiru (MN)	F	Mangrove restorer	1MMNII*	In-depth Interview
13	Hamza Ali	Kijiru (MN)	M	Fisher & Mangrove R.	2M/FMNII*^	In-depth Interview
14	Fatuma Kamba	Kijiru (MN)	F	Mangrove restorer	3MMNII*	In-depth Interview
15	Saada Suleiman	Kijiru (MN)	F	Mangrove restorer	4MMNII*	In-depth Interview
16	Sheha Haji	Kijiru (MN)	M	Mangrove restorer	5MMNFG	Focus Group Discussion

17	Dole Faki	Kijiru (MN)	M	Elder	6EMNII***	In-depth in interview
18	Abdalah Kitapa	Kijiru (MN)	M	Fisher	7FMNII**	In-depth Interview
19	Bakari Kitapa	Kijiru (MN)	M	Elder	8EMNII***	In-depth Interview
20	Mbwana Mwaita	Kijiru (MN)	M	Fisher	9FMNII**	In-depth Interview
21	Mikidadi Kidombo	Moa	M	Elder	10EMII***	In-depth Interview
22	Maburuki Rajabu	Moa	M	Fisher	11FMII**	In-depth Interview
23	Halfani Mbaruku	Moa	M	Elder	12EMII***	In-depth Interview
24	Juma Khamis	Moa	M	Fisher	13M/FMII*^	In-depth Interview
25	Makata Majambo	Moa	M	Fisher	15FMFG	Focus Group Discussion
26	Rambazo A. Mohamed	Moa	M	Fisher	16FMFG	Focus Group Discussion
27	Rehema Omari	Moa	F	Mangrove restorer	17MMII*	In-depth Interview
28	Ambassa Gunda	Moa	M	Mangrove restorer	18MMFG	Focus Group Discussion
29	Zhariu M.Omari	Moa	M	Mangrove restorer	19MMII*	In-depth Interview
30	Maridhia Abasi	Moa	F	Mangrove restorer	20MMII*	In-depth Interview
31	Mbwana Ng'azi	Moa	M	Fisher	21FMFG	Focus Group Discussion
32	Hasina Massa	Moa	F	Mangrove restorer	22MMFG	Focus Group Discussion
33	Omari Mgenya	Moa	M	Elder	23EMII***	In-depth Interview
34	Mwawingu Rashidi	Moa	M	Mangrove restorer	24MMII*	In-depth Interview
35	Ambasa Gunda	Moa	M	Fisher	25FMFG	Focus Group Discussion
36	Bakari Rashidi	Moa	M	Elder	26EMII***	In-depth Interview
37	Mzee Chuba	Moa	M	Fisher	27FMII**	In-depth Interview

Source: Field data (2012)

Description of symbols used in the table:

- * 10 mangrove restorers involved in in-depth interviews
- ** 4 fishers involved in in-depth interviews
- *^ 2 participants involved in both mangrove and fishers' in-depth interviews
- *** 8 elders involved in in-depth interviews

Note: The remaining participants were involved in the study via the focus groups.

4.6.1.2 Index coding of video/audio data field-based observations and photographic field based observations of participants

This study produced a total of 27 video clips (i.e. 12 for in-depth interview data on mangroves, 6 for in-depth interview data on fisheries, 4 for focus group meetings, 1 for discussing the draft TEK framework, 2 for experiential learning practice, and 2 for the Experiential Learning Intervention workshop). Video clips which captured individual data were indexed by using participants' names, sub-sites, recording dates, and the activity name (e.g. in-depth interview - mangroves). This was done to simplify identification of research data for further analysis. On the other hand, video clips which captured group data were indexed using a similar procedure. Collected video/audio data were transcribed into text format, translated from Kiswahili to English language, coded as per section 4.6.2 below, and afterwards analysed.

The study also captured nearly 50 still photos, some of which, as specified earlier in section 4.5.3.4, were used for experiential learning purposes. Each of these were indexed as 'plates' that bear an identification number depending on the chapters they belong to, and their sequence (e.g. if it was meant to appear in chapter 2 as the first picture it was indexed as Plate 2.1), and captioned to show its link to the main text. As Mitchell (2011) puts it, photographs are self-explanatory and may easily be linked to study contexts.

Procedures and events of research activities were hand written in the diary, and field notes were often taken to compliment video and audio data. Field notes indicated dates of events, locations, involved participants, and observed issues. Issues or clarifications that were noted in the field notes were later used to supplement analysed video/audio data for clarity and focus.

4.6.1.3 Index coding of workshop data

Workshop data were captured by using the video/audio recording digital camera. These were stored in the researcher's laptop and backed up on the external drive. Coding of video data followed the same procedure as coding of focus groups or experiential learning events (see 4.6.1.2 above). Coding of workshop data was carried out by first specifying the event itself, location of the event, purpose of the event, dates, target participants, and proceedings that emerged from the event. Moreover, each session was assigned a sub-title and sections (see appendices 14 and 3).

4.6.2 Coding of data into themes and sub-themes

As indicated above in section 4.6.1.2, collected data was transcribed from audio into textual format; and later translated from Swahili to English. A coding framework was thereafter developed to allow two main processes: first, sorting and classifying data into specific categories, and secondly, identification of emerging themes or sub-themes. Three sorts of coding in qualitative research, namely, "descriptive, topic, and analytical" were employed as advised by Richards (2005, p. 88) to assist me in working through the first and second stages of coding as specified above.

Descriptive coding focused on describing emerging themes to the level that would allow them to be further analysed. This was especially helpful to make sense of data at the empirical level. Here I tried to identify for description what people said about historical experiences, trends, threats (see Table 4.3), and other matters of relevance to the context and the broad research question and interest of the study - as these related to the establishment of indicators and social learning (as described in chapter 1). This form of coding primarily used the inductive and abductive modes of inference as described in section 4.6.3 below. Some examples of the descriptive themes that I came up with from this inductive process include:

- Participants' knowledge of the mangrove ecosystem and its management
- The practices that participants were engaged in, in management of the coastal area
- Cultural and historical aspects of participants' knowledge and practices

- Social, Ecological and Economic roles of the mangrove ecosystem
- Knowledge transfer from experienced fishers to young fishers
- Different species and how these interact in the mangrove empirical space
- Species relations (contingent and necessary relationships)
- Power relations among different actors and how this affects learning
- Ecological concepts and processes that occur in the mangrove ecosystem
- Metaphors that shape ecological descriptions
- How weather influences fish catch and interactions
- Historical representations of the mangrove ecosystem; and
- Attributes and indicators that define the health status of mangroves and fisheries.

As can be seen from the above descriptive themes, these were helpful to begin to make sense of the data using an inductive approach. However, as these descriptive themes were also partially influenced by the research interests and questions, they are partially abductive, as data was being recontextualised using some of the key categories embedded in the study questions (e.g. learning processes) – see section 4.6.3 below on modes of inference used in the study.

This led to a more focussed process of **Topic coding**, in this case referred to assigning emerging themes under specific topics or sub-topics. In this study I developed the following topics and sub-topics within the coding and categorising process:

- Abstractions and Representations of coastal monitoring practices and knowledge according to threats, trends (see Table 4.3 above)
- Epistemological nature of the abstractions and representations including those from a social learning perspective
- Ontological perspectives of the abstracts and representations, including how these were seen at the empirical level, actual level and real levels of Bhaskar's 1998's stratified ontological framework. This also involved the identification of mechanisms / drivers that triggered representations.

This form of coding and analysis primarily used the inductive and abductive modes of inference as described in section 4.6.3 below.

Emerging data from individual in-depth interviews, focus groups, and the experiential learning cycle (photographic images) were captured and coded into the above-mentioned specific themes / sub-themes (as described in more detail in chapters 5 and 6). This process involved assigning participants' representations to emerging themes or sub-themes and analysing their ontological or epistemology nature, and mechanisms or drivers that triggered such representations, as per the critical realist ontological perspective.

The overall focus was to establish the potential contribution of processes of abstraction in social learning within the coastal environment; and as described above in the section on data generation, it was therefore necessary to create platforms such as Focus Group Discussions, and individual in-depth interviews (see 4.1.2 and 4.6), to allow mangrove restorers, fishers, and local elders to abstract, conceptualise, and represent Traditional Ecological Knowledge (TEK). Such representations were expected to depict not only TEK, but also the kind of social learning processes that exist in the study area as shown in the research questions in section 1.5.2.

Analytical coding focused on recontextualising initial analyses of data, to make them useful for sub-subsequent levels or layers of analysis. A good example of this was the process of specifying, categorizing, and presenting generated input(s) that depicted the health status of mangroves and fish species (see section 5.2.10:1-4); in the manner that would allow them to be easily recognised and improved further through other analytical spaces such as the RRREI(C) explanatory process analysis (see sections 7.4-7.9); or as additional input in the fourth stage of the Experiential Learning Cycle (see section 6.8).

Analytical coding in this study involved:

- Coding the data for evidence of abstraction and representation of TEK relevant to coastal monitoring practices
- Coding the data for evidence of experiential learning processes
- Coding the data for evidence of social learning

- Coding the data using the RREI(C) explanatory framework

Analytical coding in this study drew primarily on abductive and retrodictive and retroductive modes of inference, discussed in more detail below in section 4.6.3.

4.6.3 Modes of Inference (induction, retroduction, abduction, and retrodiction)

When we carry out research, we engage ourselves in different ways of thinking, reasoning, arguing, interpreting, and making sense of what we observe. This process allows researchers to realise how observed ‘particulars’ relate to ‘the general’ or vice versa; and how the realisation of the latter leads to knowledge about the former. By so doing, we engage ourselves in ‘inference making’ or generalisation, which according to Danemark et al., 2002, p. 79) is “a fundamental precondition for all knowledge and knowledge development” since reality cannot speak for itself (Sayer, 2000).

As briefly introduced in section 4.6.3 above under the sub-headings, the analysis of data in this study drew on four modes of inference as described in the critical realist research literature; namely induction, retroduction, abduction, and retrodiction (Danemark et al., 2002; Hartwig, 2007). Hartwig (2007, p. 256) explains that inference is a “cognitive process in virtue of which a conclusion is drawn from a set of premises”. The manner in which the conclusions in this research are drawn, are based on cognitive analytical processes or modes of inference. The analytical processes or modes of inference are reflected in different parts of this thesis, especially in the field based chapters (see chapters 5, 6, & 7); but they are also informed by the contextual, theoretical and methodological aspects of the study (see chapters 1, 2, 3, 4).

Induction was firstly employed in this study to imply the process of analysing data (using descriptive coding as described above), without relying too heavily on a specific theory (by describing and interpreting empirical experiences of participants as reflected in interview and observation data inductively). Secondly, it is used to imply the process of working from specific premises/observations to general premises or broader generalizations (Seale, 2005; Gilbert, 2008). However, as noted above, in social research induction is most often

accompanied by abduction, as data is recontextualised using theory and/or contextual knowledge, as was the case in this study. I explain each of these terms separately below; but in reality in the study, the use of the modes of inference were closely associated (see also Table 4.5 below). Critiques of grounded theory (which is based on inductive reasoning) (Thomas & James, 2006) have for example, shown that pure induction in social research may not be possible, as researchers always bring some form of value position, theory and/or contextual experience to the data that they draw on to make inferences.

However, processes of inductive inference making are nevertheless useful, notwithstanding the caveat above - as they allow for the development of descriptive inferences (Thomas & James, 2006), and in critical realism they allow for inferences from the data (Psillos, 2007, cited in Hartwig, 2007) that can be further analysed using other modes of ampliative inference such as abduction and/or retrodution. Ampliative inferences, according to Psillos (2007, cited in Hartwig 2007, p. 256) differ from deductive arguments (that hold that if the premise is true, the conclusion has to be true) so the “content of the conclusion exceeds the content of the premises.” He sees inductive, abductive and retroductive forms of inference as ampliative.

According to Danemark et al. (2002), inductive reasoning gives researchers an opportunity to start from what is observed and draw conclusions beyond what is known. In this study, individual accounts or representations of ecological knowledge would, for example suggest that a certain form or typology of learning was present among coastal individuals; recurrence of similar accounts in the process of data analysis would thus lead the researcher to affirm across a range of individual experiences of such processes that indeed, a particular form of ‘social learning’ is operating in the study area. In order to interpret these experiences as ‘social learning’ however, a process of abduction is necessary, as the researcher infers meaning of social learning into a recontextualisation of the data to provide an explanation, based on the best available theoretical or contextual / experiential knowledge of social learning.

Inductive inference was also used to confirm the existing relations between mangroves and fish species; as either *contingent* or *necessary*, due to the recurrence of representations that

suggested such connections. Many mangrove restorers indicated that most of fish species relied on mangroves for their survival. This finally convinced me, as researcher, to conclude that there were substantial relations for some species; and formal relations for others. I was also able to use this kind of reasoning to suggest the existence of power relations between individuals and existing local or central authorities (see section 5.25); knowledge transfer from experienced fishers to the in-experienced (see section 5.2.2); and the influence of weather in fish catch and interactions (see section 5.28). Inductive modes of inference were also used to affirm that processes of abstractions had the potential to produce knowledge that is necessary for enhancing social learning in the coastal environment (see chapter 8.2.2). According to Psillos (cited in Hartwig, 2007. p. 257) who discusses inference making in critical realist research

The distinctive view of Critical Realism ... is that the justification of induction is largely a posteriori matter and depends on the causal structure of the world. In particular, inductive inferences are justified when there are generative mechanisms that connect particulars in virtue of their causal powers.

Abduction, as noted by Psillos (*ibid.*) is another “much discussed” mode of ampliative inference, and is a form of inference which seeks to make inferences to the best explanation. This involves selecting from a range of explanatory possibilities to identify the ‘best explanation’ in terms of its explanatory quality. For example, one may interpret learning interactions in different ways, but the best explanation for such learning interactions or processes may be social learning (as opposed to behavioural forms of learning for example). According to Danemark et al. (2002), abduction is our way of reasoning, thinking, and arguing in a wider sense, to the level that allows us to re-contextualise and re-describe our data; making inferences to the best explanation (this may be either theoretical or contextual or experiential, or a combination of all three). It is believed to be a concept that is difficult to realise or capture (*ibid.*) when compared to other modes of inference, because it is partly transfactual. It is also described by Danemark et al. (2002) as one of the most normal processes in social research, although it not often recognised as such. Through the process of abduction, researchers re-contextualise and re-interpret “something’ as something else”; and therefore understanding it in a different context according to the best available explanation of the phenomenon (Danemark et al.,

2002, p. 98) In this study, several accounts connect individuals' behaviour of clearing mangrove species to individual arrogance or the need to access quick gains (see chapters 5 and 6). While an inductive form of inference may affirm such observations, a transfactual or abductive form of inference would move further to consider the problem as (for example) having a connection with power relations, rather than arrogance or economic gains. This is one way through which abduction was worked with in the study.

Transfactual reasoning may also be depicted in chapter 8 (see the general findings) when this study links existing challenges of using scientific indicators to causal factors that go beyond what is currently being seen and assumed to be the reality. While existing evidence (KICAMP, 2004) cites the problem of reification as the cause (see chapter 1), the transfactual explanation suggests lack of historicising and contextualising as the source of identified challenges. This implies that historicising and contextualising may potentially capture a wider range of necessary requirements in the educational or learning context; and guide involved facilitators to introduce learning programmes that reflect historical and contextual realities in their attempts at working with indicators, to enable social learning and changes in practice. It may also be argued that working with two forms of knowledge (scientific and traditional) as is indicated in sections 4.5.3.8 and 7.1, require some form of transfactual moves across two different disciplines - which is also an element of abduction.

Retroduction is also a form of ampliative mode of inference, and is a transfactual mode of inference which entails explaining events that are depicted in the participants' representations, by postulating and identifying the kinds of "mechanisms that are capable of producing them" (Sayer, 1992, p. 107). This mode of inference in the study allowed me to identify some of the causal powers that generate the events that were apparent in the empirical domain as 'experiences', and which were partially responsible for generating different typologies of social learning (see chapter 5). This mode of inference also allowed me to identify enabling conditions (such as resources, capacities, and contextual aspects) as key mechanisms that enable individuals and social groups in the coastal environment to exercise their powers improving the integrity of mangrove ecosystem-fisheries inclusively (see chapters 5 and 6). These are essentially retroductive transcendental arguments, which, as explained by Bhaskar (cited in Psillos, *ibid.*) are arguments in which the premises of some

human activity or human agency in a context (e.g. mangrove restoration practices) embody some “categorical necessity” which the analysis brings to light.

Another ampliative mode of inference that was used in this study is retrodiction. This is basically a process of referring present realities to past explanations (see 7.4.3) and helps us to understand how known causes may trigger or interact with each other and eventually give rise to ‘concrete phenomena’ (Hartwig, 2007, p. 196). Several representations in this study explained the present status of mangrove resources by making references to the past. For example, the restoration of mangrove species that is currently being practiced in the study area (as a present phenomenon) was linked to previous practices of mangrove clearance for economic gains, such as charcoal burning and salt-pans making. Existing structures for experiential learning practices in the mangrove ecosystems are also connected to past events (see chapter 5, 6 and 7) that are linked by causal mechanisms such as poor economic conditions, low education levels due to lack of schooling opportunities amongst the community members in their youth, and few alternatives for coastal fishers and mangrove restorers (amongst others). Retrodiction, as explained by Psillos (ibid.) is essentially a process of “... making inferences from effects to causes or from later to earlier states of systems via retroduced explanatory structures”. He gives the example of when a doctor infers from a symptom in a patient that one of the generative mechanisms involved is an influenza virus (ibid.).

Retrodiction was also used in this research to make inferences into processes involved in the experiential learning cycle (described in chapter 6) when, for example, some learners who are experiencing a new practice of photograph taking (as a present reality), associate emerging challenges to ‘past learning approaches’ (which tended to exclude participatory photography taking). The inability of research participants to use the scientific framework of indicators (as a present reality) is explained by referring it to the ‘past’ (1990’s) when the framework was introduced to them.

Table 4.5: Summative view of the analysis of the study phenomena across chapters

SN	Chapter	Depicted analysis
1	5: Potential contribution of processes of abstraction to social learning. Modes of inference: <i>Induction, Abduction, retroduction, & retroduction</i>	- Knowledge abstraction: in-depth analysis of interviews and focus group discussions - Analysis of social learning - Generation of attributes/ indicators (first moment)
2.	6: Experiential learning cycle & representation of TEK. Modes of inference: <i>Retrodiction, abduction, & retroduction.</i>	- Further knowledge abstractions through experiential learning processes and the use of observations and audio-visual methods (i.e. photograph taking) - Generation of attributes/ indicators (second moment)
3.	7: Underlaboring scientific indicators with traditional ecological indicators Modes of inference: <i>Retrodiction, retroduction & abduction</i>	- RRREI(C) (drawing on Experiential Learning Intervention Workshop) - Indicators mirroring & integration - Indicator testing (also considered in this study as the last & fourth stage of the experiential learning) - Feedback session and confirmation of usefulness of the new set of indicators
4.	8: Ampliative conclusions Implicated inferences: <i>Induction, abduction, & retroduction, and retroduction</i>	Over all analysis of the potential contribution of processes of abstraction in social learning processes for coastal zone monitoring and management in the study area.

Description of Table 4.5

- The table suggests that knowledge that was produced through in-depth interviews and focus group discussions was combined with knowledge from experiential learning processes to form an input for the Experiential Learning Intervention Workshop (see arrows from the 1st and 2nd rows in the second column pointing to the 3rd row).
- It also suggests that input from the said intervention workshop (an integrated set of indicators) enriched the last stage of the experiential learning cycle (see arrow connecting the indicator testing practice to the experiential learning cycle).
- It is also indicates that realisation of knowledge in the first and second moments of processes of abstraction was made possible through different ways of thinking, reasoning, arguing,

interpreting, and making sense of what was observed in the field (modes of inference). Two way arrows that connect different modes of inferences (see the left column) with processes of knowledge production (the see right column) suggest existing connection between produced knowledge and ways that helped me, as researcher, to arrive at that particular kind of knowledge.

4.7 Validity and / or trustworthiness of data in all research phases

In this study 'validity' most often referred to in qualitative research as trustworthiness, is considered to be a process of ensuring the quality of the study by responding to five key critical realist questions that help to establish trustworthiness. There is very little written on trustworthiness of critical realist case study research, hence the framing of these questions that are based on a reading of how other critical realist researchers are seeking to ensure rigour, trustworthiness and quality in their studies (e.g. Price, 2007; Danemark et al., 2002; Scott, 2010; Schudel, 2013):

- Are the methods of the study appropriate to the nature of the questions being asked?
- Is the selection of cases or research participants theoretically and contextually justified, allowing for in-depth understandings of the phenomenon?
- Are the structures and mechanisms treated as real and distinct from the patterns of events that they generate, just as events are actual and distinct from the experiences in which they are apprehended? [This question is particularly framed for basic critical realism to avoid methodological individualism; the epistemic fallacy and ontological monovalence]
- Do the premises or findings emerge from the data, but within an ampliative form of analysis?
- Is there adequate evidence of the researcher's reflexivity, criticality and interpretive capabilities in working with complex phenomena?

I address each of these questions in turn below:

Question 1: To ensure that the methods of the study were appropriate to the nature of the questions being asked, I tested the open ended questionnaires for each of the three groups

of research participants (fishers, mangrove restorers and elders) among members of a team of five experienced mangrove restorers and fishers (see 4.5). The testing exercise indicated that there was a need to remove some questions from the interview schedule to avoid unnecessary repetition. It also indicated that some responses to particular questions tended to create more questions. This raised the need to only keep key or guiding questions to allow me to probe those questions that would emerge from the key questions in more depth. From these observations, 24 questions that had been previously planned for mangrove restorers were reduced to 7; questions primarily designed to guide abstractions among fishers were reduced from 25 to 8; and those planned for elders were reduced from 19 to 14 (see appendices A, B, C). The elder's questionnaire contained information on both mangrove and fisheries and had more questions than the other two.

The testing of interview questions also revealed that there was no urgent need to prepare different questions for in-depth interviews and focus group discussions at the same time, since the input that was to be used in the latter would depend on what evolved from the former. This observation was important because the research design indicated that focus group discussions were to be employed for verification purposes - hence they would rely on the availability of data that had been generated from in-depth interviews

Question 2: To ensure that the selection of cases or research participants was theoretically and contextually justified, I consulted some secondary data that shed light on the manner of conducting case study research, and capturing in-depth data using a purposive sample. I then went about carefully selecting the study sites (as described in section 1.6.2 and 4.3); sub-sites (as described in section 4.3), and research participants (as described in section 4.4) to ensure that I had a robust case study context for undertaking this research. It was necessary to locate the case study sites in the same area where the earlier monitoring indicators had been used, as this was a core aspect of the research problem. From this starting point, a more refined selection of sites, sub-sites and research participants took place to ensure a trustworthy context for this study. Working in this way from cases is acceptable among critical realists since 'transitive knowledge' as a social product "establishes" knowledge that is used to explore the intransitive structure of the world (Bhaskar, 2008, p. 11).

Question 3: I also sought to ensure quality and trustworthiness in the study by treating structures and mechanisms as emerging from the real domain (see figure 3.1 in section 3.3); and by seeing these as capable of producing events in the ‘actual domain’; and experiences that may be apparent in the mangrove ecosystem. This helped to avoid conflation of the three domains into one, which could potentially lead to the problem of epistemic fallacy or ontological monovalence as discussed in section 3.3. (Danemark et al., 2002; Sayer, 2000; Bhaskar, 2008). An emphasis was also placed on observing and specifying existing relationships and non-relationships surrounding the research phenomenon; and to consider not only what we may experience or see happen, but also underlying mechanisms that trigger the events in the mangrove ecosystem (see, for instance, representations in sections 5.2.3, 5.2.4, and 5.2.5).

Question 4: To ensure that the premises and findings of the study emerge from the data, but within an ampliative form of argument as per the philosophical and methodological premises of critical realism, I was able to make use of four different ampliative approaches to data analysis. These helped me to interpret the empirical insights offered by the research participants in inductive (as per the way induction is used in critical realism); abductive (seeking the best explanation for phenomena); retrodution (providing transfactual arguments that helped to explain phenomena further); and retrodiction which helped me to interpret effects based on causes and or historical antecedent events.

Question 5: I also practiced reflexivity throughout the research process to address the fifth quality question outlined above. Reflexivity is defined by Abercrombie, Hill & Turner (2006) as the ability to look into oneself, examine your own practice and be able to change or improve it. It also involves the ability to reflect on and talk about the reality that exists in the social world. This attribute is necessary in any qualitative study where the researcher interacts with the participants or other people in the study settings (Hammersley & Atkinson, 2007), since “interactions are influenced by who we are, what we are, where we are, and how we appear to others” (Hallowell, Lawton, & Gregory 2005, p. 42). Reflexivity also helps the researcher to “clarify dimensions of the research context and process”, and

can also deepen “the methodological and epistemological critique” in different research phases (Lotz-Sisitka, 2002, p. 105). As a researcher, I was aware of my subjectivity and the potential influence of this on the research process. This emerged as a challenge since I had previously worked in the coastal environment, and it was possible to get trapped in pre-conceived assumptions of what was going on in the study area. To avoid personal characteristics such as prior experiences, purposes, values, beliefs, and subjective qualities over-determining my conceptualization of the study environment, I chose to assume the role of a reflexive facilitator and observer, and was willing to learn from the research participants and create a suitable environment for them to assume a leading role in the processes of abstraction, conceptualisation and representation of ecological knowledge.

I also ensured that the participants themselves were decision makers in situations that necessitated collective or individual decisions, and in the day-to-day open meaning making processes. Moreover, situations that would limit full participation during focus groups and workshops were avoided, and pre-conceived conclusions and premises of the findings were also avoided. Another key technique that I used to ensure ‘reflexivity’ was to watch recorded video activities some hours after the coverage had been done (preferably at night), and reflect over the daily research process prior to facilitating subsequent research activities. This would reveal the extent to which my facilitation as a researcher reflected the study ethics and daily execution plans. Elements that would for instance, depict ‘crossing of the ethical line’ such as the researcher’s interruption in the on-going descriptions, the researcher’s failure to sensitively temper the influence of dominant speakers in the focus group discussions, and personal reactions to emerging issues during interviews/discussion sessions would be corrected in subsequent field activities; mistakes that were observed would be avoided, and situations for improvement created.

Prior to carrying on with subsequent sessions, the participants were asked to evaluate previous activities for possible corrections or improvements. This also helped in improving the research process. Opportunities were also created during the research process to allow the participants to reflexively and reflectively engage themselves in the research process. Reflectivity was observed during abstractions and representations of traditional ecological

knowledge at different levels of interaction. Details about how I did member checking of data and interacted with research participant are given in section 4.7 iii (j) below.

Both reflexivity and reflectivity were observed in the *mirroring* session of the Experiential Learning Intervention Workshop (see section 4.5.3.8), when most of the participants explained how they felt themselves disconnected from the use of scientific indicators, and how they positively reacted to the new set of indicators. Different reactions and feelings about participants' attachment to the old and new frameworks are presented in section 7.6 and 6.7.

As indicated above, the questions framed above are particularly useful for considering trustworthiness and quality in a critical realist case study context. However, there are also other frameworks for validity / trustworthiness [it should be noted here that the research literature uses these terms interchangeably, and often validity is used for qualitative studies, even when trustworthiness may be a better concept given the nature of qualitative social research]. I drew on two such frameworks to further ensure validity / trustworthiness in this study (Maxwell (2012); Shenton (2004); see below).

Maxwell (2012) cites three kinds of validity, namely descriptive, interpretive, and theoretical as key components that are mostly used in assessing qualitative research accounts (he also works from a social realist research perspective which is congruent with critical realism). These are presented and discussed below, in relation to the study itself:

i. **Descriptive validity:**

Descriptive validity refers to the 'descriptive accuracy' of participants' accounts or statements during the research process (Maxwell, 2012). It focuses on ensuring that what is reported is what was said by the research participants and not a misrepresentation. Descriptive validity helps researchers to be attentive and thus avoid mishearing, mis-transcription, and mis-remembering. To ensure that this study kept the participants' accounts and statements free from distortions, I employed audio and video recording techniques during individual interviews, focus

group discussions, feedback sessions and adhoc meetings as explained in section 4.5.3.3 above. I also conducted member-checking throughout the study to cross-check captured data. Through this process, mangrove restorers, fishers, and elders were contacted physically or by phone to confirm or clarify their previous representations. I also ensured that I recapped previous discussions in subsequent sessions to help the participants understand where they were, what had been done so far, and what the intentions were for subsequent sessions. Other techniques employed included note-taking, clarification of research goals and procedures, daily watching or listening of recorded sessions and shortlisting of aspects that needed attention or clarification.

ii. **Interpretive validity**

Interpretive validity refers to the degree to which the participants' views, thoughts, experiences, and intentions are accurately understood and reported by the qualitative researcher. It is an approach that seeks to comprehend or understand phenomena and eventually make sense of studied issues in general. Interpretive accounts, as Maxwell (2012) puts it, are grounded in the language and thoughts of studied participants, and they rely heavily on their own concepts and words. It is therefore inherently a matter of inference making from the words and actions of the research participants in the studied situations. As indicated above, this would not be the kind of inference making of methodological individualism or interpretive hermeneutic research, but the ampliative inferences of critical realist research. To ensure that this kind of trustworthiness was attained within the a critical realist research framework, I selected a study environment that I had worked in for about 10 years, and where the previous set of monitoring indicators had been used. Coastal communities along the eastern coastal of Tanzania are all Swahili speakers and of Islamic culture. The conception of this study, as is reflected in the introduction chapter, happened in the same coastal setting and at a time when I, together with members of coastal communities, were carrying out some periodic monitoring practices using a framework of scientific indicators (see section1.1). The long-term established interactions between myself (the researcher), and the research participants, and the use of the Kiswahili language which is widely or

commonly used in the country as the medium of communication (national language), helped us (research participants and researcher) to communicate throughout the study time, without seeking translation. This language was also used in the workshop sessions that focussed on indicator mirroring and testing (see sub-section 4.5.3.8). This helped me to establish a strong foundation for being able to understand and interpret participants' viewpoints and experiences as accurately as possible. I also used thick descriptions as a way of making these visible in the study, and my ampliative interpretations of these. I further sought to enhance the trustworthiness of these interpretations through applying different ampliative modes of inference, as discussed in the section above, describing my response to Question 4.

iii. **Theoretical validity**

This type of validity is directly associated with the degree to which a theory or developed theoretical explanation from the study, is relevant to the research question, context and data, and can be regarded as credible and defensible. This study sought not to develop a new theory or a model but to use existing theories as lenses that would guide the analysis of processes of abstraction in social learning, and uncover potentials for the development of coastal monitoring indicators. The study, therefore, employed critical realist and experiential learning theoretical concepts such as abstraction, conceptualisation, representation, and social learning processes, and analysed their relationship. This process was necessary, since Maxwell (2012) indicates that theoretical validity examines also the validity of the concepts themselves as they are applied to the phenomena, and the validity of the relationship that underpins those concepts.

Other validity/ trustworthiness criteria that were drawn on in this study as advised by Shenton (2004) for credibility reasons, include:

- a) *Adoption of research methods well established in qualitative investigation:* The selection of study participants, development of research instruments, data generation, and data analysis was guided by qualitative research literature such as that provided by Babbie (2001, 2007), Boyce & Neale (2006), Byrne & Ragin (2009:75), Gerring (2007, p. 41), Krueger (2000), Verschuren & Doorewaard

(1999/2010), Yin (2003), Wilkinson (2000) and Berkes (2008,2012) (see sections 4.2, 4.4, 4.5.1, 4.5.3, and 4.5.3.2). The study was thus established using qualitative investigation procedures relevant to case study research (as noted above).

- b) *Development of an earlier familiarity with the research participants prior to commencement of the study:* Familiarity with coastal communities and the social learning issues they were experiencing around coastal monitoring using reified indicators, stands to be among the key factors that influenced the emergence of this study, and its execution in the coastal environment. As already mentioned, I had previously worked with mangrove restorers and fishers in a mangrove restoration project (in the study area) for over two years (see section 1.1, and section 4.3; criteria 3) and had previously visited the area back in 2005 while working with a community-based capacity building programme that intended to address sustainable utilization of coastal and marine resources. As explained earlier in the participant selection section (4.4), I used previous contacts to identify potential participants for the study.
- c) *Triangulation:* This involved application of different methods in the generation of data on the same phenomenon (Verschuren & Doorewaard, 1999). As described in some detail above, employed research methods included in-depth individual interviews, focus group discussions, observations (including observations of participants using cameras), an Experiential Learning Intervention Workshop (ELIW) and ongoing observations of what was going on in the research process. There was also the use of a diversity of participants such as local elders, fishers, and mangrove restorers. During focus group discussions, village and ward leaders were invited and asked to take part in the discussions of the research phenomena. Research interviews were not confined to one particular site, but to 4 different sub-sites, provided that these belonged to the main mangrove ecosystem which extends from Moa to Boma (see section 4.4). This allowed for the generation of multiple sources of data using different methods in more than one sub-site, strengthening triangulation possibilities. The triangulation process was practiced through the

coding and categorising of data and the ampliative inferences that were made from the data, using a systematic, rigorous approach to data analysis as discussed above in section 4.6.

- d) *Ensuring honesty in engaging with informants when collecting data:* This focuses on the need for the researcher to create space for research participants to willingly agree to participate in the study without any pressure; as this may increase chances of securing their full support for the duration that they agreed to spend in research events. As explained in the ethical consideration section (see 4.8.6 below), each research participant was approached and asked to participate in the study. This process was confirmed by the signing of a consent form, which also gave them the right to withdraw should they wish, and not being under obligation to disclose what was against their will. Regular reflection sessions also helped with monitoring how the participants were experiencing the research process, and their ongoing willingness to continue participating in the study for its full duration (January 2011 to January 2014). As shown in Table 4.4 above, a core group of identified participants continued to participate throughout the study.
- e) *Iterative questioning:* To ensure that what the participants had said was clear, I, as researcher, would repeat some questions whenever the situation allowed, and would probe conflicting answers further for clarity. This included re-framing of previous questions, and in the case of some of the focus group discussions, allowing more contributions and possible clarifications on the matter. For example, some fishers would mention fish species in general without specifying whether or not these were mangrove-based, temporary visitors to mangroves, or not visiting mangroves at all. In this situation, I would ask them to clarify what they said and repeat my questions to ensure that all participating parties were clear about what was explained. In other instances, especially during FGD's, some participants would assign colloquial terms to certain fish species, and before listing the name of the species I would ask them to give me the name that is common and familiar to coastal people, including non-fishers. In this case, clarifications from the most experienced

fishers (retired and those who have practiced fishing for over 30 years) were very helpful not only to me, as the researcher, but also to young fishers.

- f) *Frequent debriefing sessions:* Each research session was preceded by debriefing of previous activities, and linking what was carried out with new research activities. These sessions lasted for a maximum of 10-15 minutes on average, and would incorporate questions and answers from both the participants and the researcher. The researcher also used such sessions to remind participating groups (fishers, mangrove restorers, and elders) about the purpose of the study and its importance to the study area.
- g) *Peer scrutiny of the research phenomena:* This process involved presentation of the proposed study before my colleagues at different stages (concept level, proposal development level, proposal presentation level, and at different field phases). The purpose was to enrich the study and illuminate the way forward. I was also able to present my research to various professional forums for ongoing feedback, including training courses on community-based natural resource management and social learning; and at the International Association of Critical Realism Conference in 2012. These opportunities provided valuable sources of feedback on the emerging study over the three year period in which it took place.

Peer scrutiny of the research phenomenon was also possible during focus group discussions, where village and ward leaders as mentioned earlier (see triangulation), participated not only in discussing how the research phenomenon was reflected in their respective sites, but also sharing what they had observed with other research participants. As mentioned above, the Experiential Learning Intervention Workshop was also a very important peer review process in which data and interpretations on TEK indicators as emergent from the abstraction and experiential learning processes that were mirrored back to participants, and a wider audience that included scientists and coastal zone management officials.

- h) *The researcher's reflective commentary:* This was made possible by the use of video recording, as I was among those recorded in the research process. As mentioned above, I used recorded video to observe the manner within which I organised and engaged the participants on a daily level, and the following day I would omit or skip unnecessary steps, or bring in facilitation techniques that seemed to be preferred by the participants.
- i) *Background, qualifications and experience of the investigator:* Being the key investigator in this study, I had to base my justification for undertaking a study of this nature in the coastal environment on past experiences and my background in the management of coastal and marine resources, and taking part in coastal based applied research.
- j) *Member checks:* Member checking was done by meeting concerned research participants physically after making appointments, and through the use of phone contacts that had been willingly passed to me from initial sessions. The process was aimed at seeking clarification of what had been communicated to me earlier, or confirming certain aspects of enquiry.
- k) *Examination of previous research findings:* The study made use of the findings advanced by Julius (2005), indicating that there was no effective monitoring on the eastern coast of Tanzania (see section 1.3.2), due to the lack of a reliable framework, and the failure of coastal communities to comprehend adapted monitoring tools (KICAMP, 2004). The suggestion for an effective framework which would lead to wider social learning in the study area is based on these findings. The study also worked on the research opening that had been made by Davies (2009), calling for the need to explore the significance of abstraction for social learning in coastal communities.
- l) *Thick description of the phenomena under scrutiny:* This refers to the process of ensuring that what the researcher has observed is recorded and that "observations are as detailed as may be useful" (Richards, 2005, p. 51). Thick description in this study involved the preparation of details of 'recall' and 'imagery', and entailed

contextualisation of knowledge among fishers, mangrove restorers, and local elders, upon which the study analysis in chapter 5,6, and 7 is based. Their words are used in providing thick descriptions in these chapters, to ensure authenticity and in-depth insight into the case contexts. Similarly, photographs of the study process, area and practices helped to further strengthen the thick descriptions in this study.

4.8 Ethical considerations in the study

Working with coastal communities in this study was an important decision which entailed consideration of ethical aspects that would ensure a successful research process from the planning level to the analysis of data. It required a clear understanding of the 'don'ts' and 'do's', and above all, situations that would freely engage the participants in key research activities without compromising the trustworthiness, credibility, dependability, and confirmability of the study.

Hallowell et al.(2005), and Fritz (2008) present some ethical aspects which were considered in this study. These include ensuring that:

- Participants are well informed about the purpose of the research they are being asked to participate in, in the study.
- They understand the risks they may face as a result of participating in the study
- They understand the benefits that are associated with the study
- They feel free to make independent decisions without fear or influence
- Their integrity and privacy are respected
- They are free to withdraw or join at a later point
- The researcher's institutional affiliation is known to them
- They are aware of the methods that are opted for in the research process

Upon arriving to the study area, I, as researcher, introduced myself to local authorities at all hierarchical levels beginning with the District, Ward, and Village levels. At this level, the purpose of the study was uncovered, the benefit explained, and the process of involving selected fishers, mangrove restorers, and elders discussed. It was necessary to do this, even though I had been in the area before, as I was now returning to the area with the wish to

conduct formal research. I therefore often refer to myself in this study as I, the researcher, to denote this role, which differed from earlier roles in the coastal community context, and in the study sites.

At another level, participants, depending on their group of specialisation (e.g. fishers, mangrove restorers, and elders), were first asked to participate in the study and would thereafter sign consent forms (see appendices 15 & 16) which included some ethical aspects like confidentiality, preferences, and the right to have the details they have given disseminated or used mainly for this particular research.

Prior to conducting in-depth interviews with individual participants, I, as researcher, organised pre-meeting sessions for potential interviewees to introduce the research process, and seek individual appointments. These pre-sessions were a platform for discussing the benefits of the study to the people and the ecosystem at large.

Having worked in the coastal area for nearly 10 years, and specifically interacted with communities in the study area for 2 years, I ensured that members of my team (hired drivers who occasionally drove me to the study area, a photographer and myself) were well acquainted with rules and social practices that are acceptable in the study area, including paying respect to the elders, dressing decently, employing a common salute term '*asalam aleikum*' to all social groups that happened to interact with us, respecting traditional healers, and seeking guidance from research participants when visiting potential research sites such as fish landing sites, local harbours, and areas where mangrove transplanting is being carried out.

Worshipping hours, especially those which interacted with our morning and afternoon research sessions were observed and respected throughout the study process; and continuing meetings would be adjusted to accommodate both adhoc and planned worshipping sessions. The involvement of female participants was coordinated by females from a team which helped me to select potential participants for this study, and meetings were held in open sites which did not create doubts or complaints.

During meetings; especially Focus Group Discussions (FGDs), I as researcher, reiterated the need for participants to be free to share their views, and I insisted that it was possible for someone to have experienced what others have not, and that such experiences were key to this particular research. Being also aware that FGD's were formed by individual fishers, mangrove restorers, and elders who had been involved earlier at in-depth interviews, and that they intended to verify data or information obtained from previous individual sessions, I as researcher, kept the sources of data anonymous and clarified that whatever was to be verified did not specifically seek to undo or underrate what had been previously represented, but to put data in an order that would lead to achieving the research goal.

Throughout the research process, I as the researcher, sought to ensure that the right of research participants to safeguard their integrity, and that their integrity was respected throughout the research process.

4.9 Conclusion

The chapter has shared insight into the study design, the methods, procedures, and techniques employed in the study; especially in key components such as the selection of research participants, data collection, data processing, and data analysis. The methodology of the study was constituted as a critical realist case study and thus I used 'intensive' methods - Sayer (1992, 2000); Danemark et al. (2002); Hartwig (2007); Byrney & Ragin (2009); Gerring (2007); Maxwell (2012), and additional case study insights from Verschuren & Doorewaard (1999,2010); Yin (2003 2012); Krueger (2000); Wilkinson (2000); Mitchell (2011); and Babbie (2001, 2007), to produce data in carefully selected sites. As explained in this chapter, these included in-depth interviews, audio visual methods (see chapter 6), focus group discussions (with the latter also serving a means of verification), observation and intervention workshops to analyse the potential contribution of processes of abstraction in social learning. I carefully explained the processes of ampliative inference and the coding and indexing processes that were used to manage and analyse the data. I also provided a careful description of validity/ trustworthiness and the ethical aspects of the study. Specific applications of the cited methodology, methods and approaches are indicated in the next chapter (chapter 5) as well as in chapters 6 and 7.

CHAPTER 5: THE POTENTIAL CONTRIBUTION OF ABSTRACTION, CONCEPTUALISATION, AND REPRESENTATION IN SOCIAL LEARNING PROCESSES WITHIN THE COASTAL SETTING

5.1 Introduction

This chapter seeks to respond to the question ‘What is the potential contribution of abstraction, conceptualisation, and representation of Traditional Ecological Knowledge (TEK) in social learning processes within the coastal setting?’ It brings into view how processes of abstraction, conceptualisation, and representation may potentially create a space for knowledge production and transfer of the same in the coastal environment (in the Eastern Coast of Tanzania). The chapter employs a critical realist perspective to uncover how such processes may help mangrove restorers, fishers and local elders to describe mangrove ecological systems in a manner that depicts not only necessary and contingent ecological relations, but also interactions between natural and socio-cultural systems such as power and knowledge transfer among research participants. The chapter therefore shows ways through which TEK can be represented by individuals, groups, and communities at large as an input for developing coastal monitoring indicators. The representations reported on here are those found in the interview and focus group discussion data in Phase 1 and Phase 3 of the study (see sections 4.5.2.1 and 4.5.2.3). It serves as the first *moment* of processes of abstraction (see the overview of study design i.e. figure 1.2 and section 6.1), where participants represented or described mangroves and fisheries while seeing, touching, and feeling them in the ‘on-site’ or ‘in-situ’ interviewing processes (see section 4.5.3.1). The second *moment* (see sections 4.5.2.2, 4.5.3.4-6 and 6.1) focussed on the representation of photographic images as a ‘*type*’ of the first *moment* (antitype), or means of verifying descriptions that were made in the latter *moment*.

5.2 Contribution of abstraction and conceptualisation to knowledge production and social learning

Critical realists believe that conceptualisation is made through ‘abstraction’ (a mental process which helps us to isolate or separate certain concepts in thought); and distinguish them by determining what they are, what they constitute, and how they relate to particular

objects or the concrete (Sayer, 2000; Danemark et al., 2002; Hartwig, 2007), as explained in sections 1.7.1 and 2.3). Danemark et al. (2002) and Sayer (2000) argue that employing 'conceptualisation' in a social science study (like this) has a dual advantage, in that it allows researchers to describe both the study *object* and the study *process* (double hermeneutic), unlike natural science which mainly focus on the 'process' (single hermeneutic) - leaving out descriptions of the study object. Through abstract conceptualisation, research participants can create meaning and interpret research objects (Danemark et al., 2002). This creates a space for accommodating ideas, concepts, and notions of participating individuals and social groups. Arguing in support of this, Danemark et al. (2002) state:

... we maintain that the ideas, notions, and concepts of the 'others' must be included in the social scientist's study. We also maintain that they must be included in our manner of research. Social worlds are inherently meaningful. It is necessary to understand the meaning people assign to their actions in order to understand the actions. The actions in their turn mediate everyday social phenomena as well as deeper underlying structural relations, which are constitutive of the society under study (p. 36).

Ideas, concepts, and notions presented by research participants (e.g. mangrove restorers, fishers, and retired local elders) through processes of *abstraction* and *conceptualisation* may lead to "knowledge production" (Danemark et al., 2002, p. 41). Based on the principle stated in the above quotation (see Danemark et al., 2002, p. 36), we may 'understand' the social world (particularly processes and interactions that take place in the mangrove ecosystem and their deep underlying structural relations) by understanding the 'meaning' that research participants attach or assign to it.

Ideas, concepts, notions or descriptions that mangrove restorers and fishers give, may potentially lead to understanding of:

- Social, Ecological and Economic roles of the mangrove ecosystem
- Knowledge transfer from experienced fishers to young fishers
- Different species and how these interact in the mangrove empirical space
- Species relations (contingent and necessary relationships)
- Power relations among different actors and how this affects learning
- Ecological concepts and processes that occur in the mangrove ecosystem

- Metaphors that shape ecological descriptions
- How weather influences fish catch and interactions
- Historical representations of the mangrove ecosystem; and
- Attributes and indicators that define the health status of mangroves and fisheries.

5.2.1 Social, Ecological and Economic roles of the mangrove ecosystem

It is possible to understand the social, ecological, and economic roles of the mangrove ecosystem through concepts, ideas, and notions that mangrove restorers, fishers, and retired elders represent in this study context. These are based on their knowledge of resource and ecosystem dynamics accumulated over a long period of time (Berkes, 2008; Berkes, 2012; Fabricius & Koch, 2004), which results from their day-to-day interactions with the mangroves and fisheries that inhabit them, and the manifestations of some experiences at the empirical level as they continually engage in fishing and mangrove restoration practices.

As critical realists put it, research designs that are based on conceptions of existing phenomena are 'real' in the sense that they are part of people's meanings, motives, and understandings; they are models that present what is actually taking place, and not simply what the research plans are, or intend to do (Maxwell, 2012).

Below are ideas, concepts, and notions which may help us understand how indigenous coastal communities, particularly research participants in this study, describe the mangrove ecosystem and its roles:

Mangroves are hiding sites for marine creatures, and special resorts. They are nurseries for fisheries, and can widely control erosion along the ocean shores resulting from heavy and speedy waves (1EBKII).

Fisheries use mangroves as places that offer opportunities for food and shelter. Some juvenile fish use them for protection against their predators by hiding in holes, roots, and stony areas (11FMII).

Mangroves are hiding sites for marine creatures, and special resorts. They are nurseries for fisheries, and can widely control erosion along the ocean shores resulting from heavy and speedy waves (1MMNII).

There are juvenile fish in there and other species that visit mangrove sites during the high tide (8BKEII).

Mangroves support beehive installation. We have several beehives in the mangroves and we sell honey to other members of the community, and sometimes outside our area. We also have an orderly manner which allows people to secure permits for harvesting mature mangrove species for domestic and economic purposes. (1MMNII).

We allow people to collect fire wood from the mangroves especially dry wood and loose logs (20MMII).

Presented notions, ideas, and concepts suggest that mangroves play a significant role in the coastal environment. Participant 1EKII (see participant index code descriptions in section 4.6.1.1) who is a retired fisher, highlights several ecological functions that mangrove ecosystems offer; including their capacity to protect coastal land from strong or aggressive winds. This also serves as an advantage to adjacent communities (coastal people) who live near the ocean and are thus prone to impacts of erosion or coastal floods. Mangroves are also represented in the same account as sites for fish spawning (serving as nursery grounds for a variety of fisheries). Some fish come to the mangroves to “*hide from predators*”, and some for “*food and shelter*” as participant 11FMII puts it. Juvenile fish spawned in the mangroves spend most of their early weeks in the same ecosystem for safety reasons hiding in the mangrove roots, holes, and stony areas (participant 11FMII), rather than swimming in sites that may endanger their lives.

Faunce & Serafy (2006) and Berjack et al. (2011) affirm that mangroves are a recognised habitat for a variety of vertebrates and invertebrates, and that they protect the coast from erosion. They also confirm that certain kinds of fish species visit mangroves for food, hiding against predators, and spawning. Affirmation of such indigenous understanding of the role of mangroves, suggests that coastal communities have something to offer for social learning purposes.

Descriptions from Participants 1MMNII and 20MMII show that apart from ecological functions or roles, the mangrove ecosystem also offers a space for practising beekeeping for income generation purposes. Mature mangrove plants are harvested by adjacent coastal communities for domestic purposes (e.g. firewood and building materials) and economic or commercial purposes such as boat making. In other words, given representations suggest that the said ecosystem offers a variety of functions such as ecological, social and economic.

The above notions, concepts, and ideas help us to understand not only what is going on in the mangroves but also the mechanisms and structures that generate such experiences. They indicate why juvenile fish hide in the mangroves (see the second account by participant 11FMII above), why different species visit mangrove sites, and when this takes place (see the account given by participant 8BKEII above). The descriptions also suggest what causes erosion, and implicitly propose how this particular problem may be addressed (i.e. having mangroves along the coastal strip).

Knowledge that is produced from indigenous abstract conceptualisations and represented as is the case in this section, may help us to understand not only identified functions of the mangrove ecosystem but also how and why such functions occur. Much lies in how this particular knowledge is transmitted from one individual to another through interactions, and how it leads to wider social learning (Reed et al., 2010) in the coastal area (see the next section i.e. 5.2.2).

5.2.2 Knowledge transfer from experienced fishers to young fishers

Descriptions that research participants give, can also help us to understand how traditional ecological knowledge is passed from one individual to another and how it eventually becomes situated among coastal communities. Some fishers learnt how to fish from their parents, some from their friends, and some from other members of the coastal community. Participant 9FMNII (who is approaching retirement) relates his experience about how he became a fisher.

I grew up at the time when fishing was the core activity and learnt from others how to practice fishing. Our forefathers preferred using traditional fishing skills which to me are not as destructive as modern ways are today (9FMNII).

My parents were fishers. I also followed the same trend and have practiced fishing since 1966 (11FMII).

An elderly fisher told me that fish like human beings are subject to extreme temperatures and may wish to experience cool air outside the ocean for relief; that's why you see them jumping up and down (1EBKII).

Presented accounts above suggest that fishing knowledge can be transferred from one individual to another through interactions. This assertion is also affirmed by Cundill &

Rodela (2012). Participant 9FMNII who is approaching retirement after fishing for over 50 years introduces the possibility of 'knowledge transfer' through peer groups. This simply asserts that someone who has never been inducted into fishing activities may learn from individuals or groups that are involved in that particular practice and develop a specific specialisation such as fishing. He also raises the possibility of understanding skills and knowledge that has shaped traditional fishing for many years (from his forefathers), and regards it as being more reliable than any other form of knowledge (e.g. modern fishing techniques), on sustainability grounds.

The accounts also show that knowledge can be socio-culturally 'inherited' from parents or close relatives (see participant 11FMII's representation), due to close familial exposure to the practice. This suggests that fishers' children may be likely to practice fishing (although this is not guaranteed). It may also imply that if parents are specialists in *crab* or *sardine* fishing, their children may choose the same specialisation due to the kinds of skills learned or experiences gained through ongoing close contact with the familial socio-cultural fishing practices. This relates to the socio-cultural theories of learning outlined in section 2.2 which argue that individuals learn by observing and participating in the practices of others and through participating in such practices, transform what they have observed into 'cognitive representations' and skilled practices .

Besides learning from peers and parents, participant 1EBKII suggests that young fishers may learn from the elderly fishers. The latter are believed to have accumulated fishing knowledge enough to pass it to the young generation of fishers. This is also the case where an elderly fisher (9 FMNII) notes that as he grew up, he was introduced to traditional fishing techniques (possibly by other community members). This depicts a form of 'learning through oral tradition', and also through 'doing' or getting involved directly in on-going community practices.

A recent study by Belay (2012) found that as social groups engage themselves in practice or praxis there is knowledge transfer from experienced members (elders) to the less experienced (youth). This form of 'knowledge transfer' is alluded by participant 9FMNII who

links existing traditional knowledge and skills to his ‘forefathers’ (implying that it was passed down from them to the current fishing generation).

Vygotsky states that knowledge transmission, as a process, occurs through *internalization*; where individuals who are engaged in interpersonal socio-cultural interactions, appropriate demonstrated skills or knowledge and apply them as their own (Wertsch 1985; Daniels, 2001). For example, as young fishers participate in many fishing activities with experienced fishers, they begin to appropriate the procedures, actions, and routines that are involved in the fishing practice. At a later stage, they eventually internalize those routines and begin to practice fishing as independent fishers. Though operating as independent fishers, interactions with other fishers remain available, and possibilities for other inexperienced fishers to *appropriate* and *internalize* their routine behaviours and actions exist.

Knowledge that is produced among coastal fishers by observing a constant conjunction of events in the mangrove area and confirming the same through processes of *induction*, is in turn used to guide their day to day fishing operations, and it helps them to understand species interactions in the said ecosystem over time and space. Below is an example of how mangrove fishers apply confirmed observation in the coastal environment:

If you happen to see turtle’s spoors trailing from the ocean to offshore or near mangrove sites then know that a female sea-turtle had just gone to lay eggs (7FMNII).

Such confirmed observations inform fishers’ activities, and help them to distinguish various species interactions in different seasons of the year. It may also help conservation groups to map ‘turtle breeding and movements’ for protection purposes or inform scientific research.

5.2.2.1 Knowledge transfer among mangrove restorers

Mangrove restorers like fishers also learn from each other as they engage in practice. Participant 1MMNII reflects how mangrove restorers started learning and why:

We used to clear mangroves for salt making and construction purposes. Some trainers from Tanga Coastal Zone Conservation and Development Programme paid us a visit and invited some of us to participate in some seminars or workshops. Those who took part in the training came back and shared what they had learnt with us. We decided to stop clearing mangroves and embarked on protection measures.

The essence of knowledge production depicted in the above description differs from that of fishers (see section 5.2.2). It starts by a few members attending some seminars and workshops and thereafter passing the acquired knowledge and skills on to other members. From this citation, knowledge sharing appears to be the main learning approach, without which clearance of mangroves would have probably continued.

The citation implicates the power of knowledge in reversing unsustainable practices and shaping our way of thinking and acting (Wals, 2010). It also shows how interactions and knowledge sharing aid social learning in a particular community of practice (Cundill & Rodela, 2012).

In spite of noted differences in knowledge production approaches between mangrove restorers and fishers, 'knowledge transfer' between them follows the same route (i.e. knowledge sharing among involved individuals as these interact in practice or praxis). There is also evidence of 'learning from peers' and relatives as was the case in the fishers' context, as it is revealed below by one of the restorers:

Some of us introduced mangrove transplanting as a trial activity. We had no idea whether this would work out. Then we transplanted seedlings in affected areas and urged other people such as friends and relatives to join us. They are now familiar with the practice and are able to help others take part in transplanting (20MMII).

It may also be argued that when individuals and social groups are exposed to one form of learning and they engage themselves deeper in the practice, they are likely to be shaped by existing challenges to the level that may require additional skills and knowledge. Hence creativity and a willingness to experiment with new practices emerges as a key aspect of the learning process. This is implicated in their desire to cover bare mangrove areas through the transplanting of mangrove seedlings.

There are several learning processes that can be drawn from represented fishers and mangrove restorers' accounts in this section. First, is the possibility of learning by looking back at an event and analysing it. This process is referred to by Beard & Wilson (2002) as *retrospective learning*, which is also a part of reflexivity (see below). It provides the learner with an opportunity to look back at an event and reflect more closely on what happened, why it happened, and whether it was good or bad. This is clear in the account given by participant 1MMNII who recalls how their exposure to short term training encouraged peer learning and knowledge sharing among mangrove restorers; leading to a change in understanding and acting. Practices that were once regarded as acceptable (e.g. unsustainable clearance of mangroves) are now considered to be unacceptable.

The same description also suggests a kind of reflexivity which enables mangrove restorers to step back and reflexively consider the extent to which they have been part of the problem or intervention. This is also depicted in the following description:

There's a change in the physical outlook of the mangrove species; there are plenty of species now more than before and the forest looks better. There is no more unsightly clearance of species by individuals. The focus now is on conservation and restoration activities (20MMII).

The above representation suggests a conscious reflection on what needs to be done in the mangrove ecosystem and what should not. Bhaskar (1998, p. 411) argues that "human beings are characterised by the capacity for internal agency and for the reflexive awareness and organisation of such agency". This makes them able to consciously analyse prevailing situations and decide whether or not to engage in praxis. In describing what 'consciousness' in this context means, Bhaskar says:

What is normally meant by consciousness refers to those aspects of our praxis in which we are (progressively) (i) sentient, (ii) aware, (iii) attentive, (iv) reflexively self-aware, attentive and articulate and (v) occupied in planned (controlled, deliberate, integrated) reasonable (intelligent, well-grounded, responsible) collective, coordinated or mutual activity (1998, p. 411).

From the above description, it is obvious that the process of refraining from destructive practices and opting for restorative praxis was a conscious process amongst involved players

(learners), in that they were aware of what has happened before, what part have they assumed in the play, how devastating it was, and what the best way was of approaching and addressing it to improve the condition of mangrove. This introduces us to another form of learning called 'reflexive learning' (Wals 2007; Lotz-Sisitka, 2012).

Presented representations also introduce another learning process called 'reflective learning'. In this kind of learning, learners take time to focus on their performance and think carefully about the 'thinking' that led to particular actions, what happened, and what they are learning from the experiences they have gone through, in order to inform what they might do in future with regard to what they have experienced (Rice & Pinnegar, 2012). Reflective learning, as a meaning making process, moves learners from one experience into another, exposing them to deeper understanding of its relationships, with connections to other experiences and ideas (Thorsen & DeVore, 2012), as shown in the citations below:

*We used to clear mangrove species for salt making, but have stopped. You can see how the forest is now looking good (1MMNII).
Mangrove species look good now and is free from destruction – more so than before. I ascribe the current condition to the 'transplanting initiative' (4MMNII).*

The above mangrove restorer's accounts depict three components of '*reflective learning*'. First is what Thorsen & DeVore (2012) call *descriptive reflection*. This contains not only a description of events (good or bad) but also reasons or justifications for the occurrence of those particular events or actions. The first account for example, carries visible characteristics of *descriptive reflection* of the event which proved to be unsustainable and was thus revised to allow forest recovery. It is obvious that salt pans are built near sites that collect enough saline water from the ocean; mangrove areas meet this requirement hence they are cleared to allow for commercial salt making. The reason or justification given by the learner in this context is 'ecological' (forest recovery), though in other parts of the in-depth interview social, cultural, and economic grounds are also given.

The second component of reflective learning is '*dialogic reflection*' (ibid.). Here, learners step back from the events or actions, leading to a different level of exploring the experiences or events more deeply, using qualities of judgement, and possible alternatives

for explaining and making tentative predictions in relation to what they have experienced. Such reflections help them to analyse the integration of factors and perspectives that may help in recognizing inconsistencies, while attempting to justify or critique prevailing situations. *Dialogic reflection* was clear during focus group discussions where events that are connected to the condition of mangrove species and fisheries were discussed more deeply than at individual in-depth interview level. Experienced fishers (for example), used *dialogic reflection* to expand, clarify, expound and affirm what was been said earlier by other group members, especially young fishers. The same process revealed itself among mangrove restorers.

‘Dialogic reflection’ was, for example, experienced in a fishers’ focus group discussion (see section 4.5.3.2), when an elderly fisher (1EBKII) corrected a fish term which had previously been presented as ‘*Pamamba*’ to ‘*Paramamba*’ and expounded how the same species bear varying identification across coastal space and what they should be called in the study area.

The last component in ‘reflective learning’ is ‘*critical reflection*’. This appears when learners are aware that events and actions are located in, and influenced by multiple historical and social political contexts. The link between learning and events/actions in *critical reflection* suggests that learning is not confined to the empirical domain, but it is influenced by other domains such as the real (layer of structures, powers and mechanisms). Some critical reflections may be highlighted from the following representations:

In the past we did not have joint environmental protection initiatives like we do now. People used to clear mangroves without being held accountable for what they had done. (20MMII).

Patrols were introduced in the coastal area because people ignored government rules and orders. This was not the case in the past. Without any enforcement in place, some people would have continued to clear mangroves (26EMII).

Mangrove clearance is now somehow controlled following a Government decision to initiate village environmental committees and also as the result of an increased level of awareness among coastal dwellers (19MMII).

The above descriptions suggest that learners are aware of on-going events and actions in the mangrove ecosystem, and about various contexts that influence either the destruction

or protection of mangrove species. They engage in critical reflection on the establishment of environmental structures such as village environmental committees, patrol systems, enforcement mechanisms, and increased level of awareness as multiple social and political contexts that influence the current health status of the mangrove ecosystem.

5.2.3 Different species and how these interact in the mangrove empirical space

Representations that result from processes of abstraction and conceptualisation may also help individuals and social groups to understand how fish species interact in the mangrove ecosystem over time, and this may potentially inform fishing decisions and plans in the coastal environment. Fishers, for example, may specify species that visit mangroves during high tide and give reasons that trigger them to behave so, as is depicted in the following representations:

Some fishes visit mangroves in search for food. mkizi (mullet fish) for example, prefers feeding on decomposed mpia (Sonneratia alba) fruits. Dome (cuttlefish) and chanje (small invertebrates) shelter themselves around mangrove roots (13M/FMII).

Mangroves attract species (mkizi) for many reasons, first, the temperature seems to be optimal in the mangroves than in the ocean, secondly, some mangrove fruits like Mpia (Sonneratia alba) shed their fruits between May and June every year ; visiting fisheries feed on those fruits (Fishers' Focus Group Discussion held at Moa Village, March 2012)

Mullet fish (characterised by limping or jumping while swimming) and other fisheries that are not permanently residing in the mangroves tend to visit mangroves in large companies in the rainy season than other seasons of the year (Fishers' Focus Group Discussion held at Moa Village, March 2012)

Mullet fish as indicated above, visit mangroves for several reasons; including feeding on *Mpia* fruits, and looking for favourable temperature conditions. Such interactions increase in the rainy season, involving other fish species which are not using mangroves as their main or permanent habitat. Understanding the species interaction-cycle serves as a calendar that guides and informs fishing decisions in the study area throughout the year.

Indigenous observations also go further by identifying specific sites in the mangroves where particular fish species shelter themselves (see the account given by fisher 13M/FMII). *Dome* (cuttlefish) and *chanje* (small invertebrates) which, according to the fishers' focus group, are permanent resident species in the mangrove, spend time in the plant roots or holes. This

happens during high tide when there is sufficient water in the said ecosystem. When water is shallow (low tide), cuttlefish immerse themselves in the mud and come up again when there is sufficient water, and continue sheltering themselves in and around mangrove roots as described earlier by participant 13M/FMII. Describing the cuttlefish behaviour, participant (fisher 9FMNII) gives the following account:

Cuttlefish (dome) has a tendency of immersing itself in the mud when it is low tide, and come up during high tide. One may see them in the mangroves when there is sufficient water.

This unique cuttlefish behaviour which is known to fishers, may be communicated to scientific and research institutions for further investigation and affirmation. There is for example, a need to understand deeply the process of ‘immersion’, why this occurs, and for how long. Feedback from further investigations may be communicated back to fishers. From the cuttlefish experience, it may be argued that drivers or mechanisms that cause this particular fish to behave in that particular manner remain unknown. So far, represented knowledge in the above context helps us to understand what is going on at the *empirical* level (domain of experiences), and partly in the *actual* (domain of events); leaving out key determinants which drive or generate the said fish behaviour (domain of the real). To understand fully the entire process and its implication for learning, we need to find the remaining answers as alluded to above. It is also possible to note that the represented fisher’s account about the behaviour of *cuttlefish* is relevant to fishers in the coastal area, because it may potentially help them to suggest or plan the appropriate time for catching cuttlefish. It thus serves as guiding knowledge or experience in the fishing practice.

We may also learn from fishers’ abstractions, the behaviour of juvenile fish in the mangroves ecosystem and how these go through different stages before entering deep sea water. Such knowledge is necessary for understanding fish trends, changes (dynamics), threats, and condition over time (Wagner et al., 2001). The following account describes how juvenile fish behave as they struggle to experience the new environment:

Juvenile fishes spend their early months in the mangroves from the spawning season, and they feed, learn to swim, and hide against predators. Most of these are released

to the ocean after three months to start independent life. They start approaching the ocean by swimming in the low waters, and slowly advance to high waters (13M/FMII).

The above account seems to affirm other accounts or representations which consider mangrove ecosystems to be areas for spawning (see section 5.2.1). It also affirms that such sites serve as feeding grounds for fisheries, including juvenile fish. We may learn further from the same account that the mangrove ecosystem serves as an extended arm of the ocean ecosystem, since most of deep water fish and other marine creatures (see the account given earlier by participant 7FMNII in section 5.2.2) visit such areas for spawning and other reasons (feeding inclusive).

The represented notions, ideas, and concepts of participant 13M/FMII may hardly be regarded as based on short time observations since he has practised fishing for 25 years. It depicts a process that is likely to have been observed for a long time before concluding how such juvenile fishes behave. It can therefore be said that these representations are based on inductive reasoning; since it starts by observing a single case, observing a relationship, then observing the same relationship in several more cases and finally constructing a general theory to explain the behaviour of juvenile fishes in the mangroves (Gilbert, 2008). In other words, the above representation deduces what has been proved through inductive reasoning to explain the events and processes that involve young fishes before they become independent or living on their own.

5.2.4 Species relations (contingent and necessary relations)

Represented notions, ideas, and concepts also depict a form of ‘substantial’ and ‘formal’ relations which may help us to understand how different species in the mangrove ecosystem depend on each other for existence or survival. Sayer (1992) raises the need for researchers to observe existing relations between different objects (e.g. mangroves and other biotic communities) in the social world, and specify whether these are ‘substantial’ (real) or ‘formal’ (not real). Substantial relations implies that one object cannot exist without the support of the other while ‘formal relations’ suggest that though there are no ‘real’ connections between one object and another, the two may share some common

characteristics (Danemark et al., 2002). Such relations may depict either internal and necessary characteristics, or external and contingent.

The relationship that exists between mangroves and mangrove-based fisheries can be described as being *substantial* rather than *formal*, since the latter rely entirely on the former for various *necessary* needs (including food, shelter, security, and spawning (see participants' accounts in section 5.2.1). Mangrove-based fisheries like the Red mangrove snapper are permanent to that particular ecosystem ; they feed, spawn, and shelter in the mangroves, and are thus dependent on them for their survival or existence as compared to mullet fish which are temporary residents (switching between deep water and mangroves). Fisheries, and earthworms that live in the mangroves may also benefit mangroves in different ways. Earth worms for example, aid mangrove species to absorb soil nutrients by turning and mixing the soil (Berjack et al., 2011). Some fish species such as cuttlefish, may also yield the same benefits as they routinely immerse in and out muddy soils between low and high water tides (see the account given by fisher 9FMNII in section 5.2.3 above).

Some fish may depict formal or non-substantial relations by spending time together in the mangroves, eating the same food, and spawning in the same ecosystem but without necessarily depending on each other for survival. In other words, they may share some common characteristics but still live independently. This is reflected in the following representations:

Fishes that visit mangroves have no enmity. They all go in there for survival reasons. These spend time together (11FMII).

Mullet species lives in harmony with other fishes in the mangroves (13 FMII).

Presented descriptions depict common characteristics as explained earlier, which may be referred to as formal relations. They also suggest intra-interactions between one mangrove-based species and another, and also inter-interactions between visiting species and resident species.

The relationship between mangroves and fisheries is based on 'natural necessity'. The kind of necessity that is discussed here is described in critical realism as having a natural

connection (Bhaskar, 1998). This form of connection is independent of humans and is not an artificial construct. It may become manifest to humans in experience (ibid.); although its knowledge depends upon a blending of intellectual, practical-technical and perceptual skills (ibid.).

Apart from relations that exist between mangroves and fisheries, or the former and other biotic communities, it may also be possible to view non-natural relations between coastal communities and mangroves (i.e. between humans and the mangrove ecosystem). As critical realists put it, for an *internal* and necessary relationship to exist, involved parts must depend upon each other for existence (Bhaskar, 1998; Sayer, 2000). Though humans are governed by social systems or laws, as opposed to mangroves which are governed by natural laws (ibid.), it is evident that the former relies on the latter in terms of food, building materials, firewood, protection from floods, income generation, and other social-cultural functions (see table 2.1 in chapter 2). However, this kind of relation may closely match a formal relationship or be contingent rather than substantial or necessary. This is possible because coastal communities may be evacuated in the event of natural disasters or any other reasons, to terrestrial areas and still survive; unlike fisheries which may directly be affected if moved to other ecosystems. This form of relation places humans as the key determinant of inter-connectedness between the mangrove ecosystem and activities that take place in the said ecosystem such as transplanting, harvesting, or protection. As participant 1MMNII puts it, (see section 5.2.2.1) past experiences in the study area reveal a change in humans' manipulation of the mangrove ecosystem from unfriendly to friendly relations (i.e. from mismanagement to management or protection), where mangrove users are now aware of the ecological-interconnectedness between them and the mangrove ecosystem to the level that may be considered formal; despite the fact that the two have varying characteristics (social versus natural).

5.2.5 Power relations among different actors and how this affects their learning

Events and experiences that are either apparent or not apparent to us are directly connected to powers and structures of objects that operate in a given context (Sayer, 2000). This implies that such objects (natural, social, physical or whatever is empirical to us) have capacities to act or behave in particular ways when their powers are activated (ibid.), and

may always have the potential to do the same when their powers remain inactive. Individuals and social groups such as fishers, mangrove restorers, local elders, and institutions also possess such powers whether as activated (causing them to act positively or negatively), or inactivated (having the possibility to act when enabling conditions emerge).

The power that individuals may potentially possess is centred on capacities or decisions that that particular person may engage in. This kind of power is sometimes referred to as ‘power one’ (Hartwig, 2007; Sayer, 2000 – see section 3 & table 3.1). The second type of power (power two) operates at hierarchical level such as institutional or Government structures (Foucault 1983; Sayer, 2000- see also section 3). “Powers can be possessed, exercised, or actualised” (Scott, 2010, p. 5). Possessed powers are potential powers that different objects have, whether they are ‘triggered’ by different factors or not (ibid.). ‘Exercised powers’ are powers that have been ‘triggered’ by circumstances and their effects may be observable in the mangrove ecosystem. When powers generate different effects in the mangrove ecosystem, it indicates that such powers have been ‘actualised’ and other powers have not acted against them (suppressed or counteracted them). Scott (2010) notes that powers may ‘act against’ each other and sometimes a combination of different powers may give rise to observable phenomena in the open system (ibid; Sayer, 2000) as discussed also in section 3. The following account gives a clear picture of the two types of powers and how these may generate effects in the mangroves ecosystem:

Patrols were introduced in the coastal area because people ignored government rules and orders. This was not the case in the past. Without any enforcement in place, some people would have continued to clear mangroves (26EMII).

The above description represents ‘individuals’ as having powers to resist or ignore existing rules or orders that come from ‘power two’ (Government). The effect of ‘power one’ appears to be observable or manifest in the mangrove ecosystem, as people exercise possessed power to clear mangrove species which are protected by the law. In response to the effects of individual power, the government through local government structures introduces patrols to protect mangroves from adverse effects. The latter seems to be effective to the level that limits the capacity of individuals to exercise their previous behaviours against mangrove species. Responding to this kind of situation, Scott (2010, p. 5)

argues that one form of exercised power may not give rise to observable effects or phenomena as other power (s) may “be acting against” it. This is also clear in the account represented by participant 19MMII below:

Mangrove clearance is now somehow controlled following a Government decision to initiate village environmental committees and also as the result of an increased level of awareness among coastal dwellers.

The represented description in the above context brings into view not only the invisibility of ‘power one’ as a result of ‘power two’ acting against it, but also the rise of another dimension of ‘power one’ which is reflected in Sayer’s (2000, p. 12) point, that when individual powers are activated and enabling conditions created, the “ignorant” may become “knowledgeable”. Increased level of awareness (resulting from interactions with peers, parents, and friends - see section 5.2.2.1) emerges as a dimension that operates in a friendly manner with ‘power two’ to generate positive effects in the mangrove ecosystem.

It is also important to note that causal powers are mediated through social agency, whereby coastal communities evaluate and re-evaluate their situation or personal concerns about various decisions that they are involved in, “by reflexively defining their doings” (Archer, 2010, p. 8). This seems to be the case when participant 1MMNII describes a shift from destructive mangrove practices to transplanting and restoration initiatives. In this example, reflexivity appears as a main mechanism or causal power that shapes the subjects’ decisions to embark on new practices and praxis, and in turn such decisions also shape the subjects simultaneously (ibid.).

Archer’s understanding of the subjects’ ability to shape and re-shape the social order while simultaneously being shaped by the same, suggests that individuals and social groups are likely to learn from the practices or praxis that they are involved in. This may cause them to transform their way of doing things or advance their understanding to the level that can be perceived by coastal communities as being different from the former. Arguing in support of Archer’s assertion, Mingers (2006) states that agents themselves are the result of the social activity that they govern, and through activities they reproduce themselves and transform. Describing further the role of reflexivity in various contexts; Archer (2010:6) states:

Reflexivity depends upon a subject who has sufficient personal identity to know what he or she cares about and to design the 'projects' that they hope (fallibly) will realise their concerns within society. Equally, it depends upon the objectivity of their social circumstances, which under their own (fallible) descriptions, will encourage them to follow one course of action rather than another (p. 6)

From Archer's description, it is possible to argue that mangrove restorers like any other subjects who have personal identities, follow several courses of actions such as restoration practices for reasons that they consider to be addressing the 'objectivity of their social circumstances'. Participants 1EKII and 11FMII (see section 5.2.1) for example, represent mangroves as famous nursery grounds, a source of food, and shelter for a variety of living things. Participant 1MMNII (see section 5.2.1) describes them as playing an ecological role (protecting the coast), and used for economic purposes such as boat making, and participant 8 BKEII calls them 'a common market' place (see section 5.2.7) where a variety of ecological biodiversity meet. Berjack et al. (2011) confirms the social-cultural, ecological, and economic roles of mangrove resources. These therefore serve as the 'objectivity' that drives individual and group decisions to reflexively embark on coastal management initiatives.

The identified 'objectivity' therefore serves as common goal and a collective experience which encourages knowledge sharing, shared understanding, trust, and leads to new knowledge (Lebel, Grothmann & Siebenhuner, 2010). This kind of environment attracts social learning, which according to Collins et al., (2007) promotes concerted action, leading to a common end. This affirms the common critical realist view that individuals or social groups "in virtue of their physical make up, socialization, and education..." have power (capacities) "... to behave in particular ways" (Sayer, 2000, p. 11). When such powers are activated, they engage themselves in various activities (ibid.).

Exercising such power depends on other conditions such as "...tools, resources, and the context itself" (Sayer, 2000, p. 14). This is what the following participant is communicating below:

Initially, we did not have any form of organised group work as it is the case now; people would operate individually and this was the time when a lot of mangroves were being cleared. But after sometime Tanga coastal zone programme invited us to

several seminars, those who participated helped the rest of us to organise ourselves as a team (1MMNII).

Enabling conditions therefore may include training (capacity building), such as seminars, workshops, and meetings that aim at equipping target participants with the necessary skills and knowledge that may help them to plan how to approach the 'objectivity' or a desired need. Provision of enabling conditions as specified by Sayer (2000, p. 14) depends on the context. Resources may also include traditional skills and knowledge (Berkes 2008) that coastal people have, or their moral support for initiatives that focus on agreed 'objectivity'.

The description given by participant 1MMNII is essentially representing institutional and organisational training as a form of social learning that can facilitate 'collective action around common environmental concerns' which is one of the typologies that Cundill & Rodela bring into view (2012, p. 20, see sections 1.7.5 and 2.2). This typology considers processes that allow people to interact, share perspectives and experiences, plan or strategize for purposes of achieving a collective desired goal as a form of social learning. From this, it may be argued that the occurrence of capacity building as a form of social learning depends on enabling conditions that are available in a particular context. It may, for example, depend on the economic profile of local communities, and the presence of mangroves and fisheries in the area. It may also depend on the willingness of coastal communities to participate in such programmes.

Individuals in the coastal environment have the potential to become mangrove restorers or fishers. When these engage themselves in the practice (e.g. mangrove restoration), and we observe positive results in their practice or praxis, we may assume that their powers have been actualised and are not suppressed or counteracted by other powers. If, for instance, the initiatives they have introduced operate for a while and come to an end, it may be assumed that their powers might have been suppressed by either higher powers or powers that operate at the same level.

Different powers may therefore be activated, actualised or exercised as a result of enabling conditions, but this does not guarantee that activated powers may not be suppressed by other powers. Sayer (2000, p. 12) affirms that when powers are activated, and enabling

conditions met, “we could become many things which we are currently not: the ignorant could become knowledgeable”. From this, it is possible to identify another typology of social learning (currently absent in the Cundill & Rodela (2012) typology) which is ‘learning as becoming’ (Wals, 2007; Schudel 2013). As argued by Minger (2006), agents themselves are the result of the social activity that they govern, and through activities they reproduce themselves and transform. While this study did not work with Bhaskar’s dialectical critical realism, his 1993 work on dialectical critical realism, while not stated in these exact words, shows that reflexive social learning involves an ongoing process of becoming (Hartwig 2007; Lotz-Sisitka 2012; Schudel 2013).

There is a recurring depiction of learning as knowledge sharing (being a key aspect of learning as becoming’) in this context, especially when participant 1MMNII indicates that those who participated in the training shared their knowledge with those who did not take part in the same. Another feature of ‘learning as becoming’ as noticed in this case study is participants being able to visualise alternative practices, and being willing to work together and learn from each other as depicted in the statement of participant 20MMII which says “... those who participated helped the rest of us to organise ourselves as a team” and “Then we transplanted seedlings in affected areas and urged other people such as friends and relatives to join us”.

It is also worthy to note that powers may be passive and susceptible to change (Sayer, 2000). Sometimes powers exercised by individuals or social groups may not give rise to any observable phenomenon as other powers may “act against them” (Scott, 2010, p. 98). The account given by a retired fisher below, suggests a change that results from a new higher form of power operating in the coastal area:

Our fore-fathers used traditional fishing gears which were generally much friendlier than the ones we see now. These would allow reproduction of fish and some species could grow up to the level that only three people could manage to carry and put them into the fishing vessel. When we grew up, that’s the kind of fishing gears we got introduced to. Currently, the fishing industry is focusing on quick gains and it appears superior over traditional fishing. (9FMNII).

More insights can be drawn from the above representation. The first thing to note is the emergence of new structures that have causal powers to promote modern fishing at the expense of common traditional fishing practices. Some higher powers appear to limit traditional fishers from exercising their long-term fishing experiences, and local fishers feel that they can't compete with modern fishing methods. There is also a seeming threat to the long-term 'shared knowledge' which is regarded by local or traditional fishers as being 'friendly' and sustainable.

5.2.6 Ecological concepts and processes that occur in the mangrove ecosystem

Representations that depict ecological notions, ideas, and concepts may potentially help us to understand various ecological processes, and how these have changed over time from one generation to another. Understanding the meaning that coastal people attach to ecological processes may help us to comprehend not only how those ecological processes occur in the mangrove ecosystem but also underlying structural relations that influence them (Danemark et al., 2002).

5.2.6.1 Naming of mangrove species and description of their ecological niches

Coastal communities seem to be familiar with a variety of mangrove species in their area, and how these 'selectively' grow or locate themselves in the mangrove ecology. Some species grow near the shoreline while others grow either next to other species or in other locations within the same ecosystem. Participant 1EBKII who has lived in the study area for over 40 years presents the following description:

Our mangrove forest harbours nearly 8 species but I am familiar with 6 of them. These are arranged in an orderly manner from the shoreline to the area that borders human settlements. Mangrove species that border the high water mark are locally called Mpia (Sonneratia alba); next to Mpia you will see another species commonly called Mkoko (Rhizophora mucronata), followed by Mkandaa (Ceriops tagal), Mkomafi (Xylocarpus granatum), Msinzi (Bruguiera gymnorhiza), and Mchwi (Avicennia marina). Mkoko (Rhizophora mucronata) are dominant species; they are dominant because they grow faster than other species, and are not directly exposed to ocean waves because they are protected by Mpia (which faces the ocean). Their seeds are thus not carried away by waves as it is the case with mpia species. This makes them dominant. The term Mkoko applies to a single species (singular) while 'mikoko' refers to their plural form. 'Mikoko' species are located in muddy areas which favour mangrove growth. Their seeds hang head-long up to maturity level, and when wind blow or other factors shake the plant, their sharp headlong seeds pin themselves into

muddy soils and grow. Mkandaa species (Ceriops tagal) are likely to be rare, as these are mostly cleared for construction at household level. There is also an increasing demand for Mchwi, Mpia, and Mkomafi as either material for boat making or scaffolds for the same.

Expanding on what participant 1EBKII has explained above, participant 8BKEII who has also lived in the study area for over 40 years describes the behaviour of mangroves species in the following way:

Mpia species (Sonneratia alba) tends to separate itself from other mangroves species. This particular species grows extensively and yields round fruits (distinct from fruits of other mangrove species). Its leaves are roundish and somehow wider than Mkoko (Rhizophora mucronata) leaves which have sharp angles. Coastal fishers use Mpia species for boat making. Unlike Mpia, Mkoko species, locate itself close to other species. I brought samples of some mangrove species to show you; this is Mkoko species, and you may tell from its leaves that the plant is approaching flowering. This is its seed with a cover on top (which increases in size as the seed matures). This is another mangrove species locally called Msinzi (Bruguiera gymnorhiza). It has long and broad leaves. This species has characteristics which closely match those of 'Mkomafi' (Xylocarpus granatum), and it grows close to other mangrove species and may exceedingly increase in size depending on conditions that prevail in its environment.

The above representations suggest that some ecological characteristics and processes are apparent to coastal people and may be described, explained, related and shared with other individuals and social groups. Both accounts seem to suggest that coastal communities are well versed with ecological concepts, terms, and processes that determine species distribution and interaction in the mangrove ecosystem.

Participant 1EBKII for example, represents notions, concepts, and ideas which indicate why *mkoko* species are dominant in the mangrove, and how the same relates to other species. According to the participant's account, the *mkoko* species are dominant because they use other mangroves species like *mpia* as a shield or barrier against strong ocean waves or wind which may carry their seeds away and place them in locations that have no favourable conditions for such species to grow. Another reason for their successful growth is their tendency to prefer rich muddy soils, which differs from the locations of other species such as *msinzi* (*Bruguiera gymnorhiza*) and 'mkomafi' (*Xylocarpus granatum*). Such explanations make "conceptual distinctions between occurrences and phenomena" in the mangrove

ecosystem (Danemark et al., 2000, p. 44). Their descriptions specify relationships between different mangrove species according to what is apparent to them, how such experiences are connected to events that are actualised, and the specification of underlying mechanisms that produce activated events in the mangrove area.

Table 5.1: Naming of mangroves species and description of their ecological niches

SN.	Local name	Features/characteristics as described by mangrove restorers
1.	Mpia	Green mangroves found near the shoreline, most fishes feed on its roundish small fruits in the rainy season.
2.	Mkoko	Dominant species found in muddy-fine sediments. The species locate themselves behind <i>Mpia</i> species and are therefore safe from direct ocean waves. The term 'mkoko' is also generally applied to other mangrove species in the study area.
3.	Msinzi	Have large leaves and are found in intertidal areas that contain fresh water and sea water characteristics
4.	Mkomafi	Bears brown/green fruits with rough barks. They have round fruits bigger than those that are found in other species. These species are located in the intertidal areas that have sea and fresh water in the study area.
5.	Mkandaa	Evergreen plants with clustered twigs found in well drained soils.
6.	Mkandaa-dume	Green plants found in landward areas of high salinity at Moa and Boma. The plant is widely used for boast making)
7.	Mchu	Tend to separate itself from other species by growing close to terrestrial plants. They are common and fast growing

Source: *Field data (in-depth interviews and Focus Group Discussions): see their scientific names in chapter 1 (table 1.4).*

5.2.6.2 Naming of mangrove-based fisheries and description of their habitats

Descriptions that result from processes of abstraction may also help us to understand different names that fishers attach to fisheries, get a glimpse of fish habitats, and reflect on how these species behave in and around their habitats or interact with other species in either contingent or necessary relationships (Sayer, 2000). Participant 11FMII who has

practiced fishing for 45 years shares his ecological fishing knowledge in the following description:

Mangrove-based fisheries include; Unga (Red mangrove snapper), Chewa (Grouper), Mkizi (Mullet), Dome (Cuttlefish), and Tembo (Black spot snapper), but there are other species such as 'Madizi' and Kolekole (Longrakered trevalley) that just visit mangroves sites during high water tides and retreat to the ocean at low tides. Mangroves are homes for juvenile fisheries, prawns, and many minute creatures. These leave in special holes and under stone shelters before advancing to the ocean. Some live in muddy areas beneath mangrove roots such as Mkizi, Dome, Chaa (Silver-biddy), and Kikotwe (Snubnose pompano). More fisheries enter mangroves areas in the rainy season, than any other time of the year. 'Paramamba', Unga, and 'Chachi' are among common species that enter mangrove-water during that time. Some of these species remain in the mangroves in special holes and sites that allow them to hide until the end of the rainy season. Mangrove fish share this common feature; they all use mangroves as places that offer opportunities for food and shelter. Some juvenile fish use them for protection against their predators. Fish lay eggs under stony sites in the mangroves, thereafter, juvenile fish are hatched. They stay in the mangroves for some few months and start swimming towards the ocean. They swim slowly as they approach varying levels of water and advance gradually until they are able to swim properly.

Naming of species that use mangroves as a temporary or permanent habitat, and elders' descriptions of ecological concepts and processes may serve as an important knowledge base for coastal communities, individuals and social groups who are involved in mangrove restoration and fishing practice or praxis. The above representations therefore serve as a platform for knowledge transmission to not only indigenous coastal people, but also to scientific institutions, policy makers, and planners at the local level.

Table 5.2: Naming of mangroves based fish species and description of their interactions

SN	Species: Local name	English/scientific name	Availability or presence in the mangrove
1.	Paramamba	Not identified in the FAO species identification sheets	Temporary but on regular basis. They are currently described as rare (see section 5.2.9.1)
2.	Unga	Red mangrove- snapper	Uses mangroves as their permanent habitat: spawns, feed, and spend their lives in there.

3.	Chewa	Slender grouper	Uses mangroves as permanent habitat.
4.	Dizi	Not identified	Uses mangroves as permanent habitat.
5.	Chaa	Silver-biddy species	Uses mangroves as permanent habitat.
6.	Mkunga	Not identified	Lives in mangroves that have rocky sites
7.	Kikotwe	Snubnose pompano	Visits mangroves on temporary basis
8.	Chafi	Spinefoot species	Uses mangroves as permanent habitat
9.	Tembo	Blackspot snapper	Uses mangroves as permanent habitat.
10.	Nduwalo	Black marlin	Visits mangroves in some months of the year
11.	Mkizi	Mullet species	Pays regular visits to the mangroves especially in the rainy season.
12.	Midu/Mwidu	Not identified	Uses mangroves as permanent habitat.
13.	Dome	Cuttlefish	Uses mangroves as permanent habitat
14.	Kisumba	Not identified	Lives in the mangroves at juvenile stage only
15.	Funda	Not identified	Uses mangroves as permanent habitat
16.	Kangu	Not identified	Uses mangroves as permanent habitat
17.	Kaa	Crabs	Uses mangroves as permanent habitat
18.	Chanje	Not identified	Uses mangroves as permanent habitat
19.	Kamba-wadogo	Prawns	Uses mangroves as permanent habitat
20.	Mswele	Not identified	Uses mangroves as permanent habitat

Source: Field data (in-depth interviews and Focus Group Discussions).

Descriptions that indigenous coastal people give, sometimes carry figurative language which may carry important messages and which they intend to communicate to the social world (Martinez et al., 2001). These are commonly referred to as ‘metaphors’ and are described further in the next section.

5.2.7 Metaphors that shape ecological descriptions

Descriptions that fishers, mangrove restorers, and local elders give as they engage in processes of abstraction and conceptualisation have the potential to yield representations of notions, concepts, and ideas which depict ecological ‘metaphors’.

Insisting on the need to consider the importance of metaphor in knowledge or learning, Andriessen (2008) states as follows:

Metaphors play a crucial role in the conceptualisation of abstract concepts, that they highlight characteristics and hide others, and that they can fool us when we take them as literal...Knowledge is also an abstract concept (p. 7)

Martinez et al. (2001) argue that metaphors are not just mere figures of speech, but rather essential mechanisms of our mind which enable us to lens various phenomena from a specified angle. They are regarded as blueprints of knowledge and learning which need not to be ignored by researchers (ibid.). They are therefore important communication tools which can help us understand deeper represented ideas or knowledge about ecological processes and interactions in the mangrove ecosystem. In this study, they are particularly important because it is said by critical realist researchers that they are an essential element of learning and cognition as

... embodied experience generates iconic models ... [which] ... provide the basic conceptual templates for 'image schema's' underlying thought ... Image schemas permeate cognition in large part by being extended metaphorically to *abstractions* at various levels ... [such] ... Image schemas provide the means by which we are able to conceptualise objects of investigation that we cannot perceive directly, particularly relationships amongst things ... According to critical realism, images and metaphors are essential to scientific theorisation; cognitive science not only verifies this point, but also demonstrates that it holds at the most fundamental level of thought ... [and is also central to learning and meaning making]. (Nellhaus 2007, cited in Hartwig, 2007, p. 67)

Of interest to the points made above about metaphor in meaning making, processes of abstraction and learning, and to the findings reported below in my study, are the findings of Davies (2009), Shava (2008), Mukute (2010) and Masara (2010) – all southern African environmental education researchers working on various aspects of social learning in community-based natural resource management contexts. They have all found that metaphor is an important means of representing TEK and indigenous knowledge in social learning processes, and that the use of metaphor assists with the communication of understanding (i.e. abstraction and representation of knowledge) and meaning-making. Their work reflects too that metaphors were often used to 'share knowledge of relationships amongst things' in southern African contexts.

The use or application of metaphors in this study is reflected in the description given by participant 8BKII (see participants' codes in chapter 4, section 4.9), who describes mangroves in the following manner:

Mangroves are like a 'common market' where different fish species meet; it is a meeting place for predators, fish that hide from predators, juvenile fish, and spawning fish (.....anaetafuta yuko pale, anaetafutwa yuko pale, wanaozaliwa wako pale, na wanao zaa wako pale).

The metaphor 'common market' is employed to describe the magnitude of interactions and processes that take place in the mangroves; involving fisheries that visit that particular ecosystem for various reasons. A market place is usually a place which brings together sellers, and buyers, and specified kind of goods. The prefix 'common' suggests 'continued' or 'permanent' interactions which involve large numbers of species. The said metaphor helps us to understand events and experiences that occur in the mangroves, and how these succeed each other in a complex or open environment.

Participant 8BKEII pictures the mangrove as a busy environment where a series of events take place, triggered by different drivers. Predators for example, visit mangroves to prey on other fish species, juvenile fish spend their early months in the mangroves before they swim to deep water, some fish are there for spawning reasons, and others join such interactions for feeding on mangrove fruits. Metaphors therefore may help us to understand structures and causal powers that generate various effects that may or may not be observable in the mangrove ecosystem. According to Sayer (2000, p. 11), structures and powers refer to the "capacity" of objects "to behave in particular ways". This implies that predators may behave differently from fish that visit mangroves for spawning reasons. The former may also behave differently from fish that feed on mangrove fruits. This is possible because according to several fishers' accounts, mangrove fruits are only available during a specified time of the year (see a general observation from the fishers' focus group discussion in section 5.2.3). This suggests that fish that visit such areas are mainly attracted by fruits and may thus be categorized as 'temporary visitors' to the mangroves; possessing different structures and powers which are actualised to determine their movements and interactions with other species at specified times of the year.

Some metaphors may aim at describing species diversity and how these interact in the mangrove ecosystem. The following fisher's example reflects a synonymous representation between fish diversity and human ethnic groups or tribes:

There are different fish species with varying from each other. They are like human beings (us) who are categorized in terms of ethnic groups or tribes but are all called humans (13M/FMII).

The above metaphor or figurative language is used by participant 13M/FMII to help us avoid conflating different kind of fish species into one group or category. It raises the need to consider specific kinds of fish and structures or powers that determine their interactions with other species in the mangrove ecosystem. The participant is essentially raising the need for understanding different fish behaviours, for purposes of identifying the kinds of effects they generate on the mangrove ecosystem when their powers are activated or triggered.

Participant (13M/FMII) in the same interview adds “...fishes like human beings live in different habitats”. By this, he intends to communicate the message that there are species that live in the deep sea and may not be found in shallow waters. It also suggest that some fish species spend their entire life in blackish water or in the mangroves, and some may be found moving across different ecosystems (Berjack et al., 2011), while others like juvenile fish spend part of their life span (early months) in some nearby mangroves and when they are fully able to swim and live independently (as indicated by the same participant in section 5.2.3), may spend the rest of their lives in coral reefs, shallow waters, or deep sea.

There is also another example, represented to us by the same participant in his attempt to describe how juvenile fish enter deep sea waters after vacating nursery grounds (mangroves):

Juvenile fish go through three stages before they leave mangrove areas. In the first stage, they spend their early days feeding in the mangroves, and sometimes are unable to swim to other parts of the mangroves if they are too young. In the second stage they start moving gradually to deep mangrove water and approach shallow sea waters. In the third stage, they enter deep sea water like inmates who have finished their jail sentences (13M/FMII).

The above representation suggests the presence of an orderly manner of events which is dependent on natural causal structures (Bhaskar et al., 2010) that generate effects between the mangrove ecosystem and deep sea water. These may or may not be observed or experienced by coastal communities (Sayer, 2000). In this context, fishers are likely to have sensed how actualised powers of juvenile fish trigger their movements from mangroves to deep water. The metaphor '*...like inmates who have finished their jail sentences*', suggest that as long as natural powers are still determining structural development and movements of juvenile fish, the young fish are bound to existing natural rules. These natural rules which are far from human constructs (Bhaskar, 1998) may allow other natural powers that have been triggered, to determine further interactions or movements from one stage to another. When this is reached, juvenile fish may be seen advancing to higher water levels in contrast to their previous behavioural stages, as participant 13M/FMII relates. It may also imply that higher powers (natural hierarchical structures) may act against individual powers (powers that juvenile fish have) and limit the process or mechanisms that cause them to be actualised or triggered (Scott, 2010), until the right time.

Metaphors that emerge from the mangrove context are therefore 'image schemas', 'blueprints' or abstractions which carry meanings that may be far reaching, which may help us to understand better the magnitude and level of events and relationships between things that are represented by the two participants (13M/FMII and 8BKEII). The metaphor that likens juvenile fishes to 'inmates' who are only released after their jail sentence, communicates to us an important ecological message that juvenile fish at their tender age use mangroves as the main habitat, and are not able to swim to high waters, avoid predators, or provide for themselves freely in the environment that has a high level of competition. They are thus obliged by the rules of nature to spend their juvenile life in locations where food can freely be accessed, rest is assured, security is assured, and trial and error life is possible for a specified time, and they can thereafter advance to other cycles. This metaphor therefore suggests that there are rules or structures of nature that govern natural events like fish spawning, feeding and growth. These are responsible for generating the events and experiences that are apparent to coastal communities. The metaphor also suggests that experiences that take place in the coastal environment can

provide learning spaces to communities that live near coastal ecosystems, to the level that allows them to compare what is happening in the coastal ecosystem (like mangroves) and what is experienced in normal human life (like the human legal system). It also suggests that natural structures are synonymous with agential structures in that they both constrain and enable particular conditions to operate or occur.

On the other hand, the 'common market' metaphor depicts a scenario of necessities, where fish like human beings, go to a specified location (mangroves) to access key ecosystem services such as food and other necessary amenities. Dwelling on previous representations from (participants 1EBKII, 8BKE11,1MMNII and 13M/FMII see section 5.2.1) which as specified earlier, are confirmed in the scientific literature (Faunce & Serafy 2006, Berjack et al., 2011), mangroves are sites that offer a variety of ecosystem services. They are therefore sites that guarantee fish survival just like the 'common market place' which is a reliable source of food and other key needs for human beings. Available literature indicates that mangroves are not only homes to fish, but to a variety of birds such as the little egret, the great egret, the heron species such as grey, goliath, and green-backed; reed and white-breasted comorant, the kingfisher species such as malachite, pied, giant and gangrove; the hamerkop, and wood sand piper species such as common and wood (Berjack et al., 2011). Some of these birds, especially the giant king fisher and grey heron, prey on juvenile fishes (ibid.), which also confirms the assertion made by participant 8BKEII earlier that the 'common market' involves predators as well.

The last metaphor presented in this section is intended to communicate to us a change in juvenile fish behaviour as a result of human interference with nature.

The fisher (participant13M/FMII) notes that in the past, fish species illustrated a friendly atmosphere by swimming close to humans (fishers), freely enjoying the ocean or swimming near mangrove sites without fear, but now they flee for their safety upon seeing a human shadow:

Even juvenile fish flee when they sense that someone is approaching; they think like human beings and assume that they are about to be caught or trapped..... (laughing)... I think such a fear is caused by dynamite blasts.

The above metaphor '*juvenile fish... think like human beings*' carries deep reflections. It assigns some kind of personification to fish; as if they are able to assume, think, and sense danger in the same manner that humans do. This seemingly human ability is regarded by the participant as a recent behaviour which could scarcely be observed in the past, and he ascribes such fish fear to dynamite fishing (an illegal fishing technique which causes blasts).

Dynamite fishing destroys coral reefs and ecological sites, and kills a variety of vertebrates and invertebrates (Wagner et al., 2001). Repeated dynamite blasts may generate fear amongst surviving fish - hence behavioural change. The above metaphor therefore helps us to learn that though natural laws are independent of agential structures, human agency can interfere with natural systems either positively or negatively leading to new behavioural fish patterns; which may be apparent to fishers. A positive intervention occurs when nature is not interrupted, or when there are structures in place that restrict human interference and encourage nature regeneration, or manipulations such as transplanting (see section 2.6.2 in chapter 2). An example of a negative pattern of human-nature relations is the use of unsustainable fishing gear as seen in the fish like human being metaphor.

5.2.8 How weather influences fish catch and interactions

Mangrove fishers are fully aware that changes of weather in different seasons of the year affect fish catches either positively or negatively. Their day-to-day fishing experience helps them to distinguish conditions which encourage high fish catches from those that encourage low fish catches in the mangrove area.

The following illustration indicates how fishers attribute events and experiences to mechanisms and structures that generate them; an approach which helps them to avoid confounding factors and devise better or more correct approaches to emerging challenges in the mangrove fishing context:

Fishing activities are controlled by wind seasons; we experience low fish catch when the water temperature is high, and a good catch when at its optimal level. There are different seasons for different kind of fish species, some prefer cold weather and others favour medium weather conditions (13M/FMII)

The above description provides insight into understanding how indigenous fishers develop fish-catch theories that guide their practices and help them to explain and account for various phenomena in the mangrove ecosystem.

Participant 13M /FMII, who has worked in artisanal mangrove-based fishing for 25 years, shares what he believes to be a 'general rule' or theory which guides fishing practices in the study area throughout the year. He also sheds light on the existing relationship between wind and fish catch; temperature and fish; seasons and abundance or decline of fish; and weather patterns and fish dynamics. Specifically, his account capitalises on the fact that fish catches are determined by seasonal variations of wind, and underlines the role of temperature and rainfall on fish abundance and decline.

The role of temperature and rainfall on fish interactions in the mangrove ecosystem is also depicted in the following description:

Mangroves attract mullet species (mkizi) for many reasons, first, the temperature seems to be optimal in the mangroves than in the ocean, secondly, some mangrove fruits like Mpia (Sonneratia alba) shed their fruits at that time of the year and visiting fisheries feed on those fruits (Fishers' Focus Group Discussion held at Moa Village, March 2012)

It is indicated in the above description that fruits that fall from the *mpia* species which attract mullet fish, are more available in the rainy season than at any other time of the year. This suggests that precipitation (rainfall) as an element of weather, is among key determinants (mechanisms) which cause or increase fish movements from the ocean to the mangroves. Temperature variations as suggested in the same description may attract fish interactions as is the case for the mullet species.

A study conducted by Ibanez & Benitez (2004), confirms that wind speed and water temperatures affect fish movements. The same study investigated the claim raised by local

fishers in the north western Gulf of Mexico that local fish species commonly known as *flathead-mullet* do spawn when they are stimulated by north winds. The findings later concluded that a change in the north winds reduced the water temperatures in the coastal lagoon and stimulated *flathead-mullet*' spawning, as had previously been explained by the local fishers.

Another study by Ayub (2010, p. 6) confirms that "changes in rainfall and temperatures altered the catch of some fishes" on the coast of Pakistan. This disqualifies claims that indigenous knowledge is necessarily vague or not specific, and proves that such knowledge may be useful and relevant to the coastal environment.

5.2.9 Historical representations of the mangrove ecosystem

Processes of abstraction may help us to understand past events and experiences, and therefore inform the way we plan ecological practices or initiatives. What is going on now in the mangrove ecosystem may hardly be expressed retrospectively if notions, concepts, and ideas that underpin the essence of restoration activities are ignored. Abstract-conceptualisations that lead to representation of past relations between humans and the environment may potentially help individuals and social groups in understanding both the said ecology, and its inter-connectedness to coastal communities. Below are accounts represented by local elders on the status of mangroves in the past 30 years as compared to now:

The coastal strip was once covered with beautiful mangrove species, straight and thick. You cannot compare what we see now and what we saw by then. There was no unsighted clearance of species. People observed the law and obeyed government instructions. Two government officials used to visit this area twice a week to ensure that mangrove cites remained free from human destruction. These were specifically appointed for this area; they lived just near the locality's headquarters. This increased the level of discipline among people; that is why mangroves flourished to a promising level in that particular time. After sometimes, we started to witness some commercial activities in the mangroves; such as selling of tree-barks across the country border and salt making projects (1EBKII).

In the past (over 30 years back), this mangrove forest appeared thick and very dark. One could hardly walk freely in there as it is the case now. Mangrove species looked healthier then than now. There was no any sign of destruction. We now see bare spaces in it (10EMII).

When I was a youth, there were a lot of mangrove species in this area. The forest extended up- to the harbour area, and covered the entire coastal strip. What we see now is in fact what was left after incidences of mangrove clearance for salt making, firewood, building poles. The forest looked healthier and better than now (23EMII). This area used to be covered by many mangrove species. There was no any unsighted mangrove clearance; people feared the colonial Government, and they observed the law without turning right or left. Currently, such observance of the law is done away with. People decide on their own what to do in the mangrove area and what not to. That is why there are more patrols now than in the past (26EMII).

Representations from the above elderly participants suggest a decline in the health status of mangrove species in the study area and their coverage, as compared to the past. The past in this context goes back to colonial times (see the account given by participant 26EMII), and after independence (see the account given by participant IEBKII) when the forest was thick and extensive in coverage up to areas that now remain bare due to unsightly clearance. The 'past' that the elders' accounts allude to, is different from the 'past' that a middle aged mangrove restorer describes in the following account:

I can see the difference between the mangrove forest that I saw some years back and the current one. The previous mangrove status was bad due to human induced threats. In the past, we cleared the forest for charcoal making, construction purposes, but are no longer engaged in such destructive practices...we are now focusing on restoration (1MMNII).

Participant 1MMNII seems to have not seen the 'thickness' and 'extensiveness' of the mangroves coverage from the colonial era up to some years after independence (1961). She however, appears to have witnessed the era of 'lawlessness'; when some members of the coastal communities disobeyed the existing laws and began to clear mangrove species for salt making and other commercial purposes. According to Foucault (1983), power as a relationship includes the possibility of resistance. Those who are subject to a particular kind of power, can resist what is imposed on them or fail to comply with existing rules or structures. This appears to be the case in areas where the prevalence of mangrove clearance is evident.

There are several observations that can be made from the given representations from both sides. The description affirms that experiences that form the empirical domain in the study area are 'apparent' to coastal communities, and may clearly be sensed, distinguished, and

sometimes justified or disqualified by people who experience them. It also indicates that experiences cannot be regarded as operating in isolation. They are normally connected to particular kinds of events (domain of the actual). This is the case when the said participant extends her sharing to include unsustainable events that were being carried out in the past, which according to her account mark the distinction between previous experiences and what is being experienced now; and also give rise to some possible reasons or factors that caused coastal communities to clear mangroves (domain of the real).

The account given by participant 1MMNII depicts a change in understanding, seeing things differently, and acting differently. This change suggests a learning scenario where people who were once embracing unsustainable practices are now prioritizing restoration activities. She employs the term 'we' to suggest that this particular change also involves other members of the coastal communities in the study area. In the past the focus was more on economic gains than ecological aspects; but now people seem to have a clear understanding of things which were not clear to them in the past. This confirms the occurrence of social learning; and as Wals (2010) puts it, learning leads to understanding and performing things in a different manner than before.

Processes of abstraction may therefore help us to uncover, not only the near past but also long-term ecological trends which are necessary for informing current ecological management practices and experiential learning interactions.

5.2.9.1 Historical representations of mangrove-based fisheries

Representation of abstracted and conceptualised concepts or notions may potentially help us to access the historical background of mangrove-based fish species from retired fishers, or people who are familiar with past fish interactions in the mangrove area; who are also able to compare what they see now and what they saw over 30 years ago. Such knowledge may help coastal communities to understand and compare fish trends (e.g. abundance and decline); the availability and disappearance of species; past human and ecosystem relations; competing socio-ecological processes; and drivers that determine such events or processes. Participant 9FMNII who is a retired fisher observes a change in fish abundance by sharing the following description:

There were more mangrove-based fisheries in the past than now. The number has gone down probably due to increased fishing activities in our area. In the past, one could fish between 3000-4000 species using a mere traditional gear. That can hardly happen now. Another reason for the decline could be the use of dynamite and poisons by some fishers. 'Paramamba' species which used to be abundant in the past is now either rare or has disappeared in some places. I suspect that the newly introduced modern fishing gears commonly known as "Ring-nets" are the cause. These have also affected deep-water fisheries and even those which used to visit mangroves in the rainy season.

The represented account provides a general observation of fish trends over time, and suggests a decline and disappearance of some mangrove-based fisheries due to human-induced factors such as the use of unsustainable fishing gear (e.g. poison and dynamite). It also raises the issue of the failure of traditional fishing techniques to compete with the modern fishing industry due to the pace and power of the latter in the coastal fishing. According to him, the challenges that coastal fishers experience now are largely associated with the dominance of modern techniques in the fishing industry. His views are supported by another elderly fisher who shares the following:

There is a sharp decline of fish in this area. I guess the situation will be worse in future. Educated intruders have joined the fishing industry; these have introduced a variety of fishing gears for every fish species. This is the cause for declining fish stocks in our area. Our traditional fishing techniques allow fish to reproduce, and are not as destructive as the modern gears (10 EMII).

The term 'educated intruders' suggests some form of knowledge competition between long-term knowledge (traditional ecological knowledge) and formal knowledge. Like participant 9FMNII, the above participant attributes the problem of fish decline to formal or modern knowledge and skills. Foucault (1983) argues that knowledge and power are intimately linked. The two fishers seem to acknowledge the power of modern knowledge over traditional knowledge. This kind of power operates in the coastal areas to subject other forms of fishing knowledge in the fishing industry; and according to participant 10 EMII, it has the potential to prevail in the future (when the situation is expected to be worse).

Foucault (1983) also compares 'power' to a capillary which flows throughout the 'social body' and not necessarily emanating from higher levels. Modern fishing and traditional

fishing have always operated at the same level without creating a subject and subjectivity relationship, or one of them competing to produce any kind of subject. In any competing environment there is a winner and a loser. This stands as an inevitable challenge to traditional fishing as alluded to earlier by participant 10EMII.

5.2.10 Attributes and indicators that define the health status of mangroves and fisheries

Descriptions that fishers, mangrove restorers, and local elders give through processes of abstraction and representation have potential for helping them to develop useful frameworks or plans, which may potentially guide ecological management activities such as the monitoring of natural resources (Berkes, 2008; Reed et al., 2006; Parlee, 2005b). Their ways of observing and assessing mangroves and fish species may provide qualitative insights that build on holistic pictures of the attributes or indicators of ecosystem health (Berkes 2008; 2012), which may serve as an important tool for steering experiential learning in coastal environments and enhance interactions that are necessary for steering social learning (Cundill & Rodela, 2012), at a wider level.

Indigenous descriptions of the health status of mangrove species and fisheries are based on empirical manifestations of the generative effects that are triggered by natural rules and structures; which may not be manipulated or constructed by humans (Bhaskar, 1998), but can be experienced and described. This section therefore indicates how research participants describe the health status of mangroves and fisheries; and how such traditional ecological knowledge may be used to develop a framework of attributes/ indicators that are based on indigenous understanding of the mangrove ecosystem.

Below are responses to the question: *“How would you identify a healthy mangrove species from unhealthy one; and what would you cite as determinants of good health versus poor health?”*:

You look at the roots whether they are damaged or not, the stem, epical bud (if it is removed the plant cannot grow), plant width, and leaves if they appear good or not – (3MMNII)

A mangrove plant like this (touching it) is in a good health. Its leaves are green, but that one (pointing to another plant some few metres away) is not. – (1MMNII)

You look at plant leaves, the stem, straightness of the plant, and if there signs that indicate damage. Leaves in their normal state must appear evergreen or green. Other colours such pale, red, and yellow suggest that there is a problem (17MMII).

You look at the type of soil, invasive species, human induced threats like the digging out of roots, and availability of creeping creatures. Muddy and black soils are rich while rocky, reddish, or yellow, and dry soils are poor (19MMII).

To me good indicators are branches, roots, availability of creeping creatures (which may disturb the roots), the stem if it appears good (not dry and too thin), whether there are dried or drying leaves and nearby plant species, availability of stumps, and the type of soil type. Soils must not be rocky because such cannot allow penetration of roots (20MMII).

Indicators of a healthy plant is good soil, and new leaves, good branches, undisturbed roots, free from harmful waste, free from unfriendly creeping creatures (24MMII).

If the area has mangrove stumps, charcoal kilns, and saltpans then it is threatened and therefore not healthy (5MMNFG).

The presence of solid waste cause problems to young plants and inhibit their growth (1MMNII).

Mangroves are considered to be healthy when the forest thickens; leaving no bare spaces. Everyone who lives in the coastal area can distinguish health species from unhealthy ones (26EMII).

A close reading of the given representations indicates that coastal communities have a common way of describing mangrove species; which also affirms the assertion presented earlier by participant 26EMII - that whoever lives on the coast is able to identify a healthy mangrove from unhealthy one. This suggests that coastal communities, like any other indigenous communities elsewhere in the world, have "specialised knowledge" which can be used in practices that aim at monitoring and management of ecosystems (Kofinas et al., 2002; Heaslip, 2008; Castello et al., 2009, see section 1.3.4). Such knowledge of the "empirical domain" has been proved and tested over time (Berkes, 2008), and may therefore be regarded as having social, cultural and contextual relevance.

Represented traditional ecological knowledge generally suggests that the physical outlook of mangrove species (leaves, roots, stem, branches, epical bud, and shoots) form an integral part in determining whether particular plant species are healthy or not (see section 7.4.3.2 – F (g) in chapter7).

Mangrove restorers' descriptions of the attributes or indicators of good and bad health as found in the study sites may be summarised as follows:

5.2.10.1 Indicators of good health:

- Good and soft soil that allows penetration of roots
- Leaves remain greenish most of the time
- When there are more young leaves coming out
- When roots remain undamaged or dug out
- Undamaged plant barks
- Presence of the epical bud as a sign of up-ward growth
- When there are no signs of erosion in the mangrove area
- Un-damaged stem
- When the soil appears black and muddy (not rocky and dry)
- When tree barks are thick around the stem and some other parts of the plant
- Absence of plant stumps in the mangrove area
- Absence of charcoal kilns in the mangrove area
- Absence of saltpans in the mangrove area
- Absence of solid waste (which traps seedlings and plant shoots)

5.2.10.2 Indicators of poor mangrove health:

- When the soil is dry, rocky (hindering penetration of roots) or when its colour appears reddish or yellowish.
- Presence of bare spaces in the forest
- When roots are dug out or damaged in search of fishing-bait.
- When there are signs of destructive fishing practices in the mangroves e.g. use of dynamite
- Presence of saltpans
- Removed epical bud (which limit plant growth)
- Drying or withering of mangroves species
- When leaves appear yellow in times other than seasonal shading
- When the plant appear dormant (not increasing in size)
- When there are increased numbers of crawling / creeping creatures
- When plant barks are damaged
- When roots are damaged or dug out

- Presence of stumps in the mangroves area
- Presence of charcoal kilns in the mangrove area
- Presence of saltpans in the mangrove area

Like mangrove restorers, fishers may also describe the health status of mangrove-based fisheries in the same manner. Below are responses given by some participants to the question “How would you identify a healthy fish from unhealthy one; and what would you identify as determinants of good versus poor health?”:

The skin of a healthy fish bounces back when pressed/ thumbed. If you press a fresh fish and it sticks to the bones or make a hole, then know that fish is not healthy (9FMNII)

I will inspect the fish to see if there are any wounds, scars, or bruises, or hanging hooks around the neck, or in the stomach. If the fish is free from such threats then I will consider it as being healthy (10FBSFG)

You observe the fish-air bladder to see if it is damaged or not. Any damages suggest that it has been fished out using dynamite and is therefore not healthy (11FMII)

A healthy fish can physically be identified by looking at its body parts. If some parts such as the tail, an eye, and etcetera are missing, then that fish cannot be considered to be healthy (3FBKFG).

I will look at the shape and body fats. If the fish is too skinny and dormant then I will rule out that it is not healthy (4FBSFG).

If there are many fishers in the area one may easily conclude that there is fish decline or such decline is likely to come (11FBKFG).

The first part for inspection is the colour of gills. Red colour suggests that the fish is healthy while brownish and pale indicate bad health (2MFMNII).

I will look at the fish eyes to see what colour are they. Brown and pale colours will suggest that the fish is not healthy (13M/FMII).

The above fishers’ responses as found in the study sites may give us the following summary of indicators or attributes of good or bad fish-health:

5.2.10.3 Indicators of good fish health status:

- Absence of wounds, scars, or bruises, or hanging hooks around the neck, or in the stomach.
- Intact fish-air bladder (damaged airbladder suggests the use of dynamite fishing)
- Undamaged body parts. If some parts such as the tail, an eye, and etc. are missing, the fish is regarded as unhealthy.

- Fish shape and size (a skinny and dormant fish is not healthy)
- Number of fishers in the area (large number suggests over- fishing and threats to fish)
- Gill-colour (red colour suggests that the fish is healthy while brownish and pale indicate bad health).
- Eye colour (brown and pale colours suggest poor health).

5.2.10.4 Indicators of poor or bad fish health status:

- Presence of wounds, scars, bruises, or hanging hooks around the neck, or in the stomach.
- Damaged fish-air bladder (damaged airbladder suggests the use of dynamite fishing)
- Missing body parts. If some parts such as a tail, an eye, etc. are missing, the fish is regarded as unhealthy.
- Skinny and dormant shape or size
- Increased number of fishers in the mangrove area
- Gill-colour (brownish and pale colours).
- Eye colour (brownish and pale colours).

5.3 Conclusion

Notions, concepts, and ideas that fishers, mangrove restorers, and local elders give through processes of abstraction, may potentially lead to knowledge production; as these involve descriptions of ecosystem concepts, functions, processes, interactions; and social-cultural, ecological, and economic values of the mangrove ecology. More importantly, they may help individuals and social groups to understand processes that favour knowledge transmission from one level to another (e.g. from experienced fishers to the less experienced), and uncover situations or contexts that favour knowledge transfer (such as routine practice or praxis, and the use metaphors that communicate important messages among involved individuals). Participants' descriptions may also help individuals and social groups to understand past power relations, past ecosystem events, and structures or mechanisms that determine ecological interactions and relations, such as the effect of weather on fish interactions, and the relationship between knowledge and power (e.g. how power shapes

the competition between traditional and modern fishing practices). They also set a platform for the generation of traditional ecological knowledge, which has great potential for helping coastal people to develop monitoring plans (e.g. frameworks of indicators or attributes - see section 5.2.10:1-4), to guide experiential practices and attract interactions, which are also a criterion for the occurrence of social learning (Cundill & Rodela, 2012). They are also the basis of reflexive social learning, which as described above is implicated in a process of learning as becoming, which adds additionally to the typology of social learning as framed by Cundill and Rodela (2012) that was based on their extensive systematic literature review of social learning research in the natural resource management / environmental context. The use of processes of abstraction in social learning may be broadened to incorporate the application of audio visual methods, such as image photographing and experiential learning dialogue in social learning (Davis, 2009). This may help us to assess how learners respond to different learning approaches; and how processes of abstraction mobilise the representation of traditional ecological knowledge. It also sets a space for comparing representations that are made while touching or feeling real physical objects like mangroves and fish with those that are made by observing photographic images of the same objects. Details about this extended use of processes of abstraction are presented in the next chapter (Chapter 6).

CHAPTER 6: REPRESENTATION OF TRADITIONAL ECOLOGICAL KNOWLEDGE AS AN INPUT FOR THE DEVELOPMENT OF A COASTAL BASED FRAMEWORK OF INDICATORS

6.1 Introduction

This chapter employs Experiential Learning (EL) theory in the analysis of processes of abstraction and indicates how such processes facilitated the representation of Traditional Ecological Knowledge (TEK) among mangrove restorers and fishers. It attempts to answer the question *“How can processes of abstraction and conceptualisation mobilise the representation of TEK that is necessary in developing indicators for the monitoring of fisheries and mangrove resources?”*. The chapter serves as a ‘second moment’ of unlocking indigenous knowledge through the abstraction and conceptualisation of photographic images of mangroves and fisheries species, taken by research participants themselves in desired positions within the mangrove ecology in Phase 2 of the research, as described in section 4.5.2.2. The ‘first moment’ of unlocking TEK involved interviews that were carried out at individual levels in the mangroves; where the participants would ‘touch’ and ‘feel’ mangroves and fisheries species as they continued to abstract and conceptualise them as visible and real objects (see chapter 5). Both moments used the same research participants (see chapter 4) and their sessions were extended to round-up forums (either focus group discussions or feedback workshops to allow further deliberations for purposes of enriching data that had been captured from individual fishers, mangrove restorers, and elders as advised by Berkes (2008). The latter moment (photograph taking) also served as a verification phase to the former (in-depth interviews and focus group discussions). As indicated in section 2.3, processes of abstraction take place in both research and in learning. In this research the research participants were informants (i.e. shared their insights), but were also learners who were engaging in new practices (especially the photograph taking reported on in this chapter via a process of experiential learning). In this chapter, I refer to the research participants as learners, since it is here that they were most explicitly engaged in a new process of experiential learning.

Emerging insights or accounts from this chapter are interchangeably lensed through experiential learning and critical realism theories, to establish premises that contribute to

understanding situations that may encourage a wider form of social learning (Wenger, 1998; Reed et al., 2010). The chapter also draws on the insights presented on social learning in section 2.2.

6.2 Introducing the process of representation

As explained earlier in the section that provides perspectives on the key study concepts (see chapter 1.7), representation is defined in this context as a process that leads to the description of an idea or concept, based on knowledge of the external world (Vieira & Runciman, 2008). The process uncovers how people make sense of the world and how they understand themselves and their environment (Webb, 2009); and it also accommodates representation of concepts that are abstracted from photographic images (Pole, 2004; Brown, Cromby, Harper, Johnson, & Reavey, 2011; Mitchell, 2011; Crawford, 2012), a process which forms the basis of this chapter.

It is through representation that people organize the world and reality through the act of naming its elements (Stanczak, 2007). Representations are thus dependent on abstractions and conceptualisations that are given meaning in the contexts of social practice.

6.3 Using photographic images in the study

The use of photographic images in this study, as briefly described in the methodology chapter in sections 4.5.3.3, 4.5.3.4 and 4.5.3.5, was informed by individual researchers who had used the method earlier, and communicated the same as being very useful and helpful in the process of learning.

Another reason that inspired me to opt for participant photography in this context, was its depiction of learning by doing scenarios, which are central to experiential learning theory, and as reflected earlier, its potential for engaging research participants in aspects that involve their experiences, and processes of abstraction and representation, all of which are central to experiential learning (see sections 1.7.4 & 2.5).

As indicated in the methodology section in chapter 4 (sections 4.5.3.3 and 4.5.3.5), I made use of participant photography in this phase of the research to aid abstraction and representation processes. The process was essentially also an experiential learning process as described in sections 6.5 – 6.8 below, where the different dynamics of the experiential learning process are described in more detail, along with the engagement with the photographic activity. Chapter 4 reports that the process of supporting this experiential learning process in Phase 2 of the research involved providing orientation to the use of cameras, and encouraging fishers and mangrove restorers to take images of their choice, It also involved engaging with the fishers and mangrove restorers around their photographs to discuss the representations that were made during the debriefing sessions following the photography activities. As mentioned in Chapter 4, I also made use of five questions to aid analysis and inference making from the photographic works.

The five questions explored the extent to which research participants were familiar with mangrove and fisheries species and possible interactions that link social systems (coastal communities) and ecological systems (mangrove and fisheries ecosystem). The initial two questions focussing on what the image represented and where it was taken, and the last question, focussing on how they experienced the new practice of taking photographs (see section 4.5.3.5), sought information that would uncover the level of ‘concrete experiences’ that mangrove restorers and fishers had about the images they had taken (see figure 3.2). The remaining two questions, focussing on why the participant chose to take a specific picture, and what the picture depicted about the health of the ecosystem (see section 4.5.3.5), aimed at capturing data or information that depicted reflection, observation and abstract-conceptualisation. The fourth question, focussing on what the picture represented about the health of the ecosystem was also relevant to the last stage of the experiential learning cycle (testing implications in new situations). This indicates how the input from the first, second, and third stages of the experiential learning cycle was combined with the input that was captured earlier through in-depth interviews and Focus Group Discussions to inform the development and testing of a framework of traditional ecological indicators as an ‘underlabourer’ for the existing scientific framework of indicators. All of this data fed into an overall analysis of the potential of TEK to provide a framework for indicators, and was

mirrored to participants in the experiential learning workshop, as discussed in Chapter 7 to produce input that appears in tables 7.1 and 7.2.

6.4 First stage of the experiential learning cycle (concrete experiences)

This stage of the ELT exposed learners (mangrove restorers and fishers) to the practice of photograph taking in the mangrove area during a low tide (when there was a low level of water), to allow free movements of the participants as they were being engaged in the task that appeared new and exciting to most of them. This level of the learning cycle focuses on what is experienced rather than what is reflected, conceptualised, or tested in the field. 'Experiencing' therefore, forms the entity of the 'concrete experiences' stage; and paves the way for learners to immerse themselves in doing a particular task (like photo/picture taking) as a new concrete experience, and observe, feel, and react to it in different ways. Likewise, mangrove restorers and fishers were exposed to a similar situation at different times and sessions (as explained in Chapter 4.5.3.5), and immersed in the task of taking photographic images in desired areas of the mangrove ecosystem.

The first image-taking session involved mangrove restorers who had just acquired the basics on photographing (see section 4.5.3.4). This was carried out in the mangrove area, and as explained earlier, during low tide. Setting of the time was thus guided by the water calendar obtained from the local mangrove office (Mkinga District), as well as participants' experiences or traditional ecological knowledge on water tides in their coastal area. The second session involved fishers (see section 4.5.3.5) and was carried out near fish landing sites or local fish storage stations. This session was not bound by water tides. It was carried out between 10.am and 1.00 pm, when fishers had returned from fishing; bringing with them a variety of fish species to the land sites. This would help fishers to take preferred images of fish species for experiential learning purposes.

6.4.1 Link between concrete experiences and learning

Concrete experience and learning are closely intertwined and almost inseparable; the foundation of much learning is the interactions between self and the external environment, or what may be referred to as *experience* (Beard & Wilson 2002). Commenting on the relationship between the two, Boud, Cohen & Walker say:

We found it to be meaningless to talk about learning in isolation from experience. Experience cannot be bypassed; it is the central consideration of all learning. Learning builds on and flows from experience ... learning can only occur if the experience of the learner is engaged, at least at some level (1993, p. 8).

There is a growing consensus that concrete experience “forms the basis of all learning” (Rogers, 1996, p. 107). It is from this understanding that Keen, Brown and Dyball (2005) define social learning as a “process of iterative reflection that occurs when we share our experiences, ideas, and environments with others”.

Critical realist researchers too, as discussed in chapter 5, explain how embodied experience generates iconic models which provide “the basic conceptual templates” or “image schemas” underlying thought and learning (Nellhaus, 2007, cited in Hartwig, 2007, p. 67). Bhaskar’s (1998) & Archer’s (2010) views on reflexive learning – as also explained in chapter 5, are based on reflexive engagement / thought in relation to context and experience. The point that I made in chapter 5 on ‘learning as becoming’ is related to being i.e. learning as becoming, via reflexive social learning, emerges from ‘being’. Bhaskar’s stratified ontological perspective, also outlined in chapter 5, provides in-depth insight into experiences, events and real dynamics of being. Schudel’s (2013) critical realist research shows how the depth ontological framing of being in open systems as described by Bhaskar (1998), Sayer (2000) and others shapes and influences active learning and becoming in and via reflexive learning processes.

6.4.2 An overview of mangrove and fisheries images at concrete experiences stage

Learners at this level carried out the new task/practice with particular intentions. As experiential learning theory suggests, the focus at this stage is not on the task assigned to participating social groups (learners) but rather on carrying them out with intention. Intentions may vary across involved individuals, depending on possible choices that are available to them. Some walked around the mangrove area in search of species that depicted the desired condition or state, while others went straight to either nearby species or to others located at a distance, guided by their long-term knowledge of the distribution of mangrove species in the area. The new experience seemed to be merging with previous

experiences and knowledge of the mangrove ecosystem (outlined in some detail in Chapter 5), to influence the process of carrying out the on-going task, followed by observations, feelings, and reactions which are key in the first level of the cycle. This level therefore, starts by capturing not only individual intentions, but also how participants (learners) reacted or felt about the task that was introduced to them (photograph taking).

Participant 2M/FMNII who is involved in both mangrove restoration and fishing shares his experience as follows:

I have never taken any photo before; this was completely a new experience to me. Thanks to the basics on how to use the camera which worked out very well for me. I also experienced some difficulties in deciding the kind of image I should capture; this was initially a serious challenge to me but I was finally able to take photos of both the mangrove and fish species. I am very much excited to learn that I am able to take a photograph.

It is possible to highlight some experiences, observations, and reactions from the above account which, as explained earlier (see 6.5.1), constitute the first stage of the learning cycle. The learner acknowledges that he has been exposed to a new experience - which raised several challenges as the practice was going on.

He observes that there were some enabling conditions which made the practice possible, and reacts positively to the outcome of the practice. Details in his reflections seem to be centred more on the practice itself than what the captured image contains.

In another experience, participant 24MMII shares how the 'beginning' seemed more challenging than other stages of the cycle:

Deciding what image I should capture was a big challenge to me. I felt sometimes speechless like someone who is 'stammering', but later went on with the practice. I ended up taking two photographs; one depicting good health of mangrove species and another indicating poor health status. (See plates 6.1 and 6.2)

Images of mangrove species taken by participant 24MMII:



Plate 6.1: *Mchu* (*Avicennia marina*) threatened. Plate 6.2 *Mkoko* (*Rhizophora mucronata*) healthy

Learners may react differently to the new situation. While some may take time to engage themselves fully in the new practice, others may quickly catch up with it and advance even further to other stages of learning.

Contrary to the experience that the above learner went through, another learner who assumes a dual role (mangrove restoration and fishing) appears to have not experienced any challenges as he engaged himself in the new task / practice:

The task went on very well because I was able to capture a photo of a fish called 'Chewa' (Redmouth grouper). I like the photo because it was well taken. I did not experience any worries during the task. My intention was to make those who have never seen that kind of fish to reflect its uniqueness in terms of ability to stay alive for up to three hours after it has been fished out from the ocean (13M/FMII). (See plate 6.3).



Plate 6.3: Image of '*Chewa*' fish (Redmouth grouper) taken by participant 13M/FMII.

There are several explanations that may be considered to have influenced the learning process between the two participants (24MMII and 13M/FMII). Apart from the fact that learners may react differently to the learning situation as pointed out earlier, it is also wise to consider the reality that the second learner was being engaged in the practice for the second time, after he had previously been involved in the mangrove session, while the first learner was doing it for the first time. This may suggest that when learners are exposed to the new task for the first time, and are given more opportunities to repeat what they have done before, they are likely to cope with the challenges that are associated with their involvement in the practice; especially those which require them to make individual decisions on what roles they should take and how they should bring any previous experiences into the task.

In addition to the reactions, feelings, and possibly observations that the above description depicts, the learner indicates his intention for capturing the fish image. Learners' intentions as an ingredient of the concrete experience seem to be a key factor among mangrove restorers and fishers who took part in the task. The same learner (who is involved in both

fisheries and mangroves) was given another opportunity to describe how he experienced his second attempt to capture the mangrove image, and he responded:

I deliberately focused the camera to the area which is affected by invasive species so that I may be in a better position to explain the photographic image of my choice (13M/FMII). (See plate 6.4 depicting extended canopy of invasive species).



Plate 6.4: taken by participant 13M/FMII depicting extended canopy of invasive species affecting mature 'Sonneratia alba species' (locally called *Mpia*).

The 'intention' depicted in the learners' description may suggest that he had prior knowledge about the impact of invasive species on the mangrove ecosystem. This again affirms that learners may blend new learning experiences with what they have learnt before, to address a particular challenge or situation.

Three learners (1MMNII, 2M/FMNII, and 20 MMII) for example, co-incidentally revealed some shared 'intentions' in terms of species of choice. They all opted for the most common mangrove species locally known as '*Mkoko*' (*Rhizophora mucronata*) as the most preferred image in the activity. Secondly, they all chose specific locations (where particular mangrove species are found). Thirdly, they seemed to be attracted or influenced by the physical

appearance (condition) of particular mangrove species, but their accounts or descriptions contain uniqueness in terms of representation approach, priority, and insistence; as is the case with the following account:

This picture shows a mangrove plant called 'Mkoko' (Rhizophoramucronata); this is a stem, these are branches, and these are leaves. Some leaves in this image look damaged as you can see, some parts of the plant generally look good. This branch in particular, is not good. There are signs of insects underneath the plant, but also the soil around it is dug out, not by humans but possibly by wild animals (1MMNII).(See plate 6.5).



Plate 6.5: taken by participant 1MMNII describing 'Mkoko' (Rhizophora mucronata) spp.

The learner's intention in the above message seems to be centred on communicating the status of mangroves, particularly the species of choice (*Mkoko*). The 'intention' is therefore not on communicating or representing the ecological or economic status, but on the condition of mangrove species. There is no evidence that the learner's intention or reflection is on the new task. The above description tells us nothing about how the new task was experienced; a situation which affirms that in the first stage of the cycle (concrete experiences), learners focus not on the given task, but carrying it out with intentions,

feelings, reactions, and observations, especially if they have some formality with the task as a practice.

Observations, and a sense of feeling, tend to shift from how the learners experienced the task, to what is contained in the captured images. This is depicted in the account given by learner 1MMNII, as she specifically points out some parts of the plant which appear to be damaged, and indicates possible causes for the damage. There is no indication of difficulties experienced by the learner in the identification of the object that appears on the photo, or specific parts of the image such as leaves, branches, and the stem. This could suggest three explanations: the first explanation is the possibility that the image was well taken, and clear enough, to be presented in the same manner that it appeared in the mangroves ecosystem; the second explanation is the possibility that the learner observed the mangrove species before capturing its image and the memory of what was seen earlier simplified the description or accounts; the third possibility is a combination of both explanations. Another possible explanation, which might have been the case, is the possibility that the learner used her long-term experience or knowledge of mangrove resources to describe the image she had captured. This for example, was the case when participant 2M/FMNII explained that he did not face any difficulties in identifying the image he had captured because he knew well the kind of fish which appeared in the photo. This once again affirms that learners have experiences that provide a basis for new learning (Kolb, 1984).

In the second account or description, the learner attempts to link the new task (image capturing) with the 'intention' (explaining the ecological and economic roles of that particular mangrove species), but advance further by giving more details about the species of choice than explaining how the task itself continued. This suggests that when learners are exposed to a new practice which engages their previous experiences or knowledge, they are more likely to give accounts or descriptions of what they know than what they are struggling to know:

I took a picture of Mkoko (Rhizophora mucronata species) because it helps in protecting the coast; it is used for boat making and also as habitat for fisheries. This particular species grow well in good soils and poorly in sandy soils. You can detect that the health of the plant is poor when its leaves start changing from green to

reddish/ yellowish. This photo reveals that the plant I have taken is generally healthy, though some leaves display minor attacks from insects (2M/FMNII).(See plate 6.6)



Plate 6.6: Image of 'Mkoko' (*Rhizophora mucronata* species) taken by participant 2M/FMNII.

The above description/account also suggests that learners that share previous or long-term experiences (like mangrove restorers) may experience varying 'intentions' when exposed to a new practice (like photograph taking). However, the observed level of variation may not be significant since they are all operating in the same learning context (the mangrove ecosystem). This for example, may be the case in the account given below, where the learner selects a particular species (*Mkoko*) as the image of representation, based on the criterion of dominance rather than other common values such as economic, ecological and socio-cultural:

I took a photo of 'Mkoko' (Rhizophora mucronata). This image shows several species, their roots, stems, branches, and leaves. I opted for this particular species because it is 'a dominant species' in the mangrove ecosystem. This photo indicates that captured species are not healthy because they are located in poor soils. Mangroves do well in muddy black soils but not in sandy areas like this (20 MMII). (See plate 6.7).



Plate 6.7: Images of '*Mkoko*' (*Rhizophora mucronata* species) see extreme left; taken by participant 20 MMII. In-front and at middle, are some *Avicennia marina* species (which are not described or represented by the participant in the context).

A further analysis in subsequent stages of the experiential learning cycle may place emphasis on other angles of the same description for alternative explanations in the experiential learning process.

In a nutshell, the 'concrete experiences' stage uncovers a number of similarities and differences in terms of experiencing the new practice, making observations, expressing learners' feelings and intentions, and reacting to the experiences. These elements of the concrete experiences "set the learning in motion" (Wals et al., 2007, p. 85), and allows people to deepen their learning as they reflect upon such experiences (Kolb 1984; Reed et al., 2006).

6.5 Second stage of the experiential learning cycle (Observation and Reflection)

This stage of the ELT cycle indicates how learners step back from the on-going task and review what has been carried out and experienced. They add or adjust their perceptions based on what they have learnt before (previous knowledge). They are then able to notice any differences and apply terms that help in identifying even hidden events, and communicate them to other learners. It should however, be noted that values, beliefs, and attitudes of learners will still influence their manner of differentiating certain events. In a nutshell, the second stage of the cycle focuses on 'observation and reflection'.

Learner 19MMII, for example, shares his reflections with the facilitator (researcher) and other learners (fishers and mangrove restorers) as follows:

When the facilitator asked me to describe the image I had taken, and he himself turned into a listener, I found myself stuck. I am not used to talking myself; I wished to be asked more questions. When we had interviews in the mangroves, I explained everything, but this one was somehow new for me.

The above description may sound like a reaction rather than an observation or reflection, and may probably be considered as fitting better in the first stage of the ELT cycle, but there are several aspects that are worth pointing out and analysing, since they depict some key characteristics that shape the second stage of the cycle. The learner observes that the process of describing a captured photographic image is likely to be smooth and well carried out if the facilitator continues to ask more guiding questions to involve the learners. He seems to observe and distinguish the process he went through in previous in-depth interviews and the new practice (photograph taking and description of the captured image). This suggests that the learner took time to 'reflect' not only the new practice but also on previous practices and was able to make observations, and eventually suggest or bring input to the process of learning. By stepping back from on-going practices, learners are able to clearly review the learning process and bring more input into the learning process. In this case, they themselves may learn more and contribute to learning of others.

Stepping back from the new practice allows learners not only to consider their roles in the learning process, but also to review how the actions of other players (learners) or the facilitator affects the process of learning. This kind of reflection and observation is referred to by some authors as reflexivity (Hallowell, Lawton, & Gregory 2005; Maxwell 2012), and serves as an important aspect in any research that aims at contributing to social learning (see section 5.2.2.1 and 5.2.5).

Apart from reflections and reflexivity that emerge from learner 19MMII's perspectives, one may also consider observations that are made from the description. The learner indicates that there must be some kind of a 'disturbance' to trigger representation of various experiences that the learner has gone through. It should also however, be noted that researchers (facilitators) through reflexivity, may change their inquiry techniques to avoid situations that may limit research participants (learners) from communicating what they know about the study context (see section 4.7, question 1). When the study questionnaires were being tested and also during the first moment of enquiry (when in-depth interviews were being carried out), mangrove restorers and fishers revealed a non-stop flow form of representation, which affirmed Berkes' assertion that indigenous people are well versed with long-term traditional ecological knowledge (Berkes, 2008). From such experience, study questionnaires were adjusted (see section 4.7), to keep only a few key questions from several, since the previous experience had shown that a participant's response to a single question could yield not only more details but more additional questions. The same approach was employed in the second moment (photograph taking), where individual learners were asked initial questions and were expected to respond as they had done in the first moment (in-depth interviews); but it depicted some challenges that did not occur in the first moment as another learner reveals below:

Photograph taking is new to us, when you interviewed me in the mangroves it was easier to respond than today. I found myself in a new experience, and even running short of words (17MMII). (Views based on plate 6.8).

The emerging challenges that appear in one context but not in another may trigger further analysis of the context to raise possible explanations that need to be considered in the learning process. The above scenario suggests that the learner is able to distinguish past

learning experiences from the new; this by itself is an indication of learning. The learner's attribution of the emerging challenge to the new practice (photograph taking), indicates that she has clear knowledge of what was expected of her in the new practice; which also is an element of learning. In other words, when learners are able to identify the kind of support or assistance that is required in the processes of learning, they are engaging themselves in 'observation' and 'reflection' which are indicators of learning in the second stage of the experiential learning cycle.



Plate 6.8: Image taken by learner 17MMII indicating *Mpia* species (*Sonneratia alba*)

After reflecting how he himself engaged in the new practice, learner 19MMII adds: *"I think we were able to move from standard one to standard two. I believe that next time we will have another opportunity to advance to standard three"*. This feedback affirms that in spite of faced challenges in the initial learning process, the learners were able to gain new insights which are necessary for further advancement. It also raises the expectation that any opportunities for more exposure to new situations may yield forth more positive learning results than what they had experienced in a previous level. This expectation may be true because experience from learner 13M/FMII (who is both a fisher and mangrove restorer) shows that he was more comfortable and focussed during his second attempt than the first.

Reflections and observations can also be made from the description given by learner 13M/FMII, who steps back and assesses the new practice, and reflects that the task was successfully executed. He attributes the success to the achievement realised (ability to capture the image): *“The task went on very well because I was able to capture a photo of a fish called ‘Chewa’ (Redmouth grouper). I like the photo because it was well taken....”*.

There is another reflection worth examining, which is communicated by learner 20MMII, after the initial stage of the learning cycle. The learner observes that her photo fails to represent the actual appearance of mangroves on the ground, and wishes to have first observed the plant and its surroundings before capturing its photographic image. In other words, the learner is suggesting that photograph taking as a method should be combined with physical observation of the real object to assist the learner in the process of description, or in giving accounts of the image that appear in the photo. While this kind of suggestion sounds appealing, there is also a need to consider views that contrast with what the above learner has experienced:

There was no visual difference between the image that I captured and the real situation on ground. They all appeared the same (13M/FMII). (views based on plates 6.3 & 6.4 presented in the first stage of the learning cycle).

There is a need to carefully examine the challenges experienced by learner 20MMII, which are not reported by other learners. There are possible explanations that emerge from her context which may suggest the reason for the challenges she experienced. The first explanation is the possibility that the photo was not well taken, given the reality that the learner was involved in the task for the first time. The second explanation is the possibility that the learner herself might have been experiencing visual challenges caused by undisclosed factors. Nevertheless, the said learner seems to understand well the process she had gone through, and the role she had assumed in the practice; which is also an element of learning (Reeds et al., 2010).

The second stage of the ELT cycle therefore, provides opportunities for learners to step back and review the new task to a point that allows them to make observations and reflections

from the learning environment. Such reflections form a landscape for concept formation and abstract conceptualisation, which is the third stage of the cycle, discussed below.

6.6 Third stage of the Experiential Learning Cycle (Concept formation/ Abstract conceptualisation)

This learning stage involves abstract conceptualisation or concept formation to define a particular situation. It exposes learners to the interpretation of noticed events, understanding the relationships between them, and making generalizations. It is a stage that creates avenues for learners to discuss emerging concepts as they reflect on experiences that invariably raise questions that need answers. In this stage, guidance is extremely helpful to the learners to help them in the process of abstract conceptualisation or concept formation.

To guide learners through this learning stage, they were asked to represent the physical condition or health status of mangrove or fisheries species as depicted in the photographic images of their choices. This step was necessary in the learning cycle since it had the potential to show how processes of abstraction mobilised representation of traditional ecological knowledge among learners. Description and interpretation of the image would therefore, serve as a basis for concept formation or abstract conceptualisation.

Learners were able to formulate concepts that depicted the physical condition of mangrove species (leaves, roots, stem, and branches), plant health status (good or bad), identification of threats (natural or human induced), identification of various mangrove species, ecological and economic significance of mangrove species, identification of conducive or unsuitable environments for mangrove growth, and naming of species diversity. Learner 1MMNII for example, represents her knowledge of mangrove ecology as follows:

This picture shows a mangrove plant called 'Mkoko' (Rhizophora mucronata); this is a stem, these are branches, and these are leaves. Some leaves in this image look damaged as you can see, some parts of the plant generally look good. This branch in particular, is not good. There are signs of insects underneath the plant, but also the soil around it is dug out, not by humans but possibly by wild animals (1MMNII). (See plate 6.5 in the first stage of the learning cycle).

The above representation suggests that the learner is not only familiar with key parts of mangrove species but also how they are supposed to appear when in normal condition. She cites some plant abnormalities that are depicted in the photographic image and attributes them to insects and wild animals. The accounts suggest that by looking at leaves, roots, branches, and stem, one is able to establish whether a particular plant is in good or poor health status. Damaged roots for example, suggest that the capacity of mangroves to absorb nutrients from the soil is likely to be reduced or cut off, while the presence of crawling insects may also pose threats, especially to plant shoots. The above representation also makes a distinction between plant damage that is caused by wild animals and humans. This suggests that the learner is well versed with interactions that occur in the mangrove area and their associated physical impacts.

Covered or exposed mangrove roots therefore, may help individuals and social groups who are involved in mangrove monitoring activities, to predict immediate and future plant threats for intervention purposes.

Further accounts also indicate that learners (mangrove restorers) have clear knowledge of species diversity in the mangrove ecosystem including their names, favourable environment, and soil requirements. This is clear, for example, in the representation made by learner 2M/FMNII (see plate 6.6 under 6.4.2) who describes the conducive environment for *Mkoko* (*Rhizophora mucronata*), and the kinds of soils that favour its growth. The same representation cites plant leaves as an indicator of plant health, depending on displayed colour. The account/description links yellow and red colours to poor health, and green colour to good health. The learner also shares additional insights on the ecological and economical values of '*Mkoko*' to the coastal environment. Indicated ecological values include coastal protection (protecting the coast from erosion), and acting as important habitat for mangrove based fisheries; while economic values according to the learner, refer to the usefulness of the said mangrove species in boat making.

Representation of soil type as a determinant of plant health status is also reflected in the representation made by learner 20MMII (also see 6.5.1) who describes the photographic image as depicting poor health, following its location on poor soils (of sandy or rocky

nature). The learner observes that the plant would have appeared healthy if it grew in muddy soils (which according to other learners must be black in colour (see table 7.1). This also makes soil a key indicator of plant health. Soil is also cited by learner 19MMII as determining the health status of another mangrove species, locally called 'Mpia' (*Sonneratia alba*). The learner affirms that healthy plants are normally located in rich muddy soils and poor mangrove species are those located in sandy/rocky soils (see 7.4.3.2-Fc) for details on traditional descriptions of soil as an indicator of mangrove health).

Another concept that seems to have been captured by most of learners from photographic images is the term 'threat'. This concept is basically linked to factors that are associated with poor health of the mangrove species, which are either natural or human induced as the following representation reveals:

I opted for the image that indicates a threatened 'Mchwi' (Avicennia marina) species. This kind of threat is human induced since some branches were cut down by a sharp material (24MMII) (See plate 6.1).

Mangrove clearance differs from other observable threats since it can easily be detected or spotted by learners, as it is the case in the above representation. Cut trees leave behind several stumps which also may serve as indicators for threatened mangroves (see table 7.1). Left branches may also serve an indicator for the same.

The use of 'threats' as a concept is also depicted in the account represented by learner 13 M/FMII who indicates that invasive species can also pose threats to mangrove species since they tend to compete for food or nutrients. The learner advances further to indicate the impact of such threats to the mangrove ecosystem as follows:

I opted to take a photographic image of Mpia plant (Sonneratia alba) because this particular species is more threatened than other mangrove species. This plant is a victim of invasive species as you can see at the top. This is an indicator that this particular plant is not healthy. That's why there are some signs of 'drying' from the top (13M/FMII). (See plate 6.4).

The learner discloses invasive species as a natural cause for the poor health status of mangrove resources. The presented photographic image (see plate 6.4 in the first stage of

the learning cycle) indicates a parasitic plant on top of 'Mpia' mangrove species which seems to derive all of its sustenance from the mother mangrove species, thus increasing competition for nutrients.

There are also concepts or abstractions that emerge from representations of photographic images that depict fisheries species. These include (1) fish behaviour, (2) fish health, (3) fish diversity, (4) seasonal dynamics of fisheries in the mangrove ecosystem, (5) traditional fishing gear and methods, (6) catch decline of some fisheries, (7) fish habitats, (8) traditional experiences of particular fisheries, (9) the food chain, and (10) fish spawning.

Represented learners' accounts suggest that fishers can identify fish species by local names and describe external and internal qualities based on long-term fishing experiences amongst them. One of the learners observed the image of his choice and shared the following details:

This fish is not only good but also naturally soft. It has a good shape, and no internal sharp bones, but more fillet. It is locally called 'Kangu'. This fish likes eating sea-grass and small insects; it is thus found near sea-grass beds where there is plenty of grass. We use 'malema/ madema' to trap 'Kangu' but other fishing gears such as hooks, and nets can be used as well. I like this fish, and being a fisher, I took this photo to inform other people how this particular kind of fish is (27FMII).



Plate 6.9: Image of 'Kangu' fish taken by participant 27FMII

The description also points out the kind of habitat that the identified species prefers, and fishing gear that are commonly used to catch it; most of which are traditionally or locally made. The learner describes the food chain of 'Kangu' which involves sea grass and small insects, and also represents some physical and internal fish characteristics in the form of concepts such as 'good shape', 'soft', 'sharp bones', and 'more fillet'. Such concepts help in not only describing how 'Kangu' species are, but where they can be found and how they can better be caught without causing too much destruction to their habitats. The learner prioritizes locally made gear (*malema* or *madema*) as good for catching the species of his choice. This may suggest that fishers' knowledge of different fish habitats can guide them in choosing the kind of gear that fits that particular environment. Traditional fishing gear are regarded by local fishers as being more friendly and sustainable than destructive gear such as the use of dynamite and 'utupa' (kind of plant poison), and even more friendly than some of modern fishing methods like trawling (See plate 2.1 on locally used gear).

The description also uncovers the learner's affection for 'Kangu' species. Indications such as "I like this fish, and this fish is not only good but also soft", affirms the magnitude of the

learner's affection or the extent to which he prefers it to other fisheries. Concepts such as good and soft also are considered as general indicators of fish health status.

Fish habitat as a concept is also reflected in a separate account given by learner 13M/FMII which also uncovers fish dynamics, behaviours, decline, health status, fish catching, and species identification as pointed out in the following representation:

I started fishing 25 years ago. I opted for 'Chewa' species because I know well its life and habitat. This fish lives in-shore near rocky areas, and prefers visiting mangroves sites, and hiding in holes in there. This kind of fish does not suffocate easily once it is fished-out. Unlike other fishes which die shortly when taken out of water, it may take up to 3 hours long being alive. I took this photo in anticipation that it would look good, and people would like it. The quantity of 'Chewa' is currently dwindling, and fishers can only fish them if they set traps in their habitats. I also took this photo to show people who have never seen this type of fish before (13M/FMII) (See plate 6.3 in first stage of the learning cycle).

The learner employs long-term fishing experience to describe 'Chewa' movements between two main habitats, and goes further by indicating the behaviour of such fish species in their temporary environment (mangrove sites). The said species is represented as having a unique level of tolerance which allows it to survive outside the water environment much longer than other fishes. The learner also observes a decline in 'Chewa' (Redmouth grouper) due to undisclosed factors, but possibly linked to the introduction of a wide range of modern fishing gear as also communicated to us by one of the elders who has fished for over 40 years: *"In the past, we experienced a higher catch rate than now. There were also huge fish species that could only be carried by a team of fishers. Currently, we experience a fish decline due to the increase of modern fishing gears"* (9FMNII).

The learner also presents the ecological connection between mangrove as an ecosystem and in-shore waters as a specific corridor or space which support 'Chewa' life. Concepts such as 'visiting' and 'hiding' can only be linked to experiences that have room for observation. The latter concept for example, is associated with the security of fisheries against their predators, and for this reason, some fisheries (both juveniles and adults) tend to seek refuge in the mangroves. On the other hand, the concept of 'visiting' suggests that the destination is a temporary habitat rather than permanent. Berjack et al. (2011) affirms

that mangrove sites serve as source of food for a variety of vertebrates and invertebrates (see also section 5.2.1). Accessed details from the fishers Focus Group Discussion (held in Moa) indicated that apart from serving as key feeding sites, mangroves also serve as spawning and temporary resting sites for fisheries. This is also affirmed in a separate representation cited below:

The photo I have taken displays the image of 'Koe' fish. This fish visits mangroves occasionally in search for food specifically micro-insects, and also for spawning purposes. Such occasional visits are in most cases beneficial to this fish. Its original habitat is 'under reef areas' but all this depends on the maturity stage or level. Juvenile species spend much of their time in mangroves and are released to in-shore water when they are able to swim and feed properly. This picture looks clear and good. I took it for reasons of its attraction or good looking nature of the fish itself- 2/MFMNII (See plate 6.10).



Plate 6.10: Image of 'Koe' fish taken by participant 2/MFMNII

The learner in the above account extends the descriptions made by previous learners to the level that provides generalizations of what is depicted in the photographic images, and also in the manner that creates interrelationships between raised concepts. This generally suggests that concept formation or abstract conceptualisation can lead to the

representation of new and old experiences among learners. In this context, most of what is represented above seems to be reflecting indigenous or traditional knowledge of the mangrove and fisheries ecology, which is a good input for guiding current and future coastal management initiatives in the area.

6.7 Fourth stage of the Experiential Learning Cycle (Testing or active implementation)

The fourth stage of the experiential learning cycle helps learners to realise the input that emerges from the third stage, and use it in formulating new situations to be tested. According to Kolb (1984), this level will only be meaningful if learners are involved in the planning of the learning experience. The facilitator therefore, helps learners to develop their own objectives for a preferred intervention. This is necessary in the process of social learning since learners are engaged in the development of the knowledge that is held collectively, and which is likely to influence the behaviour of other group members (Keen et al., 2005b).

To engage learners in the fourth stage of the cycle, the facilitator (I, as researcher) took them through the process of assessing inputs which emerged from previous stages of the learning cycle, and also from in-depth interviews and focus group discussions, for purposes of identifying attributes or indicators that had the potential for monitoring mangroves and mangrove-based fisheries. Analysis of all of the data revealed that 22 traditional ecological indicators (10 for mangroves and 12 for fisheries) were identified by learners on the basis of their direct connection to mangrove and fisheries resources. These are presented in the next chapter respectively, and were used as mirror data in the Experiential Learning Workshop as explained in section 4.5.3.8.

The newly developed TEK indicators and existing scientific indicators (see section 7.1) were further analysed and scrutinized by learners in the one-and-a-half day Experiential Learning Intervention workshop, to produce an integrated set of indicators which are congruent to users (see sections 4.5.3.8, 2.7, 5, and also earlier sections i.e. 1.3.2, 1.4 & 1.5). Two sets of integrated indicators (one for monitoring mangroves and another for fisheries) were

produced (see tables 7.1 & 7.2 in chapter 7). These served as an input for the last and fourth stage of the experiential learning cycle.

In this stage as indicated earlier, learners are supposed to participate fully in the testing of new situations. An indicator testing exercise was therefore organised to allow the learning team to test the new indicators and share observations from both sides; the mangroves and the fisheries. This was possible through feedback sessions (see sections 4.7 (iii) f & 6.7) and extended meetings. Learners were given special sheets to record data or information from the testing exercise. Below is the feedback from the mangrove testing session received from the group leaders:

We tested all indicators and recorded the required information as seen in this sheet. We did not face any difficulties. Every member participated effectively in the exercise (leader group A).



Plate 6.11: Members of group 'A' testing the new indicators. Participant 5MMNFG (extreme right) from Moa (North) who is a group leader takes the recording task.

We went to the eastern part of the forest and read through the indicators before testing. The indicators are easy than those in the old framework. We recorded the required information in the sheet (leader group B).



Plate 6.12: Members of group 'B' taking part in the fourth stage of the experiential learning cycle led by participant 1EBKII (second right) from Boma-Subutuni.

We successfully tested the indicators though there were some signs of high tide, we did not finish all the indicators but what we did was successful, there was no problem (leader group C).



Plates 6.13 & 6.14: Members of group from group 3 observing different attributes in the mangroves led by participant 13M/FMII (with a pencil) from Moa (South).

The first group of learners, as it is communicated above, was able to test the entire framework of traditional ecological indicators; and according to the group leader, no challenges or difficulties were experienced. It also appears that all members (at least 5 per group) were part of the testing process or exercise which is a necessary requirement in this stage of the experiential learning cycle. When all learners are part of the learning process as is the case in group A, and effectively work together to the level that allows every member of the group to participate effectively, it is then possible to consider ‘participation’ as an important element of learning, since social learning is also regarded as “learning how to participate and how to get involved with other learners towards desirable results” (Bouwen & Taillieu, 2004, p. 141).

Lack of difficulties or challenges in the process of indicator-testing can be attributed to the fact that the indicators were created by learners themselves and not adapted or imposed on them from other sources. In other words, learners were familiar with the language of description that was being used in the indicator testing and it was thus easier for them to understand and participate fully in the learning.

Shared understanding before, during, and after social practices is an important element of social learning, which may help in keeping all learners involved in the desired learning process. This criterion is clear in the three accounts (A, B, and C). The description from group

B, for example, suggests the need for learners to revisit the new framework of indicators together, prior to commencing the testing exercise. The use of the term 'we' by all group leaders also suggests that the entire testing process was carried out collectively (this was confirmed by my observations of the process); thus affirming a typology which describes social learning as a process which allows people to engage with one another and share various ideas and experiences necessary for the development of a common framework (Cundill & Rodela, 2012).

The description given by group leader C brings into view consideration of factors that are likely to interact or affect the learning process. It is true that when the planning for the indicator-testing was done, there was no consideration of whether the water would be at high or low tide. This nearly affected the performance of the group since they experienced higher water levels as they were approaching the end of their task. Such an experience may also be considered as part of learning, since it reminded them of the need to consider the water calendar when planning for future experiential learning practices such as monitoring of mangroves and fisheries resources.

The act of re-reading and revisiting the new framework of indicators (see group B's account) affirms the assertion that social learning is an iterative learning process which allows interactions that facilitate co-knowledge production (Steyaert et al., 2007). When individuals and social groups repeatedly engage themselves in carrying out learning processes that have been interactive, they create chances for a better understanding of what they are involved in. With clear understanding, they are then likely to share knowledge amongst themselves, extending it to wider levels in the community (Reed et al., 2006).

This stage of the experiential learning cycle exposes learners to the so called 'learning by doing' processes (Kolb, 1984). As they get engaged in activities such as indicator testing, and periodic monitoring of coastal and marine resources, especially mangroves and mangrove based fisheries, they continue facing new experiences and situations that can be further improved.

It is through learning by doing – through using the indicators – that the fishers and mangrove restorers (learners) were able to observe that the existing scientific framework of indicators raised social, cultural, and contextual challenges that needed to be collectively addressed (see individual testimonies in chapter 7. 6-retrodiction). Participant 5MMNFG, for example, affirms that the new indicators were found to be not only simple and easier than the old ones but also time saving. On the other hand (see section 7.6), participant 1MMNII makes an additional observation that the scientific indicators were for a specific kind of group (the educated, and not for common coastal communities). This assessment can be considered as resulting from the ‘learning by doing’, in that these observation would have not been raised if opportunities for indicator-testing was not availed to mangrove restorers and fishers (learners). In other words, it can be argued that when learners are exposed to practices that encourage or prioritize learning by doing, they are able to make comparisons between the kinds of learning they had previously gone through, and the on-going or new learning. This may eventually assist the learning team to correct past mistakes and accommodate new learning situations that are key in the experiential learning cycle.

Creating opportunities for experiential learning in the coastal environment may therefore not only enhance social learning among coastal resource users but also guide learners to distinguish existing and new challenges and give them tools that may best address prevailing situations.

6.8 Conclusion

The use of photographic images in the experiential learning cycle, as shown in this chapter, creates a good platform or means for representation of traditional ecological knowledge and sharing of the same through individual and group experiences. It creates a platform for observing and capturing reactions, observations, feelings, reflections, abstract-conceptualisations, and collective testing of new situations to capture more experiences, observations, and feedback that emerge from the learning process. This chapter has shown that it is a necessary dimension of the social learning process that can encourage wider social learning which is meaningful in coastal management local contexts.

As shown in this chapter, the experiential learning cycle is therefore a tool that can help learners not only to create new knowledge, but also engage previous experiences (such as information and data collected during in-depth interviews and focus group discussions) in processing and advancing new learning. From this, it may be argued that the experiential learning theory as expanded through a realist analysis thereof (as explained in chapter 5), can enhance social learning among coastal learners (mangrove restorers, fishers, and local elders).

Input that emerges from the experiential learning cycle and chapter 5, may further be discussed, corrected, and improved by learners to produce useful indicators that may potentially guide participatory monitoring practices, as it is depicted in the next chapter (chapter 7). It is important to note that the fourth and last stage of the experiential learning cycle (in section 6.7 of this chapter) which focus on testing of the new plan or model (in this case TEK indicators), advances further to the stage of correcting, improving, and applying the plan (see section 7.9) which is reflected in the next chapter (see table 7.1 and 7.2).

CHAPTER 7: USING A FRAMEWORK OF TEK-BASED INDICATORS AS UNDERLABOURER FOR EXISTING SCIENTIFIC INDICATORS

7.1 Introduction

This chapter presents the process and procedures adopted by mangrove restorers, mangrove fishers, local elders, and marine scientists, to discuss and analyse two different frameworks for monitoring indicators, namely the existing scientific framework, and the new framework of Traditional Ecological Indicators (TEK), for purposes of coming up with a set of indicators that are regarded by resource users as being potentially less reified, more contextually and culturally congruent, and which may easily guide community-based monitoring practices and attract a wider social learning process. The TEK-based monitoring indicators were developed through processes of abstraction, conceptualisation, and representation by mangrove restorers, fishers and local elders (as presented in chapter 5 and 6) as ‘*underlabourer*’ for the long-term scientific framework which to date, as explained in chapter 1, has yielded little significant impact on the process of social learning on the Eastern Coast of Tanzania (see sections 1.3.2, 1.4, & 1.5).

As indicated in chapter 4, the analysis of the two frameworks of indicators and the entire process that leads to their integration were guided by the Experiential Learning Intervention Workshop (ELIW), which was structured according to the methodological process recommended by the critical realist scientific framework of explanation, commonly known as RRREI(C) (see section 3.3, and 4.5.3.8). The chapter also provides a reflection of discussions carried out during the Experiential Learning Intervention Workshop in the study area, and brings into view ideas and results of ‘trial monitoring exercises’, already briefly introduced and discussed in section 6.7. It attempts to answer the last research question *“How can abstracted TEK indicators be used as underlabourer for existing scientific indicators and attract a wider social learning process of detecting trends, threats, changes and conditions of mangrove and fisheries resources?”*

7.2 Critical realism and knowledge integration

Critical realism endorses situations that necessitate “knowledge integration” for purposes of producing particular results, which may be applied at a particular level (Bhaskar et al., 2010, p. 19), for example, in a coastal community.

It is obvious that the context that involves two forms or systems of knowledge (traditional and scientific/western) is complex and of a systemic nature; indicating what critical realists call an “open system” (Bhaskar et al., 2010, p. 19); implying that it contains phenomena that are not generated by one, but by a multiplicity of “causal mechanisms, structures, and processes or fields”. In this kind of situation, Bhaskar (1998; Bhaskar et al., 2010) suggest the use of an applied scientific model of explanation called the RRREI(C) (introduced in section 3.3) to help in the process of producing particular results, especially where studied phenomena are surrounded by ‘complex’ or ‘open’ systems (as is the case with the complexity or systemic nature of the scientific and indigenous/traditional ecological knowledge systems).

7.3 Description of the RRREI(C)

As explained in section 3.3 and in section 7.2 above, the RRREI(C) model is normally applied to explain, describe or analyse complex phenomena in the social world (Bhaskar et al., 2010). It helps researchers or users of the model to clearly distinguish causal mechanisms that generate particular kinds of events or experiences from a multiplicity of causal mechanisms, structures, and processes or field, and can also be applied to explain how various processes occur, including theory development, model development (Hartwig, 2007), or the development of frameworks as is the case with this study.

The RRREI(C) model is applied in this chapter to explain the process that was employed by fishers, mangrove restorers, local elders, and representatives of the scientific community under the facilitation of myself, the researcher, to mirror the two different sets of indicators (see section 7.1) and arrive at an agreed framework which is regarded by resource users as potentially being less reified, more contextually and culturally congruent, and familiar to coastal people (see 1.2, 1.4, & 1.5).

7.3.1 Components of the RRREI(C)

As mentioned in section 3.3, the RRREI(C) model contains 6 elements / letters represented in its acronym - which stand for processes that are employed when applying the said tool. The first letter (R1) stands for resolution, R2 for re-description, R3 - retrodiction, E - elimination, I - identification, and C - correction (Bhaskar, 1998; Bhaskar et al., 2010; Hartwig, 2007).

The presented analysis therefore shows how research participants together with myself, the researcher and intervention workshop facilitator, named, described, and analysed various component parts and relations of the two systems or frameworks of indicators (resolution); how they contributed to a re-description of the components in a way that made them relevant or theoretically significant (re-description); how they helped to explain the events by making inferences back to mechanisms that were capable of producing them (retrodiction); how they helped to eliminate alternative expressions and explanations that suggested existence of confounding mechanisms (elimination); how they helped to identify generative mechanisms from those considered (identification); and ultimately how they helped to make corrections (C) that were necessary for producing one framework of indicators (see tables 7.1 & 7.2).

7.4 Application of the RRREI(C) in the study context

Application of the RRREI(C) model of explanation (from resolution to the correction stage) was made possible through the landscape of the Experiential Learning Intervention Workshop (ELIW) as explained in section 4.5.3.8; which created sufficient space for research participants and representatives of the marine scientific community to engage with the mirrored data from each form or system of knowledge, in the light of social learning that attracts a wider level. It was preceded by the engaged process of knowledge abstraction and representation as explained in chapters 5 and 6, which were essential to this process.

7.4.1 Experiential Learning Intervention Workshop

As explained in sections 7.1 and 7.4, the Experiential Learning Intervention Workshop (ELIW) was a platform for mirroring the two frameworks of indicators according to the order of the

RRREI(C) model. A summary of procedures of the workshop is presented in sub-section 4.5.3.8 (see also appendix 14).

7.4.2 Linking the Experiential Learning Intervention Workshop to the RRREI(C)

As explained in section 7.4.1, this workshop created as space for workshop participants to mirror the two frameworks of indicators according to the order of the RRREI(C) (see sections 4.5.3.8 and appendix 14). Below is the description of this order (model) and how it eventually helped them to produce an integrated set of indicators that appear in tables 7.1 and 7.2.

7.4.3 Resolution phase (R1)

The first stage of the RRREI(C) (resolution) involved choosing, breaking down, and describing key components of the two systems of monitoring indicators, namely the scientific framework (in place since 1990's) and the traditional ecological knowledge framework (developed through processes of abstraction to complement the scientific framework). This approach was employed to reduce 'complexity' in the two systems and pave the way towards knowledge integration.

The resolution stage therefore involved choosing necessary attributes/indicators, key properties, and monitoring techniques; firstly for the existing scientific framework, and secondly for the traditional ecological knowledge framework.

It should however, be noted that the resolution stage did not involve development or formulation of the attributes/indicators, but rather discussing and describing, improving, and perfecting the existing scientific framework and the newly developed traditional framework through different sessions of the experiential learning intervention workshop. These were to be reviewed and turned into an accepted level of congruence.

7.4.3.1 Identification of attributes that constitute the scientific framework of indicators for monitoring mangroves

This process was carried out in the second and third sessions of the experiential learning intervention workshop with the help of the researcher and local mangrove scientists/

coastal and marine specialists (see 4.5.3.8). Although the said workshop appears to have largely facilitated deeper description of the scientific attributes/indicators, it is worth noting that a synthesis of the information that is presented hereafter through the RRREI(C) model is complemented with representations made during in-depth interviews, focus group discussions, and experiential learning cycle.

A. Description of the scientific attributes/indicators

Description of the scientific attributes was guided by available information sources such as KIMP (2005), English et al.(1994; 1997), and Hill et al. (2005). It should be noted that these attributes / indicators were being used in all coastal monitoring initiatives in the country (see sections 1.3.1 & 1.3.2), and it was necessary to review their content and processes of use to allow workshop participants, including invited marine scientists, to specify areas that required improvement or support from traditional ecological knowledge.

B. Common scientific attributes / indicators for monitoring mangroves:

- Community structure and Biomass
- Primary Productivity
- Leaf litter production
- Soil characteristics
- Area coverage
- Species composition and diversity
- Dynamics (change)

C. Description of the attributes / indicators:

a. Community structure and Biomass (biological material derived from the mangroves):

Accessing information that uncovers community structure and biomass in the mangrove ecosystem requires setting or establishing a Transect Line Plot (TLP). This is the basic approach and it works well when at least three transect lines are created in two sites, at each location, in a manner that they appear perpendicular to the shore. Communities that are involved in the practice of monitoring, will thereafter, set or create three plots of about 10x10 metres in size on a random basis, along each transect, and use the Geographical

Positioning System (GPS) to record the measurements or readings. The process does not end here; it requires measurements of involved species, their heights, and positions using a tool called a hypsometer, and also measuring of each mangrove tree girth (stumps inclusive).

b. Primary Productivity: (the rate at which mangroves plants accumulate energy)

Recording of information that is related to primary productivity involves the leaf area. The leaf area is correlated with the process of photosynthesis; and it can thus serve as an indicator for mangrove health. To measure the leaf area index, one would need a measure that has underwater quantum sensors and another tool called a clinometer which measures the solar zenith angle¹⁶.

c. Leaf litter production

Leaf litter is believed to be a sensitive attribute to many environmental factors. Falling leaves can be trapped using suspended net traps spread around several mangrove trees. There are no details as to how to avoid trapped leaves from being drawn away by water at high tides before they are collected by the monitoring team. Dried leaves can thereafter be burnt and used for soil moisture correlation (analysis of relationships between plant leaf and soil moisture through laboratory techniques).

d. Soil characteristics

Soil characteristics emerge as an important attribute or indicator due to their influence on the productivity and structure of mangrove forests. Gathering of information that depicts soil characteristics; especially soil changes, requires the calculation of Redox Potential or Eh (the extent to which soils are conducive to microbial decomposition/ nutrient production) and the pH level (acidity/ alkalinity), since the latter tends to influence chemical transformation of nutrients. The soil pH, structure, texture, and moisture content affect vegetation as some species will be found only on alkaline soils.

¹⁶ Zenith angle is the direction where the reference is taken which is normally above the observer's horizon. It is also called a point of culmination. <http://www.thefreedictionary.com/zenith>.

Another soil characteristic which is normally measured is the level of salinity (soil salinity). The device used in the process of taking measurements is called a *refractometer*, and it captures an index of refraction). Temperature level (normally at a depth of 10 cm) is also recorded, and grain size (proportions of mud, sand and gravel), which determines the level of permeability, is also measured using either the simpler hydrometer method or the particle size fraction method.

Soil moisture is also captured because it is correlated with its organic matter content which differs between soil types. Soil organic matter is measured by igniting samples of dried matter in a laboratory and measuring mass loss after burning.

e. Area coverage

Measurement of area coverage can be useful in the detection of changes that occur in the mangrove forest. This attribute requires the use of aerial or satellite images such as LANDSAT, MSS, and XS) but also ground truthing methods such as the use of Transect Line Plot (TLP) methods. These are believed to be essential in determining mangrove health and generating other information needed for management purposes.

f. Species composition and diversity

Measuring species composition and diversity involves recording information of about five key aspects or components. These include; extent of old, mid and young growth, extent and configuration of felling patches and canopy gaps, rotation of managed stands, stock of particular size classes, and thinning degree and extent of communities. The techniques include the use of quadrants in transects, aerial photographs, stock mapping and species' lists.

g. Dynamics (change)

Detection of dynamics or change involves measuring open spaces, and specifically their extent and location, seedling regeneration, composition, number, and distribution of planting, and provenance of planted stock and natural regeneration. The monitoring techniques used include fixed–point photography, aerial photography, enumeration, and ground vegetation condition.

7.4.3.2 Resolution of the attributes that constitute the Traditional Ecological Knowledge (TEK) framework of indicators for monitoring mangroves:

A. Key information:

- Monitored resource(s): Mangroves
- Source of attribute/indicators: generated through processes of abstraction by research participants (in-depth interviews, focus group discussions, and experiential learning processes)
- Location of monitoring: Mkinga District, in Tanga Region
- Target community: Fishers, mangrove restorers, local elders, and coastal communities in general.
- Nature of monitoring : periodic

B. Common attributes/ indicators for monitoring mangroves:

- Drying or withering of mangrove species
- Presence of stumps
- Soil type
- Presence of invasive species
- Presence of charcoal kilns
- Presence of saltpans
- Physical outlook of the plant species (leaves, roots ,stem, branches, epical bud and shoots)
- Dense canopy
- Accumulation of solid waste in the mangrove
- Presence of invertebrates and vertebrates

C. Description of the attributes/ indicators:

a. Drying or withering of mangrove species (*kukauka au kunyauka kwa mmea*)

Drying or withering of mangroves is associated with human induced threats, disease, or natural disasters occurring in the coastal areas such as tsunami, invasive species, and deprived nutrient levels. Human-induced factors can be mangrove cutting for domestic and

commercial use, root digging in search of bait (mainly earthworms), and the accumulation of solid waste around young plants. Monitoring techniques that can lead to drawing conclusions that the plant has withered / dried, include physical observation and inspection of leaves, branches, and the stem. A mangrove plant that is under this kind of threat will indicate a condition of dried/drying leaves, falling of leaves onto the ground, and possibly drying branches.

b. Presence of mangrove stumps (*kuwepo kwa visiki vya mikoko*)

The presence of mangrove stumps in the mangrove forest indicate that there has been mangrove clearance in the area. Stumps can indicate the extent of damage and suggest the time when such a threat occurred. This is possible since old stumps are dry and their colour is different from new stumps. The level or extent of damage will be established by counting the number of stumps, and by making a certain number of strides (counting human steps) to measure the affected area. Identification of the affected mangrove species is also possible, and can be done by observing neighbouring species. If nearby species are *mchu/mchwi* (*Avicennia marina*), then the damaged species will be the same, since species of the same kind or type tend to grow together.

c. Soil type (*aina ya udongo*)

Soft-muddy soils allow plant-roots to penetrate deeper into the ground and absorb nutrients. Plants that grow in this area are likely to be healthy. Their leaves remain green, and their height is higher than those in rocky areas. On the other hand, rocky areas suggest that mangrove roots cannot easily penetrate the ground. Such species will appear short, with roots coiled on top of the ground, and the colour of their leaves will remain between green and yellow. Rich soil will also be black in colour, while rocky and poor soil will depict a yellowish or reddish colour. The indicator for health status will be the type of soil, height of plants, soil colour, and colour of leaves. The techniques involved will include examining whether the soil is soft (muddy) or rocky, and indicating this on the report form, carefully identifying the colour of leaves and describing them, and thereafter using the agreed indigenous measures (*pima*) in establishing the plant height.

d. Presence of invasive species (*mimea vamizi*)

The presence of invasive species suggests that mangrove plants are subject to competition for nutrients with species that do not belong to their colony (intruders). These may encroach on the mangroves from nearby ecosystems, or may be caused and accelerated by other factors such as human activities or natural causes. To determine whether there are invasive species in the mangroves, monitoring teams can do physical observation around different mangrove species, and inspect the specific parts such as plant canopy, the ground, and any other possible areas. Species that are not of mangrove origin can be seen or identified by the naked eye. Other identification techniques include smelling, and comparison (comparing their leaves with mangrove species).

e. Presence of charcoal kilns (*tanuru za mkaa*)

The presence of charcoal kilns in the mangrove forest suggest there has been clearing of plants in the area and is therefore a good indicator that destruction of mangrove species has occurred. The extent of damage will depend on the number of charcoal kilns seen in the area, and also the number of stumps that may be associated with such a clearance. The most affected species can also be identified by observing their proximity to their mother colonies.

f. Presence of saltpans (*majangwa ya chumvi*)

Like charcoal kilns, the presence of saltpans indicate that there has been a significant clearance of mangrove species in the area. Saltpans require enough land-space for salt making; and mangrove areas prove to be suitable for this kind of economic activity, since they allow lodging of saline water from the ocean, which is exposed to evaporate under controlled environment and leaving behind salt as an output or product. Establishing the extent of damage can be done by counting the number of saltpans, and striding the size of each saltpan. Counting stumps is not possible in this case since mangrove clearance for saltpans is normally accompanied by uprooting and levelling of the area. The most affected species can also be observed and recorded.

g. Physical outlook of the plant species (*leaves, roots, stem, branches, epical bud and shoots*)

The physical outlook of the plant is among key indicators of good or bad plant health among indigenous coastal communities (see chapters 5 and 6). The plant leaves, roots, shoots, stem, branch, epical bud, and length are themselves independent indicators which can show the status of particular plant.

Leaves (*majani*): Mangrove leaves range from green to an evergreen colour depending on the species type. Change in colour from evergreen to yellow, pale, or red, suggests that either there is a change in season, or a threat from both natural and human induced factors. Monitoring teams may closely make an inspection to determine the cause for change in colour and establish whether it is a result of poor soil, human threats or natural causes.

Roots (*mizizi*): Plants with roots that are fully covered under the soil are considered to be stable and safe from human induced activities and wild animals. Exposed roots indicate a short life-cycle of a plant since roots hold it and keep it in contact with the nutrients from the soil. Fishers tend to dig out earthworms from mangrove roots as bait that might attract particular fish species, and wild animals dig out various worms for food. Carrying out a careful inspection beneath mangrove species can lead to establishing whether the roots are *fully covered, partially covered, fully exposed or partially exposed*. The status of identified species will be established based on the above factors.

Stem (*shina*): The plant stem indicates its width and level of nourishment. A good looking stem suggests that the entire plant is likely to be healthy. Peeling of tree-bark around the stem may lead to mortality of mangrove species. The stem is regarded as a store for the plant food. Its damage or destruction may lead to starvation of the plant and ultimately death. Physical inspection of the stem (damaged or undamaged) and its size (width) may help in establishing the plant's health status. A clear observation of the plant's bark to identify possible damages and likely causes, will also help. Measuring of stem-width can be done by using a tape measure or traditional measures (*pima*).

Branches (*matawi*): Straight branches with well aligned bark-thickness indicate uninterrupted growth. Past records in Mkinga show that mangrove branches are selectively cleared for boat making and construction of residential apartments. In such a process, young branches are damaged and dwarfed. Observation of branches' straightness and the presence or absence of noticeable damage in mangrove branches in selected mangrove plots, will help in establishing their health status.

Epical bud (*sehemu ya mmea inayokua kuelekea juu*): Removal of the epical bud suggests a limitation of plant growth upward, hence limited length. The presence or absence of the epical bud therefore will determine whether a particular mangrove plant is growing upward or not. Inspecting the plant canopy or top will help the monitoring team to establish whether the epical bud is present or absent.

Plant shoots (*mimea chipukizi*): The presence of shoots around the plant suggests a promising future of the forest - growth or recovery from threats. The absence may suggest an ageing forest or seasonal changes. Plant shoots in specified plots will be traced and counted. Secondly, inspection will be done to establish whether they are sparsely distributed or concentrated in particular plots, followed by a decision as to whether they indicate good or bad mangrove health.

h. Dense canopy (*mwonekano wa umbo la juu la mimiea*)

A **well** aligned canopy with a distinguished green colour suggests that the forest is in good health. Poorly spaced mangrove species depict a spaced canopy that is only good in some parts of the forest and poor in other parts. Appearance of the forest canopy from at least a distance of 300 metres, the number of bare spaces in the identified plots and the general outlook of the forest colour, will help in establishing the health status of the mangrove forest. Monitoring techniques will thus involve standing within a arrange of at least 300 metres away to observe the appearance of the canopy, counting bare spaces in the specified plots, and ranking the canopy as either good or bad.

i. Accumulation of solid waste in the mangrove (*taka ngumu*)

Accumulation of solid waste in the mangroves impairs growth of plant seedlings and shoots. Discarded fishing nets, clothes, plastic materials, ropes, broken boats/fishing vessels and other forms of waste that can trap seedlings and shoots are harmful to the mangroves, and also to other vertebrates and invertebrates like juvenile fish, that use mangroves as their habitat. Observation of the presence or absence of solid waste in the mangroves will therefore help to establish whether such a threat exists or not. It may also be possible to locate the source of waste in order to address the threat.

j. Presence of invertebrates and vertebrates (*kuwepo kwa viumbe wadogo chini ya mimea*)

The presence of some crawling organisms in the soil/ ground that harbours the mangrove species, may suggest threats to seedlings and plant shoots. Other organisms like worms will, on the whole, indicate good aeration of the soil. A notable indicator in this case will be the presence or absence of insects or any other marine organisms that are considered as having a positive or negative relationship to the plant. A careful observation and identification of encroaching organisms near mangrove species, and particularly in the shoots, seedlings, and roots will be required.

7.4.3.3 Resolution of the attributes that constitute the scientific framework of indicators for monitoring mangrove based fisheries:

A. Key information:

- Monitored resource(s): Mangroves based fisheries
- Source of attribute/indicators: KIMP 2005; Hill et al., 2005
- Location of monitoring: Mkinga District, in Tanga Region
- Target community: Fishers and fishing community in general.
- Nature of monitoring : periodic

B. Common attributes/ indicators for monitoring mangrove-based fisheries:

- Population size
- Population structure

- Breeding success
- Weight and length of fish by species
- Type of gear used to catch the fish
- Distance to fishing ground (time taken to reach the fishing ground)
- Type of vessel used and size
- Means of vessel propulsion
- Number of crew
- Incidental catches of endangered species

C. Description of the attributes/ indicators:

a. Population size

Population size is regarded as a key attribute for determining the condition of fish surveys. Collecting data about fish population size has been mostly favoured in commercial fishing rather than for other purposes. The method involves taking a census of adult breeding fish and juvenile fish present in a particular location. Scientific methods for estimating fish population size differs with contexts, and more efforts are still being made to improve or develop proper monitoring techniques or methods. Currently, the methods suitable for still and slow-flowing water include hydroacoustic sonar (the use of sound signals in water in the process of fish tracking), counters, gill netting, seine netting, and trawling.

b. Population structure

Population structure is another demographic attribute which is prioritized in scientific fish monitoring. It entails assessment of fish birth-rate or recruitment, growth rate, and mortality. Recruitment focuses on the age that a fish can be caught and counted, and growth rate involves measuring the growth of individual fish in terms of size and length. Fish mortality may be regarded as caused by natural or harvest factors. The former refers to deaths which occur as a result of non-human predation, disease, and aging; and the latter (harvest mortality) is induced by fishers in the process of fishing (harvesting). Population structure also helps in tracking year class strength (identifying the number of young or juvenile fish surviving each year).

c. Breeding success

Reproductive output in maturing fish is influenced by both their physical size and condition. Fecundity is therefore dependent on prevailing conditions and the size of maturing fish. To determine fish size and their age, age and size distribution samples must be taken. Other monitoring and survey methods that accompany breeding success include eco-sounding (sonar) and catch returns (catch per unit effort).

d. Weight and length of fish by species

Establishing the weight and length of fish is an attribute that creates several links with other attributes and helps in establishing the status of fisheries per unit area. Fish length-weight data are useful in estimating growth rates, age structures, length, and fish population dynamics. Length-weight relationships help scientists to develop fish stocks assessment models by converting growth-in-length equations.

e. Type and gear used to catch the fish

Fishing gear is associated with fish catch selection, decline, and abundance. Small meshed nets are likely to catch juvenile fish and thus affect future breeding or spawning. Large nets are regarded as 'selective'; catching mostly adult or mature fish. Information about the type, and the gear used, can be collected by asking fishers who are involved in fishing, and recorded on special forms.

f. Distance to fishing ground (time taken to reach the fishing ground)

The distance from the high watermark or the fishers' homes to the fishing grounds may suggest the abundance or decline of fish catch. Short distances covered suggest the abundance of fisheries, while long distances raise possibilities of fish decline. Other factors for abundance and decline may also be observed, to avoid confounding possibilities such as weather and unsustainable fishing practices. Information on the distance covered can be accessed from fishers in specified areas and recorded.

g. Type of vessel used

The type of vessel used indicates the magnitude and pace of the fishing practice. Small fishing vessels suggest small scale or artisanal fishing while the use of 'trawlers' suggests

large scale fishing. Trawlers are considered to be a threat to both adults and juvenile fish when used in shallow water. Information about the types of vessels used can be collected near fish-landing sites, by asking involved fishers questions that respond to the above attribute.

h. Means of vessel propulsion

Powered vessels are associated with having wider fishing-coverage than non-powered ones (vessels without engines), since fishers with such vessels may more easily move from one reef area to another, than those who operate their vessels manually (depending on wind direction and manual steering). The means of collecting data about vessel propulsion include physical observation of the vessel, and conducting short interviews with involved fishers.

i. Number of crew

The number of crew members on a particular vessel may be linked to the abundance of fish catch. It may also suggest the scale of fishing (small or large). Data about this particular attribute can be collected through physical observation and non-formal interviews with the captain (vessel leader) or some members of the crew.

j. Incidental catches of endangered species

Incidental catching of endangered fish species may suggest a gradual recovery of affected fish populations, and inform management decisions. The size of fish caught may help in determining whether incidental catches involve juvenile or adult fish. Information or data about incidental catches of such species can be obtained from fish-landing sites, and by interviewing fishers.

7.4.3.4 Resolution of the attributes that constitute the Traditional Ecological Knowledge framework of indicators for monitoring mangroves based fisheries:

A. Key information:

- Monitored resource(s): Mangroves based fisheries
- Source of attribute/indicators: Processes of abstraction and experiential learning

- Location of monitoring: Mkinga District, in Tanga Region
- Target community: Fishers and fishing community in general.
- Nature of monitoring : periodic

B. Common attributes/ indicators for monitoring mangroves:

- Gill colour
- Colour of eyes (pale /brownish are bad)
- Skin condition (soft/hard) bouncing back or not
- Presence of wounds/ scars/ bruises
- Weight in relation to fish size
- Condition of the air bladder (good or bad?)
- Presence or absence of body fats
- Fish shape (physical appearance)
- Catch frequency of various species (most fished fisheries/ least fished)
- Frequency of blasts in case of dynamite fishing
- Number of fishers involved in mangrove fishing in the area
- Body parts (missing/ damaged?)

C. Description of the attributes/ indicators:

a. Gill colour (*rangi ya mashavu*)

The normal gill colour for a fish that has just been caught is supposed to be red. If the gills display a pale or whitish colour then the monitoring team may consider that particular species as being not healthy. Possible assumptions for bad health status may include the possibility that such a fish was already weak before being caught. Traditional methods or techniques for detecting the status of gills include the physical observation of the gills in selected fish-landing sites, and recording observations on a monitoring sheet.

b. Eye colour (*rangi ya macho*)

Colour of the fish's eye may indicate whether a particular species is healthy or not. Pale and brownish colours suggest poor health. Besides those two bad colours, different fish may

have different eyes, depending on their types. Key methods for accessing information that capture such an indicator is to observe caught fish in selected fish-landing sites, and involve experienced fishers who can easily distinguish the eye colours of different fish species.

c. Skin condition (*ngozi ya samaki*)

Condition of the skin may also indicate the health status of a particular fish. A healthy fish that has just been caught, when pressed hard, its skin bounces back to its original form. Unhealthy fish, when pressed with the thumb, do not bounce back, but rather attach themselves to the bones / flesh and show a thumb mark in the pressed area. Identifying healthy fish through this indicator can be done near fish landing sites. Other collected information that may go along with the above indicator may include recording of the species type, and whether it is a juvenile or adult fish. This may help to explain the category of the affected species, and guide management plans.

d. Presence of wounds/scars/bruises (*makovu, majeraha, na michubuko*)

The presence of wounds /scars / bruises in a fish that is displayed in the fish market or landing site suggests that a particular fish is not healthy. Wounds may suggest that the concerned fish species might have sustained injuries from hooking, dynamite blasts, or any other causes, including escape from natural predating; and that its health status has thus been affected. Confirmation of fish health status can therefore be done by examining whether there is a piece of hook hanging around the throat and in the stomach; and the presence of wounds, scars and bruises. This physical inspection or observation has to be carried out in a nearby or designated fish-landing site. Records of the availability of scars and possible cause of injuries will be recorded on the monitoring sheet or form.

e. Weight in relation to fish size (*urefu kuwiana na uzito wa samaki*)

Local fishers believe that fish weight is supposed to be proportional to their size. Any mismatch between these two may suggest that there is a health problem. Fish that have the specified length are also expected to weigh according to the fishers' expectations. This requirement varies from one species to another. Mangrove-based fish species such as the mudskipper (*dome*) have an average length and weight that can easily be estimated by indigenous fishers. Physical observation and estimation of caught fish may be verified by

weighing them and taking their measurements. Thereafter, fishers may link the fish-weight relationship to their health status.

f. Condition of the air bladder (*kondo la hewa la samaki*)

A damaged fish airbladder may serve as an indicator for the use of dynamite in fishing. When the bladder is intact, it indicates that that particular fish has been caught using common fishing gear such as nets. Confirmation of used fishing gear may be done through physical inspection of fish in a landing site. Hooked fishes will show scars around their throats or gills. A damaged air bladder is mainly used in establishing whether dynamite fishing was used or not. Information on whether the fish airbladder was intact or damaged can be recorded on special forms / monitoring sheets.

g. Presence or absence of body fat (*kunona kwa samaki*)

The presence of fats in a fish suggests that it is in good health. On the other hand, fish that lack fats in their body are described as being skinny and unhealthy, and not suitable for human consumption. To detect body fats, fishers look around the abdomen and examine the fish body alignment. Breeding fisheries are regarded as having such indicators and are thus good in health. In instances where the monitoring team may not be able to directly use local experiences to establish whether a particular fish has body fat or not, the abdominal part may be opened (using an agreed device such as a sharp knife) to see what is inside, and establish the cause. Records of the number of fat fish against those which are not, can be taken by the team.

h. Fish shape (*umbo au mwonekano wa samaki*)

The physical appearance of caught fish or their shapes, may indicate their health status. Thin, small, and dormant fish species are generally regarded as being unhealthy. Big and huge species are linked to good health status. If, for instance, mullet species are on average huge, any caught mullet species that appears long but thin, unlike the majority of other species, will be considered as having poor health. Collecting information for the above particular indicator may involve physical observation of fish in designated landing sites or at markets. Records that are associated with size may be recorded using tape measures, and scales.

i. Catch frequency of various species (most fished fisheries/ least fished)

(kukamatwa kwa aina kadhaa za samaki mara kwa mara)

Catch frequency may be used as an indicator for species abundance or decline. Those that are caught on a regular basis may be regarded as being abundant, and those that are rarely fished may be regarded as 'endangered'; and therefore inform management or conservation decisions. Collecting information or data that indicate catch frequency per species can be done at fish landing sites or markets, using special forms or sheets.

j. Frequency of blasts (*milipuko ya mabomu/baruti*)

Frequency of blasts in the ocean indicate that 'dynamite fishing' is likely to be taking place. Information about this indicator can be collected by counting the number of blasts heard per day or week. Some members of the monitoring team may be assigned the role of recording frequencies of dynamite blasts and report cumulative blasts during periodical monitoring of fisheries resources.

k. Number of fishers involved in mangrove fishing in the area (*idadi ya wavuvi wanaovua kokoni*)

The number of fishers involved in mangrove-based fishing may indicate whether there is fishing pressure in the mangrove or not. A small number may suggest that fish-growth is assured, as more juvenile fish in the mangroves (as nursery grounds) are allowed to grow to maturity level, and also the possibility of having breeding species which spend some time in the mangroves in spawning seasons to survive longer. More fishers, on the contrary, may suggest a future decline in fish catch, and possibly 'extinction' of mangrove fisheries. Information or data about this particular indicator can be accessed by making inquiries among fishers about the number of fishers who are specialized in mangrove fishing, and keep on updating the list periodically.

l. Body parts : missing or damaged (*ulemavu unaosababishwa na uvuvi*)

Some fishes may have missing or damaged body parts such as tails, gills, fins, eyes, or cut mouth. These may suggest that involved fisheries are physical impaired; and are therefore, not considered as being healthy. Possible causes for this condition include, dynamite fishing, and the use of unfriendly fishing gears. Fisheries with missing or damaged parts can be directly observed from nearby fish-landing sites and recorded in special forms. Records should indicate the affected part, specie type, and age (juvenile or adult).

7.5. Re-description phase (R2)

Re-description (R2) is the second moment (level) of analysis in the RRREI(C) model, which involves re-description of the phenomena that have been 'resolved' in the first moment; in a manner that make them theoretically relevant or significant (leading to emergence and outcomes). Re-description raises the need for users of the schema to make a decision about the level that is appropriate for describing the component cause, and deepening the analysis further to allow possibilities that can anchor explanatory mechanisms (Bhaskar et al., 2010).

This level presents the analysis of emerging attributes /indicators from the two systems or forms of knowledge (scientific and traditional), as discussed and analysed by research

participants and myself, the interventionist researcher, during the Experiential Learning Intervention Workshop (ELIW), and pursues a comparative route as an appropriate level for describing their component causes. It further deepens the analysis to allow possibilities that show synergies and contrasts in the two systems, and uncovers possibilities of either integration or prioritization of the attributes that local communities consider to be contextually relevant and most appealing.

It is quite interesting to observe that some of the attributes /indicators that emerge in the TEK framework are also prioritized in the scientific framework, in spite of varying techniques or methods in the two systems, on how data or information that describe them should be collected.

The Traditional Ecological Knowledge framework does not prioritise gathering data or information that reflects community structures and the biomass of the plant; neither does it consider the necessity for measuring a plant's primary productivity (see section 7.4.3.1C-b). The former attribute involves transect methods and scientific recording of data as techniques for information gathering, and the latter also requires carrying out scientific measurements of the leaf index. It is worth noting that both frameworks of knowledge choose or identify 'plant leaf' as a necessary element for monitoring of mangroves. Scientific institutions use plant leaves in the analysis of 'Primary productivity' (the rate at which plants accumulate energy) as mentioned above, while indigenous coastal communities use 'plant leaf' as an indicator for mangrove health - by simply observing the colour of the leaves and describing the health status of the plant that contain the leaf (leaves). An evergreen colour is associated with good health, while a yellow colour is an indicator of poor health.

Scientific measurement and analysis of the 'plant leaf' involves the use of a ruler and clinometer to capture the *zenith* angle and leaf index. Indigenous ways of collecting 'leaf' data are purely based on physical observation, touching, feeling and the application of simple methods such as striding, counting and associating (Berkes, 2008). The emerging contrast in this case is the use of the 'plant leaf' for capturing different information or data depending on the requirements that appear in the two frameworks. The most important

aspect that emerges from this contention is the fact that 'plant leaf' contains useful information which may help in explaining the health status of the mangrove ecosystem.

Plant scientists also consider 'leaf litter production' as an important attribute which may indicate the health status of the plant, and help in the correlation of soil moisture. Collection of data that reflect this particular attribute is mainly done through suspending a net on the ground to capture falling leaves. This may be possible in a terrestrial ecosystem where leaves may easily be trapped in the suspended nets and collected for further processing. The mangrove environment on the other hand, is characterized by high tides which can easily move every falling leaf to different positions, and may even move away leaves which are already trapped in the net and possibly damage or carry away suspended nets to other locations.

Besides the challenges that emerge from applying the suggested method, indigenous coastal communities consider the process of collecting leaf litter data as being long, cumbersome, and indirect, in that it does not directly indicate the health status of mangroves as is the case with their observation of plant leaves; which prioritizes leaf-colour as an indicator of the plant health status. By cumbersome, they refer to its methodological path of carrying out correlation procedures which are not easy for them to follow. They also don't see the necessity of analysing soil-moisture levels in the mangrove area since such areas are considered to be 'wet' throughout the year.

Soil is an attribute which appears in both frameworks. This particular attribute appears in the TEK framework as 'soil type' and in the scientific framework as 'soil characteristics'. The 'double appearance' suggests that soil is an important indicator which should not be ignored when carrying out community-based monitoring of mangroves. Re-description in this case, entails analysing indigenous descriptions of soil as an emerging attribute/indicator, as contrasted to scientific explanations of the same. This form of analysis creates some kind of duality or dichotomy which, when analysed, may lead to further emergence and outcome of explanations about the mechanisms that surround the two ways of viewing 'soil' as an attribute.

Scientific understanding of 'soil characteristics' as presented at the 'resolution' stage (see 7.4.3.1C-d) involves ex-situ and in-situ analysis of soil changes, including calculation of the extent to which soils are conducive to microbial decomposition or nutrient production (Redox Potential-Eh), pH analysis, structure, texture, and moisture content levels that affect the mangroves. It entails having not only specialized knowledge, but also the need to secure necessary equipment, facilities, and devices for facilitating the process of data collection and analysis.

On the contrary, indigenous understanding of soil as an attribute, focusses not on its chemical analysis, but on physical observation, perceived condition, and type. The main reason given by indigenous coastal communities for choosing 'soil type' as an indicator of a healthy mangrove ecosystem, is the premise that mangroves that are located where good soils are, are likely to be healthier than those located in 'bad' soils. For indigenous coastal communities, good soils (suitable for mangrove growth and flourishing) have two main characteristics. First, they should appear 'muddy, and secondly, must display a black colour' (an indicator of nutrient richness) while bad soils refer to rocky soils (which limit the penetration of roots), and soils that depict reddish and yellowish colours. This description therefore, suggests that mangrove sites that are fully covered with 'muddy black soils' tend to generate more healthy mangrove species than those that are covered by rocky or poor soils. In this case, soil type (muddy versus rocky) and soil colour stand as reliable indicators of a flourishing mangrove forest.

There is also a need to extend analytical comparison of soil as an attribute, by examining the manner in which the scientific and TEK frameworks link it to its ecological context. This may shed more light on whether carrying out some scientific soil analysis in the mangrove ecosystem is necessary or contingent. It may also affirm or lead us to mirror whether indigenous description and understanding of soil as an attribute is sufficient or not.

Carrying out a pH analysis of the mangrove soil for example, may be taken as a contingent act, rather than a necessary step, since marine water tends to encompass mangrove species at all times (via low and high tides), and such an ecosystem will by no means avoid high

levels of salinity; which tends to attract acidity rather than alkalinity, leading to low pH levels. It is thus a known fact that mangroves, being a salt tolerant plant species (Kathiresan & Bingham, 2001; Campbell, 2011) will in most cases experience “low pH levels” (Barbier & Sathirathai, 2004, p. 49). Indigenous observation of the soil as an attribute, appears to be simple and directly linked to the health status of mangroves, and less cumbersome than the scientific way which takes a series of events to arrive at the link between an indicator and the health of mangroves. Analysis of nutrient content for example, is carried out by simply observing whether the soil has a top dark layer (humus) or not. Soil characteristics are categorized into types, good/bad, and specific indicators to guide the identification of good versus bad soils are made and linked to the health status.

The scientific framework also raises the need to consider ‘area coverage’ an attribute that can help in detecting changes that occur in the mangroves. Scientific approaches suggest the use of aerial or satellite images (LANDSAT, MSS, and XS) and ground truthing methods such as the Transect Line Plot. While the attribute itself appears to be relevant to the mangrove situation, suggested methods or techniques raise several implications among coastal communities. These may be framed in a form of questions that seek immediate answers prior to incorporating the above attribute into the final congruent framework. The first question that emerges is: Can the coastal indigenous community (the majority of whom are poor) afford the use of aerial or satellite images in periodical detection of changes that occur in the mangrove forest?; secondly, do they understand the methods and are they able to apply them as suggested?; thirdly, is this the only approach for detection of changes in the mangroves?; and lastly, what is the familiar and favoured approach among coastal communities for addressing the same attribute?. The likely answer, as also confirmed in workshop discussions, to the first three questions is no. Available information reveals that coastal communities are very poor and they rely heavily on coastal and marine resources for survival (NICEMS, 2003). Poor people can therefore not afford to carry out aerial or satellite techniques. Seeking financial support to address this challenge may also not address long-term monitoring plans and can thus be regarded as being unsustainable. The need for communities to understand the methods and apply them is key to community-based monitoring since it ignites social learning and causes it to expand to a wider level of the community (Reed et al., 2010).

The traditional way of explaining or detecting changes that occur in the mangrove area is through physical observation of the plant leaves, roots, stem, branches, epical bud, and shoots (as opposed to 'area coverage') which depicts proxy indication. A change in colour from evergreen to yellow, pale, and red suggests a change in season or a threat (natural or human induced). A close observation or inspection of the plant or concerned forest patch will confirm the prevailing situation or change. Changes that occur around mangrove roots can be detected by observing the condition of roots (whether they are dug out, damaged, or exposed), while changes around the plant stem can be detected by inspecting the presence or absence of damage or other related threats. Changes in plant growth can be tracked by observing height, the presence of epical bud, plant shoots, and the general forest canopy, from a distance of at least 300 metres (see 7.4.3.2C-g).

Instead of using 'area coverage' as a means towards the detection of changes in the mangroves as suggested in the scientific framework, the said attribute can stand on its own as an indicator of the total mangrove coverage. Establishment of the forest coverage may easily be done by dividing mangroves into specific plots, and thereafter, make strides to establish the plot size, number of individual plants in a particular plot, and type of species that dominate individual plots. This is possible since mangrove restorers in the study area have for a number of years kept records of transplanted mangroves per plot, and are able to describe the forest area by plant categories. Considering 'area coverage' as an independent attribute or indicator, and accessing its information or data by creating manageable plots, may help the monitoring team to establish species composition and diversity (which is another scientific attribute - see 7.4.3.1C-f), and also help in the detection of dynamics or change (attribute vii), hence triple advantages. Activities such as the observation of old, mid, and young plants; counting the number of gaps or open spaces, and manual stock taking per individual plot, can be done by using the TEK framework.

It is also worthwhile to note that the TEK framework suggests a number of attributes which are relevant to the mangrove context and which are not reflected in the scientific framework. For example, it raises the need to observe invasive species in the mangrove ecology, the presence of charcoal kilns, and saltpans, as indicators of threats to the

mangrove ecosystem. Such information is not only contextual, but relevant to the description of mangrove status. Proposed methods or techniques for collecting data or information are simple and clear to coastal communities. Most of the suggested indicators are direct and not proxy (indirect), as it is the case with some of attributes that appear in the scientific framework (compare 7.4.3.2C with 7.4.3.1C). Scientific explanations require that certain conditions be met prior to arriving at the actual indicator. Most of scientific indicators of the health status of mangroves therefore, tend to appear in a form of 'attributes' rather than direct indicators, while TEK indicators appear 'actual' and can be applied directly without associating them with pre-processes or conditions. Taking for example the presence of charcoal kiln, any member of the monitoring team can easily and directly link charcoal making to mangrove clearance, and may simply count the number of kilns and record them on special forms to indicate the level of destruction in the area.

Having re-described scientific attributes or indicators that depict the health status of mangroves, it is now necessary to examine the second side which focusses on the scientific and TEK explanations of the attributes or indicators for mangrove-based fisheries.

With the exception of the first three attributes/indicators (see 7.4.3.3C-a,b,&c), the remaining ones seem to be closely linked to the kinds of information or data that may be accessed by local fishers in the study area; though there may be some methodological challenges which can be adjusted for congruence. This does not however, mean that there is a direct match with those that appear in the TEK framework, but rather contains an indication of possible evidence that sought information is familiar to fishers, and can easily be understood and accommodated in the TEK framework. For example, identification of gear that is used in fish catching, vessels used and their size, number of crew in a particular vessel, and the distance that fishers cover to fishing grounds, are common or familiar attributes among indigenous coastal fishers. Capturing of such detail is possible since they are experienced by fishers on daily basis, and can therefore, be accessed easily and recorded for monitoring and management purposes. Discussions held during the Experiential Learning Intervention Workshop confirmed that indigenous fishers are able to identify or recognize fishing vessels at least 5 kilometres away, as they approach the landing

site (on their way back from fishing activities), which may not be possible for people outside the fishing community to do.

In spite of the identified potentiality or possibility for incorporating some scientific attributes into the TEK framework, there are contextual challenges that emerge from some of the scientific attributes mentioned above. This focuses on the existing contrast between fishing activities that occur in the mangrove ecosystem and those that are carried out the ocean reefs. Mangrove fishers tend to be few in number as compared to the majority who fish in the ocean. There is also a difference between fishing gear in the two scenarios as described below by one the experienced fishers in the study area:

Mangrove fishing involves few fishers who use traditional fishing gears such as hooks and traps. Most of fishers prefer fishing where there is much water or ocean reefs. There is a difference between now and in the past. In the past most people could fish nearby; in areas such as mangroves because the catch was high by then than now. Now modern fishing is prevalent and there is increased number of fishers and fishing vessels (9FMNII).

It is therefore clear from participant 9FMNII that mangrove fishing is carried out at a smaller scale than reef fishing. Attributes that seek identification of the vessel propulsion may not be contextually relevant, since mangrove fishing rarely prioritizes powered vessels but rather small boats (which can carry one to two individuals).

Other scientific attributes which are not prioritized in the TEK framework due to their methodological challenges include population size, population structure, and breeding success. Possible challenges for incorporating these three attributes in the TEK framework lie not only in the difficulties of employing suggested scientific monitoring techniques such as calculation of recruitment/birth-rate, growth rate, and fish morality levels, but also in affordability of involved costs; for example in the use of eco-sounding (sonar).

It is interesting to note that at least two (20 %) of the attributes that appear in the scientific framework are prioritized in the TEK framework. One of these, is 'weight and length of fish by species' which appear in the TEK framework as 'weight in relation to fish size'. The second attribute is the 'number of crew' which appears as 'number of fishers involved in

mangrove fishing in the area'. But it is also a great challenge to observe that the scientific framework leaves out almost 80 percent of the TEK attributes/ indicators (compare the scientific framework for monitoring mangrove-based fisheries in section 7.4.3.3C: a-j and the TEK framework in section 7.4.3.4 C: a-l).

Leaving out indicators like 'catch frequency of various species' which entails collection of data that reflect the most or least caught fish in the mangrove area, may lead to a lack of information that specify species that are likely to be endangered in future as a result of overfishing, or detection of whether fish that were once extinct are back in the fishing cycle or not. Catch frequency of various fish species as an indicator can therefore, not only help the monitoring team to detect *trends* of caught fish but also *changes* in fish catch and diversity. One way of using such an indicator to detect *trends*, is by establishing whether the most caught fish species are juveniles or adults. The former may suggest not only a change in future reproduction *trends* but also a pending *threat* or a decline (as most juveniles are caught before the reproductive age).

The scientific framework also leaves out indicators that may suggest occurrence or prevalence of *threats* in the fishing area. Field data from fishers indicate that unsustainable and illegal fishing practices are common in the study area, especially the use of dynamite. During focus group discussions, most of examples that fishers gave related to dynamite and poison fishing; this was the main reason for the inclusion of indicators such as 'frequency of dynamite blasts' 'condition of the skin', and 'condition of the airbladder' in the TEK framework (see section 7.4.3.2 C:a-l). Suggested TEK indicators therefore, carry a contextual reflection which is meaningful to the study area. They do not only aim at collecting data or information that mainly prioritize *trends* and *changes* as is the case with those that appear in the scientific framework, but also *threats*, and the *condition* of monitored fisheries, since monitoring as an experiential learning praxis includes all four parameters (Wagner et al., 2001).

TEK indicators for mangrove-based fishing appear to be direct to the desired condition or situation than indirect. For example, observing the colour of fish gills, particularly, as an

indication for good or bad fish-health (see 7.4.3.2 L-a), is not only simple but also clear. This is also the case in other suggested TEK indicators (see 7.4.3.4 C:a-j).

Indigenous assessment and interpretation of the scientific attributes (discussed in this section) conclude that it is not easy to exactly pursue a prescribed scientific methodological route in realising attributes such as community structure and biomass, and primary productivity of mangrove plants or fish population structure and breeding success, but rather use contextual relevance as a key criterion. The latter implies ensuring that attributes or indicators that are added to the TEK framework from the scientific side, reflect the mangrove ecosystem scenario and can be comprehended by mangrove restorers and fishers, and applied without difficulty.

Challenges raised by mangrove restorers during the analysis of the scientific framework revolved around the meaning and relevance of attributes, to the realisation of mangrove health, and difficulties in collecting the required data or information. Attributes that proved to be directly linked to indigenous ways of monitoring, and which could easily be adopted by them, were accepted and incorporated in the new framework. Some methodological aspects of the scientific framework, such as dividing the mangrove ecosystem into specific plots, seemed to be relevant and useful to mangrove restorers, in that they could simplify the process of physical observation as a key monitoring technique prioritized in the TEK framework.

7.6 Retrodiction (R 3)

Retrodiction is the third level of the RRREI(C) analysis which involves explaining or interpreting ideas or information by making assertions about the past, and making inferences from effects to causes (Bhaskar et al., 2010; Psillos, 2007, cited in Hartwig, 2007; see section 4.6.3). It is a process of inferring present realities to past theories or explanations. Retrodiction also creates a platform for involved individuals and social groups to examine the manner in which known causes may trigger or interact with each other and eventually give rise to “concrete phenomena” (Hartwig, 2007, p. 196). In this particular context, it offers a landscape for mangrove restorers to retrodict various situations that surround scientific and traditional ecological knowledge (as known causes that may trigger

or influence social learning), and arrive at the point where their input gives rise to congruent indicators.

Prevailing discussions about the current status of mangroves, are in most cases attached to what happened in the past (see chapter 5). Mangrove restorers, local elders, and mangrove-based fishers, appear to be convinced that mangrove forests in the study area are far better off now than before (when they were being harvested unsustainably, not only by communities that live around the coast but also people from other locations). In such a situation, it is common among coastal dwellers to associate practices such as charcoal burning and salt making with clearance of mangrove resources. This implies that seeing one or several charcoal kilns or saltpans in the mangrove area would suggest that some mangrove plants have been cleared for a particular purpose; which depicts what Hartwig (2007) would call 'retrodiction'.

Indicators play a great role in 'retrodiction', since they tend to create direct links or associations between what is being observed and possible previous explanations that are responsible for causing or generating them. Indicators or attributes that lack such capacity may not be very useful in practices such as community-based monitoring, which also encourage experiential learning or learning by doing (see chapters 5 & 6).

An indicator such as the 'presence of mangrove stumps' in an area may suggest that some mangrove species have been cleared in a particular forest; the presence of piles of mangrove logs in the same area may help in 'retrodicting' that the piles were cleared from the area that has several stumps.

Through 'retrodiction' (Bhaskar, 1998), indigenous coastal communities can assess a prevailing situation with reference to the previous condition, and avoid circumstances that may limit community-based plans, practice and praxis.

In this study context, retrodiction as the process created opportunities for users of the two frameworks of knowledge to dialogue or analyse the potential contribution of the new set of indicators in addressing the health status of the mangrove ecosystem, by making

reference to the old framework. The process therefore, created a platform for testing the effectiveness and relevance of the new situation (use of the new framework), by comparing the application processes to past or previous experiences. This helped in affirming what has been produced, and also in seeking comments or input which could help in improving the new framework.

The statement given by one of the participants below, who had participated in the testing of the Traditional Ecological Indicators, depicts a form of retrodiction which describes the present situation in relation to the scientific framework of indicators which has for decades existed in the study area:

As we were testing the new indicators, we found them to be simple and easier than the old ones. They are straight forward and can be done in a very short time. All group members played a role in the testing (5MMNFG).

There are three observations that emerge from the above statement. The first one is connected to the group members' ability to apply the methods or techniques that accompany the TEK framework. The second observation is related to connectivity of the indicators to the desired state (health status of mangroves), and the last one is related to time as a key factor in the process of monitoring. Perhaps it is also important to observe that all members in the said group participated effectively in the testing exercise. This suggests an environment where knowledge sharing is not only possible, but more easily assured. Positive views regarding the usefulness of the TEK framework seem to bring into view a new situation which was not there when the old framework was being applied.

Views from 5MMNFG (the group leader) suggest that when the indicators are simple and easy, participating members are likely to participate effectively in numbers, more so than when there some barriers which may limit them from taking part fully in the practice or praxis. This is also the case when the indicators are regarded by users as being 'straightforward'; which implies that individuals and social groups that are involved in the process of applying them are able to understand not only what the indicators seek to accomplish, but also what the whole framework is about. The opposite may also be true of

the implications of the old framework of indicators to the same group of people as the statement below indicates.

Those indicators were for the educated. You could count two or three individuals who could at least use them. But these ones are simple because you just observe and record what you have observed (1MMNII).

A close analysis of the above statement affirms that there must have been a methodological problem which made the application of the old framework of indicators difficult or impossible to use for some. It also suggests that the framework itself divided coastal communities into two groups, namely the educated and non-educated. This is affirmed by two more accounts from mangrove restorers which reflect the same sentiment: *“The former indicators were not easy; I was unable to use them as compared to these ones”* (17MMII); *“One could hardly understand that framework of knowledge; this one is clear”* (22MMFG).

This may be the case when the above three accounts rule out that the scientific indicators were for the ‘educated’ or in other words, they may only be applied by those who happened to go to school and not those who did not. Their comments about the new framework erase their previous negative perception of the indicators, and raises a state of belonging and hope for future participation.

On the other hand, comments from the above participants (1MMNII, 17MMII, and 22MMFG) suggest that before the development of the new framework of indicators, interaction (which is a key criterion for occurrence of social learning) was limited to the so called ‘educated’. This may thus imply that the old framework did not create sufficient opportunities for learning. As Newig et al. (2010) puts it, learning may occur through social interaction when involved social groups and individuals share knowledge about new ideas and facts, and as they communicate in the social practice. Learning can hardly occur when opportunities for interaction are limited by prevailing conditions, as it is the case with the application of the old framework of indicators.

Retrodiction therefore, in the above scenario, is basically a process of experiencing a change in seeing, understanding, and carrying out community-based monitoring of mangroves in a

different way (much better than before). It is simply a new way of looking and doing things, as compared to previous approach (es) in the same context.

7.7 Elimination (E)

As presented in the introduction of the RRREI (C) model (see 7.3), this stage seeks to eliminate competing alternatives or confounding explanations in order to keep those that explain the situation better and in a more pure manner. The process of 'elimination' is therefore, crucial and must be supported by 'evidential grounds' (Hartwig, 2007, p. 196).

The application of elimination in this chapter involves leaving out some of the attributes or indicators that fail to directly address contextual relevance, and those that are likely to limit social learning among individuals and social groups on grounds that are raised and analysed by research participants (as representatives of coastal communities).

The section therefore, presents views from research participants on why some indicators or monitoring techniques may be regarded as relevant to their context or not. Some of these views already appear in the description part which presents the relevance of some indicators in the monitoring process.

The sole purpose for developing or adapting indicators in the coastal environment is to be able to capture data or information that reflect the conditions, trends, threats, and changes that occur in the mangrove ecosystem (KIMP, 2005). Through this process, participating communities are able to not only interact and share knowledge at different levels (Reed et al., 2006; 2010; Pahl-Wostl et al., 2007) but also detect the health status of the said ecosystem (Wagner et al., 2001), and continually learn through repeated experiential learning practices to a wider level of social learning. In this case, only attributes or indicators that are capable of steering such a learning process are likely to be meaningful or relevant.

As discussed earlier in the re-description section, coastal communities consider choosing neither 'community structure' nor 'plant biomass' as an indicator for mangrove health, nor do they see the necessity for collecting data on 'primary plant productivity' (see 7.4.3.1C-a & b). Presented grounds for discarding the above two indicators include their total reliance

on scientific measurements and cost implications. Another reason for their elimination in the congruent framework is their failure to directly indicate the health status of mangroves. Research participants instead, remain convinced that the health status of mangroves can be detected without necessarily pursuing the route that is prescribed in the first indicator (community structure and biomass), but through the experiential intervention workshop they chose 'plot method' (a modified form of Transect Line Plot) to simplify physical observation processes which are common and familiar to them, for inclusion in the new framework.

Regarding the second attribute/indicator (primary productivity), which requires measurement of the leaf-index-area (due to its potential correlation with the process of photosynthesis), research participants acknowledge its importance but prefer picking 'leaf-colour' instead, as the indicator for the health status of mangroves. The main ground here is the fact that scientific understanding of the 'primary productivity' has to first be associated with the analysis of leaf-index measurements, a scenario which depicts an indirect route, rather than the one that 'leaf-colour' as an indicator would take. In other words, the TEK framework prefers direct indicators to indirect ones, and only accommodates the latter, where the former is not in place.

Capturing of leaf-litter production (a third scientific attribute/indicator) is also not preferred in the proposed congruent framework of indicators, due to lacking contextual relevance in methodological terms and also on grounds that the data or information that it seeks to capture and eventually link them to the health status of mangroves, can be captured from physical observation of the plant leaves, not only by colour but also the general outlook of plant leaves depending on seasonal variation. The scientific framework does not consider the latter as influencing plant health as is the case with the TEK framework.

Scientific monitoring techniques for collection of soil data, or information such as the calculation of Redox Potential and analysis of soil structure, texture, moisture content and pH levels are eliminated or replaced with physical observation of soil condition and colour. Observed soil types will be categorized as either muddy or rocky, and the colour of plant leaves will be observed to determine whether the soil is good or bad. A black colour, as

communicated earlier (see details on the relationship between muddy soil, rocky soil, soil colour, and colour of plant leaves in 7.4.3.2C-c) indicates healthy soil. Reasons for retaining soil as an important attribute, but discarding its methodological approaches include the inability of research participants to apply suggested methodologies, cost implications, and research participants' confidence that methodologies that are suggested in the TEK framework are contextually reliable.

There is also elimination of aerial, stock mapping, and transect methods and techniques that are suggested in the scientific framework for monitoring species composition and diversity and dynamics (change), on grounds similar to those that appear under 'soil'. Stock mapping is replaced by manual stock taking per individual mangrove plot, and aerial methods are replaced by ground observation techniques. While aerial monitoring techniques tend to be expensive, they tend also to accompany ground truthing, which emerges as an additional cost (see 7.4.3.1C-e). The TEK framework prioritizes ground observation and recording methods which are similar to ground truthing, but serving different purposes.

Elimination is also reflected in the fisheries part (See section 7.4.3.1C-a, b & c), where three scientific attributes out of 10 are discarded from the congruent list (final framework), on grounds of contextual relevance, methodological difficulties, and cost implications. These include population size, population structure, and breeding success. The remaining attributes / indicators such as weight and length of fish by species, type of gear used to catch fish, distance to fishing ground, type of vessel used, number of crew, and incidental catching of endangered species, closely match the TEK framework and are therefore, congruent to research participants.

In a nutshell, the process of elimination in this chapter leaves out two scientific attributes for monitoring of the health status of mangroves (community structure and biomass, and primary productivity), and modifies some components of the remaining attributes through the process of 'correction' to make them congruent to those that appear in the TEK framework). The process also discards three scientific fisheries attributes (population size, population structure, and breeding success), on methodological, affordability, and contextual grounds, and opts for the remaining as relevant to the mangrove context.

7.8 Identification (I)

The identification stage involves choosing generative mechanisms that are believed to be correct from those considered (Hartwig, 2007). It thus qualifies certain explanations as being relevant causal factors for the prevailing conditions or situation in preference to those which are considered to have little or no influence. In this chapter, identification is applied to choose indicators or attributes that are believed to be more relevant to the coastal environment than those which are not. Criteria that are applied in the process of 'identification' involve several aspects of concern which are regarded by coastal communities as being necessary rather than contingent. In other words, the process of identification involves several questions that when addressed, will show a meaningful end or outcome:

- First; identification of the indicator as being relevant was based on its connection to the mangrove context (is the indicator appropriate to the mangroves scenario?)
- Second; was the extent to which users of the indicators are familiar with it (is the indicator familiar to coastal communities?)
- Third; was the capacity of the indicator to distinguish natural from human-induced impacts (does the indicator distinguish natural from anthropogenic threats or impacts?)
- Fourth; was the methodological level of the indicator (can the indicator be measured by common individuals?)
- Fifth; costs implications (does the indicator involve manageable costs?)
- Sixth; interpretation (can the indicator lead to collection of data that can easily be interpreted?), and
- Seventh; usefulness (is the indicator able to directly indicate the health status of mangroves or mangrove-based fisheries?).

An answer to the above questions would directly lead to the choosing of indicators that meet the above criteria. It is obvious that most of the indicators that appear in the TEK framework were developed in line with the above criteria, and therefore, most of them were identified as being relevant and specific to the coastal environment. However, observations from 'field testing' / testing of the TEK framework suggested some

adjustments, not in the indicators themselves but in the techniques that capture length and size (see section 7.9 below).

On the other hand, some indicators from the scientific framework were also identified as qualifying for guiding monitoring of mangroves and mangrove-based fisheries, with the exception of those that depicted methodological, contextual, and cost implicated challenges (see section 7.7, and section 7.9 below).

The scientific fisheries indicators or attributes seemed to be less reified as compared to those in the scientific mangrove framework (see evidence in first session of the Experiential Learning Intervention Workshop in section 4.5.3.8), although some of its methodological approaches were either eliminated/replaced or corrected by workshop participants as I facilitated the workshop, on grounds that are discussed above and in the last stage of the RRREI(C) model (see section 7.9 below).

7.9 Correction stage (C)

The correction stage is the last part of the schema which allows users of the model (the research team) to remove possible errors that appear in the process of phenomena analysis, to keep the outcomes of the analysis as pure as possible. The process of correction in this section is depicted in several forms. First, it involves the correction of some traditional ecological monitoring techniques by replacing them with methods that were considered by participants of the Experiential Learning Intervention Workshop (mangrove restorers, fishers, local elders, and invited local coastal and marine scientists) as being most reliable; second, it considers cost implications for periodical monitoring; and lastly, as it is the case in the elimination stage, it foregrounds contextual relevance (including the ability to directly indicate the health status of mangrove species in the coastal environment).

The original indigenous proposal for measurements, taking for instance length size, and weight, favoured the use of pure traditional methods such as strides (in estimating plot size), '*pima*' (hand method to determine plant length), and estimation method (to determine the fish weight and length). These were, however, corrected and improved during the Experiential Learning Intervention Workshop, following some challenges which

were experienced by some workshop participants during the (afternoon) indicator testing session (see sections 4.5.3.8 and 6.7). Feedback from this exercise revealed that indigenous forms of measurements may be applicable for mangroves in general, but can hardly show the rate of growth, or increase at a centimetre level or below. The main concern in this case, was the fact that mangroves take a gradual growth process and sometimes it may not be easier to detect the rate of growth by using 'pima' (hand-stretch method).

We found out that it is not easier to measure all levels of plant growth by 'pima'. One 'pima' is reached when you stretch both hands. Half 'pima' is one hand. You know that mangroves grow very gradual; sometimes to an inch level. We need to bring-in the 'metre' to help in catching different levels of length, up to at least a centimetre level (5MMNFG).

For the above reason, traditional methods were corrected to accommodate the use of a ruler in taking measurements, and scale or balance for recording fish weight. With the exception of using a ruler in taking size and length measurements, it appeared that most fishers were able to estimate the weight of fish without using a scale with no or minimal errors. This indicates that in the absence of weighing facilities, fishers may still carry out monitoring practices, and the presence of facilities will even enhance their monitoring practices.

Correction is also made to at least two scientific mangrove attributes or indicators, to make them reflect or bear contextual relevance, be meaningful to users of the framework, and manageable in terms of costs. 'Area coverage' for example, is presented as a means towards detection of changes that occur in the mangrove forest; with attached techniques such as the use of satellite images such as LANDSAT, MSS, and XS. Participants' analyses of the above indicator, corrected the indicator from standing as a means for detection of changes, to an independent indicator which can be detected by physical observation of species composition per individual mangrove plot; where species type, number, and diversity can easily be observed and recorded without necessarily using satellite image techniques as suggested above.

Correction is also made to the last scientific mangrove attribute in the resolution stage (see dynamics/change in 7.4.3.1C-g) by re-framing the kind of information or data that is

supposed to be collected, and replacing aerial techniques with ground methods that are in line with the TEK framework.

Generally, the process of correction involves tuning indicators or attributes and their associated monitoring techniques from a too reified level to the congruence stage, which may be regarded by the model as pure.

7.10 Supporting (underlabouring) the scientific framework with TEK indicators/attributes

Tables 7.1 and 7.2 present the indicators / attributes that were considered by workshop participants as being less reified, and more contextually and culturally congruent after processes of resolution, re-description, retrodiction, elimination, identification, and correction. The fourth column (titled 'nature of the indicator') shows the source of the attribute / indicator. Most of attributes that seemed to appear in both frameworks (the existing scientific framework and the new TEK framework) were given more weight, and selected after discussing other associated aspects such as methods or techniques, that will accompany them in the new framework. The second column presents an *attribute* that needs to be monitored, the third column shows the *indicator* that will be used to monitor that particular attribute, and the fourth column as explained earlier shows the source of that attribute (e.g. TEK or Scientific). Indication of '*TEK/ Scientific*' in the same column suggests that the indicator appeared in both frameworks before the process of integration; and 'TEK' alone, implies that it originated mainly from the new traditional ecological framework. The fifth (last) column suggests the methods or techniques that will be applied for each indicator.

Table 7.1 Integrated monitoring framework for mangrove species

SN	Attribute	Indicator	Nature of the indicator	Monitoring technique/method
1.	Soil characteristics	Soil type and colour: Muddy-black soils indicate high nutrients; rocky reddish or yellowish indicate poor soil.	TEK/ Scientific	Physical observation of soil layers and colours and recording observed details.
2.	Species composition and diversity	Area coverage	Scientific/TEK	Dividing mangroves into specific plots, taking strides/tape measurements of plot size, counting individual plants per plot, observing and recording dominant species per plot and Recording total young and mature species.
3.	Dynamics (change)	Physical outlook of plant species: leaves, roots, stem, branches, epical bud and shoots.	TEK	Observing whether leaf-colour is ever-green (good), pale/red (poor) and yellow (very poor); Indicating the cause of change (e.g. poor soil, human threats, or natural). Observing whether the roots are fully covered by the soil, exposed or partially exposed; checking the stem (is its bark peeled off or not; any threats to the branches, and shoots? Epical-bud removed or not?
4.	Presence of mangrove stumps in area	Number of stumps in the mangrove area	TEK	Counting the number of stumps, taking strides or tape measurements to establish the size of damaged area.

5.	Drying or withering mangrove species	Number and type of affected mangrove species	TEK	Physical observation of leaves, branches, and stem per plot and recording observed condition.
6.	Presence of invasive species	Type of invasive species, size of the area covered, and number of affected mangrove trees	TEK	Inspecting specific parts such as the tree canopy, the ground recording observed details. Area covered by invasive species can be measured by metre or strides depending on the affected part.
7.	Presence of charcoal kilns	Number of charcoal kilns in the mangrove area	TEK	Physical observation and recording of details.
8.	Presence of saltpans	Number of saltpans in the mangrove area, size of the damaged area.	TEK	Physical observation of the affected area and taking strides or metre measurements to establish the size of the damaged area.
9.	Dense canopy	Canopy appearance (thick or poorly distributed), and number of open spaces/gaps in the mangrove per plot.	TEK	Observing the appearance of mangroves from at least a distance of 300 metres, and counting the number of open spaces/gaps per plot.

10.	Solid waste	Accumulation of solid waste in the mangroves	TEK	Observing the presence or absence of solid waste in the mangrove and classifying the kind of waste trapped in the mangroves (eg plastic, broken boats, discarded fishing nets, clothes, ropes, etc. and indicating affected mangrove species.
11.	Presence of invertebrates and vertebrates	The kind of vertebrates or invertebrates present under the mangrove tree	TEK	A careful observation and identification of crawling organisms around the plant, particularly in the roots, shoots and seedlings.

Source: Developed from field data/ELIW 2012

Table 7.2 Integrated monitoring framework for mangrove-based fisheries

SN	Attribute	Indicator	Nature of the indicator	Monitoring technique/method
1.	Weight and length of fish by species	Fish length and weight	Scientific/TEK	Weighing caught fish per species, using a metre to measure their length, and comparing recorded weight of selected species by size to observe possible differences
2.	Used fishing gear	Type of gear used to catch fish, (unsustainable gear suggest threats to fisheries or high mortality rate while sustainable gear indicates assured future	Scientific/TEK	Asking fishers to help in identifying used fishing gear and recording them.

		birth-rates).		
3.	Distance to fishing ground	Distance in metres or kilometres from the launching point to the fishing area.	Scientific/TEK	Use of 'estimation method' to establish possible distance or measured boats when such equipment is available.
4.	Mangrove fishers in the area	The number of fishers involved in mangrove fishing in the area	TEK	Physical observation (counting) and seeking confirmation from fishers in the area.
5.	Incidental catches of endangered species	Number and type of endangered species caught	Scientific/TEK	Interviewing fishers in fish landing sites and recording given information or data.
6	Gills cover	Colour of gills (red colour suggest good health while pale and whitish indicate good or bad health)	TEK	Physical observation of the gills at a fish-landing site and recording the observed colour.
7.	Eye colour	Colour of fish eyes (pale and brownish suggest poor health)	TEK	Observing caught fish in fish-landing sites, and involve experienced fishers in the colour identification.
8.	Skin condition	Ability of the 'skin' to bounce back when pressed/thumbed. Skin of a healthy fish bounces back when pressed as opposed to unhealthy one.	TEK	Pressing caught fish with thumb at a fish-landing site to observe whether the skin bounces back or not, and recording the observation. Species type /age (juvenile/mature) may also be recorded to indicate the affected species.
9.	Wounds/scars	Presence of	TEK	Inspection or observation of

	/bruises	wounds, scars or bruises indicate a health threat.		wounds, scars, or bruises in a nearby fish-landing site, and any other threats such as hanging hooks.
10.	Condition of fish air-bladder	A damaged fish-airbladder indicates the use of dynamite in fishing	TEK	Physical inspection of the fish-airbladder in a nearby fish-landing site with the assistance of experienced fishers. Recording the affected species by type and age (juvenile/mature)
11.	Fish body-fats	Presence of fat in a fish suggests a good health while those without fat are regarded as skinny and unhealthy.	TEK	Using agreed device (eg a sharp knife) to inspect the abdominal part and getting assistance from experienced fishers.
12.	Fish shape	Physical appearance of a caught fish may indicate their health status. Thin, small, and dormant fish are linked to poor health while big/huge fish are associated with good health.	TEK	Physical observation of caught fish in designated fish-landing-site or markets to establish whether caught fish are regarded as having good shape or not.
13.	Catch frequency	Catch frequency indicates abundance or decline of fish catch.	TEK	Record taking of most frequently caught species to predict a possible future decline and records of rarely caught species for conservation decisions.
14.	Frequency of	Number of	TEK	Interviewing communities and

	blasts	dynamite blasts heard per week		recording the number.
15.	Fish-body parts	Missing or damaged body parts such as eyes, tails and fins or severe damage of the above parts.	TEK	Physical observation of caught fishes in the fish-landing-site and recording of missing parts, species type and specie age (juvenile/adult)

Source: Developed from field data/ELIW 2012.

7.11 Conclusion

The RRREI(C) model, as shown in this chapter, proves to be a useful tool for resolving the complexity that prevails in the open environment like a mangrove ecosystem, which accommodates social, ecological, economic, and cultural interactions; and may potentially help researchers to retain or produce expected results (e.g. integrating a costal monitoring plan which contains attributes or indicators that originate from different knowledge systems).

The said model is not only useful in examining and analysing possible synergies, contrasts, relationships, and comparisons between two or more complex systems/frameworks of knowledge, but also in explaining how research participants or local communities (like mangrove restorers and fishers) may arrive at pure results, from a complex situation. It offers opportunities for identification, elimination, and correction of the indicators/attributes that do not meet the required criteria, and retains those that are relevant to the context. It thus simplifies the process of ‘underlabouring’ Traditional Ecological Knowledge (TEK) indicators with those that contain scientific abstractions (scientific framework of indicators) as is the case in tables 7.1 & 7.2. The process depicts “typology v” of social learning (see Cundill & Rodela 2012, p. 19), that “social learning facilitates collective action around common environmental concerns”.

CHAPTER 8: RESEARCH SUMMARY, FINDINGS, REFLECTIONS, RECOMMENDATIONS, AND CONCLUSION

8.1 Introduction

This chapter provides a summary of the research, and highlights some of the specific and general ampliative inference-based findings that this study yields. It also presents reflections that necessitate suggestions on the way forward and eventually leads to some conclusive remarks. Specific findings here refer to knowledge that directly responds to the key research questions while the general findings focus on knowledge that results from the analysis of data that emerged from crosscutting issues in the study.

8.2 Research summary

As explained earlier (see sections 1.5, 1.6, & 1.6.1), this research sought to uncover the manner in which processes of *abstraction*, *conceptualisation*, and *representation* of TEK may potentially contribute to the development of coastal management indicators that are less reified, more contextually and culturally congruent, and which may easily be used by resource users in the wider social learning process of detecting trends, threats, changes and conditions of mangrove and fisheries resources.

To realise the above goal, the study employed critical realism and experiential learning theories to help me, as researcher, explain, interpret, and analyse the potential contribution of abstraction, conceptualisation, and representation in social learning processes within the coastal environment; and explore how these mobilised representation of traditional ecological knowledge as an input for developing monitoring indicators for fisheries and mangrove resources in the study area. Moreover, the said theories were intended to serve as analytical and methodological tools in the process of not only developing traditional ecological indicators, but also in lensing how research participants used the indicators they had developed to support the existing scientific framework indicators. The latter process is represented in this study by a critical realist term commonly known as ‘underlabouring’ (see section 1.7.10).

While this study cites low levels of education, inability to access western scientific knowledge, preference of top-down approach, and non-consideration of traditional ecological knowledge as reasons for ineffective participatory monitoring in the coastal area, other factors may also affect experiential learning practices in the process of monitoring mangroves and fisheries. These might include lack of interest for some community members, preference of other activities, and lack of time given the struggle for subsistence. These are however, not documented and therefore not directly considered as key hypothesis in this study. It may also be noted that the study prioritizes Traditional Ecological Knowledge (TEK) over other hypotheses as having the potential for underlabouring western scientific knowledge. This is based on contextual data that shows that the majority of coastal communities employ TEK in their day-to-day interactions as it is revealed in chapter 5, and documented in KICAMP (2004) and NICEMS (2003).

The conception and description of the study context (see chapter 1) brings into view a reflection of key concepts that underpin this work and their relevance to realisation of the study goal, especially processes of abstraction, social learning, indicators, scientific and traditional ecological knowledge, mangrove and fisheries species, and the coastal and marine environment. The study presents the contextual and socio-cultural challenges of adopting and applying scientific indicators or monitoring plans as a constrainer to social learning on the eastern coast of Tanzania (see section 1.3.2), and brings into view the potential of traditional ecological knowledge (see sections 1.3.3 and 1.3.4) as useful and necessary in areas where such challenges prevail. However, unlocking TEK and enabling social learning in the coastal area requires the use of processes of abstraction and experiential learning, as shown in this study.

Representation of scientific and traditional ecological knowledge is not primarily aimed at prioritising any of these types of knowledge, but rather at finding ways that may favour their integration; and allow access of knowledge between scientific institutions and coastal local communities - especially mangrove restorers and fishers, in a manner that attracts useful interactions and knowledge sharing in the study area (see figure 1.1 in section 1.3.3; and chapter 7). The two types of knowledge are presented in this study as having the potential to complement each other (see tables 1.1 & 1.2 in section 1.7.6; and in chapter 7, table 7.1

and 7.2) and this may be identified by examining their contrasts and similarities in terms of style and use, as discussed in detail in chapter 7. The concept of 'social learning' (1.7.5 & 2.2) is represented and discussed in this study not as new or emerging, but as a term that has partially been in use or implied across paradigms (behaviouristic, cognitivist, and constructivist) and across theories such as situated learning; cognitive, and knowledge management), and is increasingly by itself considered to be an independent theory (theory of social learning). The study observes a shift in the understanding of social learning among social science researchers from a general perspective to include specific contexts or disciplines such as natural resource management (Muro & Jeffrey 2008; Cundill & Rodela, 2012), in which refined and in-depth analyses of the characteristics of such learning are being developed (as in the Cundill & Rodela (2012) typology of social learning developed from an in-depth systematic literature review of social learning research in natural resource management contexts).

The study links praxis and practice to social learning, particularly learning by doing or experiential learning; where involved individuals and social groups interact and share knowledge, leading to knowledge transfer and sharing amongst the most experienced and the least experienced (see sections 5.2.2 & 5.2.2.1). It makes a distinction between praxis (actions or practices that are guided by a particular theory, plan or model and aiming at serving societal interests and mere actions that may not be regarded as praxis see sections 2.5 & 2.6). Cited examples of praxis include preparation of nurseries for mangroves species, transplanting of selected mangrove species, beekeeping in the mangrove area; seaweed farming, crab fattening, and oyster farming (see sections 2.6.1 - 2.6.6). Five forms of knowledge transfer and/or knowledge sharing may be drawn from the study context:

- The first form is based on 'learning by doing' via participatory monitoring of coastal and marine resources; which according to this study, failed to attract a wider social learning due to its scientific nature of abstraction, and overlooked social, cultural, and contextual concerns.
- The second form of learning is also based on 'learning by doing' but with a focus on the transplanting of mangrove species to affected areas and observing how transplanted

seedlings respond to natural adaptation. Most of learning in this form is based on a communal form of sharing knowledge on seed selection, nursery preparation, transplanting saplings, and understanding of germination seasons for timely harvesting of different mangrove seeds. The criterion for seed selection is based on traditional ecological knowledge, and this knowledge is transferred to new entrants and spread among participating individuals. This form of learning is however not guided by any framework, and is mostly practiced by female participants. Like the first form of learning, it faces the challenge of addressing learning at a wider scale, although there were signs of processes that participants were using to expand the learning by involving family and friends in the new practice, which they had been exposed to via training.

- The third form of learning is based on short-term training offered by NGO's, scientific institutions, and local government departments through workshops, seminars, and meetings. This was very active in the 1990's and is no longer prioritized in the study area due to a change in funding policies, and varying donor priorities. The focus in this form of learning was to involve small groups of individuals which would share what they had learnt from facilitators with other members. Its impact is represented by research participants in sections 5.2.2 & 5.2.2.1.
- The fourth form of learning involves learning via oral tradition or cultural transmission of fishing practices; which encourages knowledge sharing between retired fishers (the elderly) and young or middle aged fishers; also within a familial context where children learn from their parents and elders how to participate in practices that are valued in the social-cultural context. This involves learning how to mend nets, making traditional traps (*malema* or *madema*), understanding seasons as determinants of fishing seasons, and social and cultural aspects that govern traditional fishing. This form of socio-cultural learning about fishing seems to be internalised well, although it is being challenged by wider mechanisms that are changing the nature of practices, such as those challenges that are associated with the emergence and expansion of modern fishing practices (increasing the amount of fishing gear, vessels and crews, and trawling as discussed in chapters 5 and 6,) and illegal fishing.

- There is also the potential for ‘learning by interacting with fishers from other communities’ (Pemba and Unguja Islands - Zanzibar) who sail across the eastern coast of Tanzania. Details about the existence and operation of this form of learning were captured through the observation of temporary apartments near the beach and researchers’ interactions with some foreign fishers during field work. Learning that may emerge from such interactions has however, not been proved to be effective since it is ‘seasonal and sex (male) selective’, and therefore may not be regarded as a reliable approach that may attract wider social learning in the coastal area. Moreover, experience from other coastal localities like those along the Dar es Salaam coast, suggests that foreign fishers tend to disassociate themselves from local coastal management plans and focus on ‘fish catch or quick economic gains’, rather than taking part in coastal protection or management (KICAMP, 2003); though they share fishing techniques and gear with local fishers, and have interactions that have attracted intermarriages and religious practices.

The study additionally presents the abstraction of indicators as a learning process which is supposed to affirm praxis, and insists on the need for involved individuals and social groups to comprehend or understand not only the process of indicator development, but also the indicators themselves (see section 2.7). This, as argued and shown in this study, may help them to realise the need for improvement of used frameworks and attract full involvement and learning.

Monitoring is presented and developed in this study as a specified form of praxis which has the potential to attract wider social learning (see section 2.8; chapters 6 and 7). To attain this, it is argued that there is a need to **historicise** proposed monitoring contexts, and to choose a monitoring route which is based on actors’ priorities and contextual realities. There is also a need for monitoring programmes to have a defined approach or agreed standard which should specify what is supposed to be monitored (i.e. what is to be included or excluded, see section 2.12, chapter 7). Questions such as ‘Who are the actors or learners?’ and ‘How are they involved in the learning process?’ are crucial. It is reemphasised that learners’ experiences, their ability to cope with introduced praxis, contextual realities, and the relevance of proposed learning initiatives should feature in

coastal and marine monitoring contexts; as should experiential and social learning processes that enable the mobilisation and use of TEK.

The study presents 'culture' as either an 'enabler' or 'constrainer' of praxis and experiential learning, and also as a conduit which may potentially facilitate social learning (see section 2.10). As shown in chapters 5, 6 and 7, culture may enable learning if it prioritises and allows human interactions with nature, for example by making free visits to sites where monitoring is carried out or if it has restrictions that compel its people to protect species. On the other hand, it may serve as a constrainer if it encourages over exploitation of resources or restricts its people from interacting in particular sites such as mangroves, for activities such as transplanting and monitoring.

The study explores and specifies both existing relationships and non-relationships surrounding the research phenomenon; and considers not only what we may experience or see happening but also the underlying mechanisms that trigger the events in the mangrove ecosystem (as shown in chapters 5, 6 and 7).

The study, its methodology and approach, and its associated findings create a space for understanding ways through which traditional ecological knowledge may be represented by indigenous coastal communities (fishers, mangrove restorers, and local elders) as a useful input for informing experiential learning practices, such as the monitoring of coastal and marine resources - a process which has the potential to increase interactions and knowledge sharing, leading to wider social learning (Reed et al. 2010; Cundill & Rodela 2012).

While development of learning materials and a manual was not the focus of this study, it can be seen from the quality of the inputs made by the coastal community participants reported in chapters 5, 6 and 7 that were involved in this study, that their input, in the form of their abstractions and representations that informed a formalised, revised set of indicators (presented in chapter 7), may potentially also be used for developing learning manuals in community-based natural resource conservation projects or programmes (i.e. a manual could be developed from the outcomes of this research for coastal monitoring. However, but it would have to take cognisance of the contextuality of the specific TEK and

how to mobilise and use these as underlabourers for more widely generalisable scientific indicators). Such materials could also potentially be used for other educational purposes such as training materials for students at tertiary levels, and for facilitating students' interactions with nature during field work (although this was also not the focus of the study). Outdoor sites, such as those engaged with during the course of this study, may also serve as good demonstrations or practical grounds for learners who wish to examine the relationship between theory and practice. Fisher (2001) considers the involvement of students in field work that involves walks, recording of observations, and collecting materials in the outdoor environment as an integral part of environmental learning pedagogy. Dillon et al. (2005, p. 2) raises the need for teachers and students to learn about nature, society, and existing interactions between the two and oneself. They observe that increased understanding of ecological, geographical, and socio-cultural environment may lead to wider descriptions of 'curriculum-related outcomes', which drawing from this study, could enrich the way students can engage with practical monitoring activities. They state further that outdoor education or learning involves working with other communities for purposes of acquiring knowledge and skills and understanding practical conservation, but they do not provide methodological guidance on how such processes can unfold. This study has provided methodological guidance for working with communities to explore diverse forms of knowledge potential for conservation monitoring in a coastal context (ibid.).

The study also brings into view a way of working with knowledge that is abstracted from other fields, disciplines, and contexts (e.g. scientific knowledge); by not necessarily rejecting it for its 'foreign' qualities or reification, or by discarding or ignoring its potentiality, but rather uncovering the kind of challenges that emerge from it, and using local solutions to improve or support it (underlaboring). This way of working with knowledge, as shown in this study, is particularly important for southern African environmental education, as much natural resource management knowledge is contained in the local knowledge and practices of indigenous communities as they interact with their natural resources for livelihood and other practices (as also shown by Shava, 2008; Davies, 2009; Mukute, 2010; Masara, 2010; Belay 2012 and other environmental education scholars working with communities). This study, and the studies referenced here, show that many community members in southern Africa have not had the opportunities to complete formal schooling and therefore do not

easily have access to more generalised, universalised forms of scientific knowledge and the discourses that accompany this form of knowledge. As shown in this study, finding ways of expanding both formalised scientific knowledge (through engagement with TEK) and TEK (through engagement with formalised scientific knowledge), and making it accessible and useful to enhance natural resources management practices in community contexts, is not a simple matter of rejecting one form of knowledge in favour of another, but rather the challenge lies in finding ways of bringing such forms of knowledge into a process that Beck (1992) named 'inter-epistemological dialogue' - but for which environmental education still has few methodological tools. The methodological process and analytical explanatory descriptions that have helped to bring these knowledge forms together in ways that validate TEK without simplistic oppositionalising of formalised forms of scientific knowledge and TEK, or rejection and/or over-romanticism (which are common problems of engaging with indigenous knowledge as described by O'Donoghue and Neluvhalani (2002), as I see it is potentially one of the key contributions of this study to the field of environmental education praxis. Additionally, I have conceptualised and described this process in terms of its learning potential from an experiential learning perspective, but also from the perspective of the potential for mobilising wider forms of social learning.

As shown in this study, this community-based knowledge generation process involves communities in the practices that they are familiar with, but in this process they find themselves in interactions that give them opportunities to immerse themselves in their task of choice, and observe it, feel it, and react to it in different ways (Kolb, 1984). They add or adjust their perceptions based on what they have learnt before (previous knowledge), are then able to notice existing differences, and apply terms in identifying even hidden events and communicating them to other members (interactions). Such collective interactions create space for them to learn increasingly from experienced practices, but also through reflexive engagement with their context, knowledge and experience (Keen et al., 2005b; Bhaskar, 1998; Archer, 2010). Inputs that emerge from continued interactions, and which according to this study help to improve or enrich existing monitoring frameworks or plans, may steer 'learning by doing' or learning by taking part in participatory monitoring practices and potentially attract wider social learning.

Employed approaches in this study also create a space for understanding possible processes that favour knowledge access between scientific institutions and local communities. An understanding of the same may potentially uncover the enabling and constraining conditions which determine positive learning interactions between institutions that favour scientific knowledge and coastal communities. While there might be other relevant learning theories which have the potential to be applied in natural resource management contexts (coastal area inclusive), this study opted for experiential and social learning approaches since it sought to enhance social learning processes on the eastern coast of Tanzania. It also considers 'experiential learning' as a component of social learning which attracts learning by doing as people engage directly in participatory monitoring practices in the study area (NEECS, 2005-2009).

The study therefore makes a contribution to knowledge by identifying some of the existing contextual and socio-cultural challenges that constrain knowledge sharing, and proposes processes and methods that may potentially increase and enhance learning interactions among involved parties.

8.3 Specific findings

8.3.1 The potential contribution of abstraction, conceptualisation and representation in social learning processes within the coastal environment (see chapter 5):

Notions, concepts, and ideas that fishers, mangrove restorers, and local elders represent as they engage in processes of abstraction and conceptualisation may potentially lead to knowledge production (Danemark et al. 2002); as these involve descriptions of ecosystem concepts, functions, processes, and interactions; and uncover social-cultural, ecological, and economic values of the mangrove ecology. As shown in this study, produced knowledge may help coastal communities to improve experiential learning praxis such as participatory monitoring of mangroves and fisheries and mangrove restoration, by attracting interactions and encouraging knowledge sharing and transfer through peer relations, relatives, and friends; and from experienced individuals to the less experienced (see sections 5.2.2 and 5.2.2.1). Specifically, in the context of this study, the use of processes of abstraction yielded knowledge on how mangrove species protect the coast from erosion and how their presence reduces chances of strong or aggressive winds to reach adjacent communities (see

section 5.2.1); how they serve as important habitats for a variety of living organisms; how different fish species including 'mullet', cuttlefish, and red-mangrove-snapper interact or behave in the mangrove ecosystem (see section 5.2.3); and causal mechanisms that produce such interactions or behaviours. Moreover, processes of abstraction in this study yield representations that uncover how weather affects fish catching and interactions (see section 5.2.8); how species relate to their habitat (substantially or formally - see section 5.2.4); how individual and hierarchical powers act against each other or work together to achieve a desired goal; how modern fishing knowledge acts against traditional ecological knowledge; and how power may affect learning (see section 5.2.5). The process of naming mangroves species and the description of their ecological niches (5.2.6.1), and naming of mangrove-based fisheries and description of their habitats (5.2.6.2) by local elders, reveals knowledge that may potentially enrich and inform practice and praxis in the study area (see lists of mangrove and fisheries species and related ecological characteristics in tables 5.1 and 5.2 respectively).

Represented notions, concepts, and ideas from fishers, mangrove restorers, and local elders may also potentially enrich social learning processes in the coastal environment; since used language carries metaphors that are familiar to coastal people (see section 5.2.7). Most of these represent relationships and meanings that move across ecological, economic and social-cultural systems and are embedded in their day-to-day language. For example, the metaphor of '*fish like a common market*' links ecological realities to economic and social realms. As Martinez, Sauleda, & Guenter (2001) put it, metaphors are not just mere figures of speech but rather 'essential mechanisms' of our minds which enable us to lens various phenomena from a specified angle. They are therefore important communication tools which may help us understand deeper represented ideas or knowledge about ecological processes and interactions in the mangrove ecosystem.

Represented concepts, notions, and ideas may yield knowledge about how people learn, and processes that facilitate their exposure to such learning (see section 5.2.2.1). This study reveals that mangrove restorers and fishers learn by looking back to an event and analysing its implications on the present (retrospective learning). They also learn by focusing on their performance, and think carefully about the 'thinking' that led to particular actions, what

happened, and what they are learning from the experiences they have gone through - in order to inform what they might do in future with regard to what they have experienced (reflective learning). This kind of learning which is also discussed by Rice & Pinnegar (2012), yields three forms of reflections, namely descriptive, dialogic, and critical (see section 5.2.2.1). This study also revealed that learning in the coastal context that formed the focus of this study, reflected some or all of the process and outcome aspects of the social learning typology put forward by Cundill & Rodela (2012); discussed in section 2.2):

- Typology 1: Social learning takes place through deliberative processes involving sustained interactions between individuals, and the sharing of knowledge and perspectives in a trusting environment; *evidenced in chapters 5, 6 and 7.*
- Typology 2: Learning takes place through deliberative experimentation and reflective practice involving joint actions such as monitoring; *evidenced in chapter 6.*
- Typology 3: Social learning is a self-organising process of social-ecological interactions over long periods of time; *evidenced in participant reflections on historical aspects and changes in chapters 5 and 7.*
- Typology 4: Social learning improves decision making by increasing awareness of human-environment interactions, and by building relationships and the problem-solving capacity of stakeholders; *evidenced by use of revised indicators in chapters 6 and 7.*
- Typology 5: Social learning facilitates collective actions around common environmental concerns; *evidenced in chapters 5, 6 and 7.*
- Typology 6: Social learning leads to behavioural change; *evidenced in more inclusive approaches to monitoring in chapter 6, and changes in approaches to praxis in mangrove transplantations in chapter 7.*

Additionally, as discussed in chapter 5, this study also revealed a potential addition to this typology, namely that social learning is also a reflexive process of becoming, which was brought to the fore via the critical realist analysis of the learning processes.

This brings us to additional findings that social learning processes in the coastal environment do not exist as **independent entities**. They are **embedded** in practice and

praxis and may only be captured and used through processes of abstraction, as these allow not only abstraction and conceptualisation, but also the representation of coastal based traditional ecological knowledge.

Represented concepts, notions, and ideas may yield traditional ecological knowledge that has the potential for supporting existing monitoring frameworks or plans that fail to address contextual, and social-cultural realities in the coastal area; and which tend to limit or constrain learning rather than attracting wider social learning (see tables 7.1 and 7.2).

8.3.2. How processes of abstraction and conceptualisation mobilise representation of traditional ecological knowledge that is necessary in developing indicators for monitoring fisheries and mangrove resources (see chapter 6)

While there may be other ways that may suggest how processes of abstraction and conceptualisation can mobilise the representation of traditional ecological knowledge in the coastal environment, this particular study has demonstrated the use of the experiential learning cycle (see section 6.1) as a necessary stimulant that has the power to mobilise the representation of TEK that has the potential for enriching, improving, or developing indicators or attributes for monitoring fisheries and mangroves in the study area.

Dillon et al. (2005) propose the need to enable individuals and social groups to take part in new practices that encourage them to learn from what they experience. Moreover, they highlight the need to closely work with ‘communities of learners’ to ensure that the process of learning leads to a change in understanding and approaching the social world. As indicated above, this recommendation of Dillon et al. (2005) was given meaning via the experiential learning methodology, and abstraction and representation processes revealed in this study. In this study, the *experiential learning cycle*, using the photographic method, offered a space for engaging learners in the new practice, and led them to different reactions, observations, feelings, reflections, abstract-conceptualisations, and collective testing of new situations to capture more experiences, observations, and feedback that emerged from the learning process. As shown in chapters 6 and 7, concepts, notions, and ideas that emerged from different stages of the experiential learning cycle yielded knowledge that may potentially enrich coastal management practices.

Specifically, in this study learners (mangrove restorers and fishers) were involved in the practice of taking *photographic images* of either mangroves or fish species of their choice (see sections 6.3, 6.4.1, and 6.4.2). After going through the first three stages of the learning cycle, including abstract-conceptualisations or forming abstract concepts (see 3.4.1-3.4.3); learners represented notions, concepts, and ideas which described key attributes of the images they had taken, including the physical health status of mangroves and fisheries (see section 6.6); which they used in field-based monitoring activities.

Since the experiential learning cycle serves as a ‘learning tool’ which can help learners not only to create new knowledge, but also engage previous experiences (such as data collected during in-depth interviews and focus group discussions as demonstrated in this study) (Kolb, 1984), attributes which were generated in the first *moment* of processes of abstraction (see sections 5.2.10 and 5.2.10.1-4) were combined with those generated through the second *moment* (*taking photographic images*) ,to facilitate an input for the fourth and final stage of the experiential learning cycle (see tables 7.1 and 7.2), and for steering the periodic monitoring of mangroves and fisheries in the study area.

8.3.3. Using abstracted TEK indicators as ‘underlabourer’ for existing scientific indicators and in attracting a wider social learning process of detecting trends, threats, changes and conditions of mangrove and fisheries resources (see chapter 7)

The concept of ‘underlabouring’ as indicated earlier in this study (see section 1.7.10) is applied to suggest the process of supporting something which is already in place to make it more functional or useful. As also explained in chapter 7, it was used in this study to explain the process of ‘supporting’ the existing scientific framework of indicators with the input from traditional ecological knowledge (accessed through processes of abstraction), to improve experiential learning practices (participatory monitoring of mangroves and mangrove-based fisheries) in the study area and enhance social learning. While the same processes may also be employed in generating inputs for new monitoring frameworks other than merely supporting existing plans or frameworks, the focus here is to uncover how the latter may be realised rather than the former.

As shown in this study, input(s) accessed through processes of abstraction and representation need to be presented / mirrored and deliberated on in participatory forums such as the Experiential Learning Intervention Workshop, which should ideally, as in the case of this study, be attended by research participants and representatives from scientific institutions under the coordination and facilitation of the interventionist researcher for discussion, analysis, and improvement (see sections 4.8.4, 4.8.4.1, and chapter 7.1). Existing ideas (old inputs or plans) that require improvement also need to be worked with via the same process. As shown in this study, workshop participants can be supported via interventionist research facilitation processes (as modelled in this study), to discuss specific component parts or attributes that appear in the old plans (resolution), and thereafter, re-describe, retroduce, eliminate, identify, and correct the old plans (see section 7.4.3.1-4). The same process can be applied to the new framework of indicators, as demonstrated in this study; and the two frameworks can afterwards be integrated at a different session to produce a set of indicators that may potentially be less reified, congruent to users, and address social-cultural challenges without losing scientific rigour or relevance (see tables 7.1 and 7.2). These have to be tested and this should be followed by a feedback session which allows involved participants to discuss experienced challenges and engage participatory solutions, to strengthen the practice of using the indicators. By so doing, they are engaging themselves in learning by doing, and in interactions that attract social learning.

This study therefore demonstrates how TEK indicators can be established, and how these may potentially support or help to improve the applied / revised use of existing scientific indicators, and enhance experiential learning practices in the coastal environment. This may be possible if conditions that are necessary for stimulating learning in outdoor settings (e.g. the coastal environment) can be prioritised by facilitating interactions between scientific institutions and coastal and marine practitioners at community level. Within this process, this study raises the need to:

- **Historicise** or **contextualise** the educational settings where learning is to be stimulated or encouraged. This condition is seen by Dillon et. al. (2005) and southern African environmental educators such as O'Donoghue and Neluvhalani (2002), Shava (2008), Davies (2009), Masara (2010), Mukute (2010) and Lotz-Sisitka (2012) as a

useful space for consideration of contextual learning needs. Critical realist ontological perspectives have helped, in this study, to provide in-depth understandings of such historical / contextual aspects of the educational settings.

- Secondly, the study raises the need to prioritise designs and approaches that suit the learning environment (based on the outcomes of historicising or contextualising (ibid.).
- Thirdly, it raises the need to consider elements such as affordability, accessibility, capability, acceptability, applicability, and understandability of proposed learning plans or interventions (section 2.12; chapters 5, 6 and 7).
- In a nutshell, this study suggests that the process of '**underlabouring**' has to involve:
 - ✓ Creating platforms for processes of abstraction as a source of TEK through individual in-depth enquiry (Sayer, 2000).
 - ✓ Creating forums for focus group discussions as useful spaces for affirming and verifying in-depth individual representations, to allow clarification of previous inputs (Berkes, 2008). Such forums are necessary since they are likely to generate in-depth insights (Krueger, 2000) that reflect community views rather than merely individual perceptions; and may potentially enhance praxis (Kemmis & Smith, 2008).
 - ✓ Conducting an Experiential Learning Intervention workshop (ELIW) to allow 'mirroring' of data and previous monitoring plans against the new ones, and attract discussions that will lead to selecting of indicators that are easier to use, and whose abstractions are based on the realities of the educational setting (Dillon et al., 2005).
 - ✓ Testing integrated framework(s) to examine the extent to which it yields descriptions that uncover the condition, threats, trends, and changes of the mangroves and fisheries that use them as key habitat.
 - ✓ Convening a feedback meeting to discuss the process of indicator-testing (how did it go, what are / are not the challenges that emerge from the testing, and how does the new framework differ from the previous).
 - ✓ Setting an agreed time for conducting periodical monitoring as part of a wider social learning (learning by doing).

8.4 General findings

The study also yielded some general findings in addition to those discussed above:

- As shown in this study the coastal environment offers a promising landscape for outdoor learning through knowledge sharing and interactions that may not only benefit involved individuals and social groups, but also help in building and maintaining the ecological, economic, and social-cultural values of coastal resources - particularly mangroves and fisheries.
- Most of challenges that constrain learning in the study area result from a lack of **historicising or contextualising** existing realities in the educational settings. As shown in this study, attempts to historicise the context can uncover learning needs and lead into the development of designs or plans that addresses the real situation on the ground.
- This study reveals further that coastal communities, especially fishers, local elders, and mangrove restorers have a 'knowledge base' that up till now has largely remained un-explored (as I found almost no specific studies that were capturing or reporting on this knowledge and its potential for social learning when undertaking my literature searches); and which can be used as an input for advancing and improving learning in formal and informal contexts. As shown in this study, fishers for example, are well acquainted with the dynamics of fisheries and have records that go back to over 30 years and are thus able to undertake a comparative analysis between fishing trends that happened in the past and what is happening now. This poses great challenges to scientific institutions that are involved in fisheries research, whose databases remain un-updated. When this study was being carried out, there emerged a need to look for *a species identification-field-guide* for marine and blackish water in Tanzania. The only available guide for the country was developed by the FAO in 1985 and has not been updated since then. Coastal fishers can help to fill this kind of gap by providing key information to marine scientists,

which may lead to an investigation quest and eventually help in enriching and updating the current knowledge base.

- Fishers and mangrove restorers in the study area have rich traditional ecological knowledge not only on fisheries and mangrove species, but also on other coastal and marine resources such as sea grasses, coral reefs, and seaweed. This knowledge may potentially be accessed through processes of abstraction for enriching classroom learning, and advancing basic and applied research. Some of this knowledge was evident in the data, but because I was only focussing on fisheries and mangroves, I did not report much on this knowledge.
- In articulating the study problem, it was found that the use of scientific methodologies in community-based natural resource management initiatives constrained knowledge sharing between the former and the latter; a situation which suggests that scientific learning and teaching programmes were also not benefiting from local or indigenous knowledge; a potential gap that was filled by the work undertaken through this study.
- It was also found that communication between scientific institutions and coastal communities was 'a one way traffic' rather than a two way approach. This implies that institutions that are involved in building the capacity of local communities to manage coastal and marine resources tend to communicate to target communities what they themselves wish to advocate rather than what coastal communities prefer and choose to engage in. The emphasis is thus placed on making individuals and social groups adopt or adapt scientific plans or frameworks with little or no consideration for methodological challenges, contextual, social and cultural relevance, and / or the preferred forms of abstraction and representation of the same communities that are worked with.
- The failure of coastal communities to effectively adopt the existing scientific framework of indicators suggests that knowledge that is 'abstracted' and made

concrete in particular contexts may more easily be comprehended by individuals who took part in its development, than recipient communities. For the latter to understand the *concrete*, uncover component relations, adjust it, and apply it; they need to isolate its component parts through processes of abstraction and conceptualisation as demonstrated in this study (Sayer, 2000).

8.5 Proposed areas for future research:

This study also raises a number of areas for future research; as not all aspects that were interesting to focus on could be covered in the study, due to its bounded nature:

- The study raises the need to explore the impact of the modern fishing industry on traditional or indigenous fishing knowledge, to establish the extent at which the former is likely to affect fishers' knowledge practices in the coastal environment. This appears to be necessary since indigenous fishers (as found in this case study) who claim to have learnt fishing practices through cultural transmission, consider expansion of the modern fishing industry as a threat to traditional fishing knowledge and techniques. It is also observed, in the same case study context, that traditional fishers have reduced the use of traditional fishing gear (which are regarded by them as being sustainable) because they cannot compete with modern fishing gear. This suggests not only a threat to cultural knowledge transmission processes but also cultural heritage practices. While this finding was identified as significant in the case study context, generalisation from the level of (Danemark et al., 2002; Sayer, 2000) would suggest that modern development patterns would have wider impacts on other fishing communities, making this a question that can potentially have wider implications for more than just the fishing communities involved in this case study.
- There is also a need to explore the potential contribution of social learning to the preservation of cultural knowledge transmission and heritage practices in the coastal environment. This may help researchers to uncover different ways of protecting valuable traditional ecological knowledge from emerging parallel powers or competing technological processes that have shown to be marginalising such knowledge, despite its continued relevance in a sustainability and coastal zone

management context as shown in this study. This does not mean reification of TEK, but rather critical engagement with it, as shown in this study, in ways that realise its validity and value in contemporary societal and social-ecological contexts.

- The study also raises the need to investigate changing fish *behavioural change patterns* as a result of unsustainable fishing practices such as dynamite fishing; and increased fishing practices in the coastal area. This kind of study may involve juvenile and adult fisheries (both reef-based and mangrove-based fisheries).
- It is also worthy to investigate how learning that is generated from experiential learning praxis such as community-based monitoring of mangroves and fisheries may mediate trans-disciplinary challenges in the coastal environment. Some aspects of this were hinted at in this study, but were not fully developed, due to the boundaries of the case study and the focus of the research questions.
- There is also a need to further explore how community-based knowledge (as abstracted and represented by way of example in this study), when combined with knowledge that marine scientists produce through coastal-based research, can improve or enrich a wider range of environmental education programmes (other than community-based education which was the focus of this study) such as school curriculum and teacher education programmes. This would be an interesting area for further research as most formal curricula currently only draw on formal scientific knowledge, and fail to incorporate community knowledge and TEK (Shava, 2008; O'Donoghue & Neluvhalani, 2002), leading to the alienation of learners in the school context. As shown in this study, examples of such inter-epistemological dialogue such as that opened up through the RREI(C) process in this study, can potentially enrich learning curricula. As mentioned earlier, this was not a key focus of this study, but the potential for this was noted within the wider field of environmental education and its objectives, which are not only limited to community-based education for sustainability.

8.6 Conclusion

This study has shown that processes of abstraction may potentially unlock knowledge that coastal communities have; which is normally embedded in practice and praxis. This may increase chances of understanding among learners in the coastal environment, and encourage knowledge sharing and interactions amongst them and between them and scientific institutions; which may eventually attract wider social learning processes. Moreover, improved experiential learning practices in the coastal area may potentially enhance fishers' and mangrove restorers' ability to address emerging social-cultural, ecological and economic challenges in the coastal area and help them to think, see, understand, and react to the social world in a more focussed manner. The emphasis is placed on learning that leads to new thinking; which gives involved participants opportunities for engaging themselves in creative solutions, and mirroring existing ideas, values, and views against available alternatives.

Monitoring frameworks that result from participatory learning processes (like the one that appears in tables 7.1 and 7.2) are likely to yield more learning opportunities, since they are based on user's own conceptions and understanding in such contexts. Users are therefore likely to freely adjust, correct, eliminate, or add what might be relevant to their context. Through this, they are also in a better position to share emerging knowledge with scientific institutions for better learning results. In such a scenario, communities are not treated as mainly recipients of knowledge but as producers or co-producers of the same.

References

- Abercrombie, Hill & Turner (2006). *Dictionary of Sociology*. London: Penguin Books.
- Ajzen, I. & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour*. Englewood Cliffs: Prentice Hall.
- Alongi, D.M. (2007). Mangrove forests: Resilience, protection from tsunamis, and responses to global climate change. *Estuarine, Coastal and Shelf Science*, 76, 1-13.
- Anderson, M.K. & Barbour, M.G. (2003). Simulated indigenous management: a new model for ecological restoration in national parks. *Ecological Restoration*, 21, 269-277.
- Andriessen, D.G. (2008). Stuff or Love? How metaphors direct our efforts to manage knowledge in organisations. *Knowledge Management Research & Practice*, 6, 5-12.
- Argyris, C. & Schön, D. (1978). *Organisational learning*. Reading: Addison-Wesley.
- Archer, M.S., Bhaskar, R., Collier, A., Lawson, T., & Norrie, A., (Eds.). (2002) *Explaining Society. Critical Realism in the social sciences*. Lund: Routledge.
- Archer, M. S. (2003). *Structure, agency and the internal conversation*. Cambridge: Cambridge University Press.
- Archer, M.S.(2007a). *Making our Way through the World: Human Reflexivity and Social Mobility*. Cambridge: Cambridge University Press.
- Archer, M.S. (2010). *Reflexivity*. University of Warwick: Sociopedia.isa.
- Aswan, S. and Lauer, M. (2006 b) Incorporating fishers' local knowledge and behaviour into geographical information systems (GIS) for designing marine protected areas in Oceania. *Human Organization* 65:80-101.
- Ayub, Z. (2010). Effects of temperature and rainfall as components of climate change on fish and shrimp catch in Pakistan. *The Journal of Transdisciplinary Environmental Studies*, 9, 1-9.
- Babbie, E. (2001). *The practice of social research*; (9th ed.). Belmont: Wadsworth Thomson Learning.
- Babbie, E. (2007). *The practice of social research*; (11th ed.). Belmont: Wadsworth Thomson Learning.
- Bandura, A. (1977). *Social learning theory*. Englewood Cliffs: Prentice Hall.

- Ballantyne, R., & Packer, J. (2002): Nature-based excursions: School students' perceptions of learning in natural environments. In *Geographical and Environmental Education*, 11, 218-236.
- Barbier, E.B, & Sathirathai, S. (Eds.) (2004). *Shrimp farming and mangrove loss in Thailand*. Cheltenham: Edward Elgar Publishing Limited.
- Beard, C., & Wilson P.J (2002). *The Power of Experiential Learning; a handbook for trainers and educators*. London: Kogan page Limited.
- Belay, M. (2012). *Participatory Mapping, Learning and Change in the context of Biocultural Diversity and Resilience*. Unpublished doctoral thesis, Rhodes University Grahamstown.
- Bennett, F., & Roche, C. (2000). Developing Indicators. The scope for participatory approaches. *New Economy*, 7, 24-28.
- Benton, T. & Craib, I. (2001). *Philosophy of Social Science*. Basingstoke: Palgrave.
- Berjack,P., Campbell, G., Hockett, B., & Pammenter, N. (2011). *In the Mangroves of South Africa*. KZN: WESSA.
- Berkes, F. (1993). Traditional ecological knowledge in perspective. In J.T. Inglis, (Ed.). *Traditional Ecological Knowledge: Concepts and cases..* Ottawa: Canadian Museum of Nature and the International Development Research Centre.
- Berkes, F., Folke, C., & Gadgil, M. (1995). *Traditional ecological knowledge, biodiversity, resilience and sustainability*. Dordrecht: Kluwer.
- Berkes, F., Mahon, R., & McConney, P. (2001). Managing Small-scale Fisheries. *Alternative Directions and Methods*; Ottawa: International Development Research Centre
- Berkes, F., & Adhikari, T. (2006). Development and conservation: indigenous business and the UNDP Equator Initiative. *International Journal of Entrepreneurship and Small Business*, 3(671-690).
- Berkes, F. (2008). *Sacred Ecology*. (2nd ed.). New York: Routledge.
- Berkes, F. (2009). Indigenous ways of knowing and the study of environmental change. *Journal of the Royal Society of New Zealand*, 39(151-156).
- Berkes, F. (2012). *Sacred Ecology*. (3rd ed.). New York: Routledge.
- Bhaskar,R.(1975/2008). *A realist Theory of Science*. London and New York : Routledge.
- Bhaskar, R. (1998). Critical realism: Essential readings (critical realism: interventions). In M. Archer, R. Bhaskar, A. Collier, T. Lawson, & A. Norrie, (Eds.). (2002). *Explaining Society. Critical Realism in the social sciences*. Lund: Routledge:.

New York.

- Bhaskar, R. (1986). *Scientific realism and human emancipation*. London: Verso.
- Bhaskar, R., & Danemark, B. (2006). Metatheory, interdisciplinarity and disability research: A critical realist perspective. *Scandinavian Journal of Disability Research*, 8, 278-297.
- Bhaskar, R. (2008). *A Realist Theory of Science*. London and New York : Routledge.
- Bhaskar, R., Frank, C., Hoyer, K.G., Naess, P., & Packer, J. (2010) Interdisciplinarity and Climate Change. *Transforming knowledge and practice for our global future*. London and New York: Routledge.
- Blasco, F., Saenger, P., & Janodet, E. (1996). Mangroves as indicators of coastal change. *Catena*, 27, 167-178.
- Borowski, J. (2010). Social learning beyond multi-stakeholders platforms: a case of on the Elbe River basin. *Society & Natural Resources*, 23, 1002-1012.
- Boud, D., Cohen, R., & Walker, D. (1993) (Eds) *Using Experience for Learning*. SRHE and Open University Press: Buckingham.
- Bouwen, B., & Taillieu, T. (2004). Multiparty collaboration as social learning for interdependence: developing relational knowing for sustainable natural resource management. *Journal of Community and Applied Social Psychology*, 14, 137-153.
- Boyce, C., & Neale, P. (2006). *Conducting In-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input*. Pathfinder International.
- Brown, S.D., Cromby, J., Harper, D.J., Johnson, K., & Reavey, P., (2011). Researching "experience": Embodiment, methodology, process. *Theory Psychology*, 21, 493.
- Brumann, C., (1999). Writing for Culture: Why a Successful Concept Should Not Be Discarded. *Current Anthropology; Special Issue*, 40, 1-27.
- Byrne, D., & Ragin, C. (Eds.). (2009). *The SAGE handbook of case-based methods* (pp. 15-101). London: Sage.
- Campbell, L.M., (2000). Human need in rural developing areas: Perceptions of wildlife conservation experts. *The Canadian Geographer*, 44, 167-181.
- Campbell, L.M., & Vanio-Matilla, A. (2003). Participatory development community-based conservation: Opportunities missed for lessons learned. *Human Ecology*, 31, 417-437.

- Canadian International Development Agency (CIDA). Guide to gender-sensitive indicators.(1997). Office of the Minister of Public Works and Government Services, Canada.
- Castello,L., Viana,J.,P, & Watkins, G. (2009). Lessons from integrating fishers of Arapaima in small scale fisheries management at the Mamiraua Reserve, Amazon. *Environmental Management*, 43, 197-209.
- Chalmers, N. and Fabrcious, C. (2007). Expert and generalist local knowledge about land cover change on South Africa's Wild Coast: can local ecological knowledge add value to science? *Ecology and Society* 12,1-10
- Cheng, A.S., & Mattor, K.M (2010). Place-based planning as a platform for social learning : Insights from a national forest landscape assessment process in western Colorado. *Society & Natural Resources*, 23, 385-400.
- Collier, A.,(1998a) The Power of Negative Thinking. In M. Archer, R. Bhaskar, A. Collier, T. Lawson, & A. Norrie. (Eds.). (2002). *Explaining Society. Critical Realism in the social sciences.*(pp.688-694) Lund: Routledge: New York..
- Collis, B., & Moonen, J. (2001). *Flexible learning in a digital world: Experiences and expectations*. London : Kogan Page.
- Collins, K., Blackmore, C., Morris, D., & Watson, D. (2007). A systemic approach to managing multiple perspectives and stakeholding in water catchments: Three UK studies. *Environmental Science and Policy*, 10, 564-574.
- Compact Oxford English Dictionary for College and University Students* (2006). Oxford: Oxford University Press.
- Creaven,S. (2010). *Against the Spiritual Turn: Marxism, Realism and Critical Theory*. London & New York: Routledge.
- Cundill, G.(2010). Monitoring Social learning processes in adaptive management : Three case studies from Southern Africa. *Ecology and Society*, 15, 3.
- Cundill, G., & Rodela, R. (2012). A review of assertions about processes and outcomes of social learning in natural resource management. *Journal of Environmental Management*, 113, 7-14.
- Cundill, G., & Rodela, R. (2012). A search for coherence: social learning in natural resource management. In H. B. Lotz-Sisitka. (Ed). *(Re) views on social learning literature: A monograph for social learning researchers in natural resources management and environmental education*. (pp. 12-26). Grahamstown/Howick: Environmental Learning Research Centre, Rhodes University/EEASA/SADC REEP,.

- Craps, M. (Ed.). (2003). *Social Learning in river basin management, WP2 report of the HarmoniCOP project*. Brussels: Belgium.
- Crawford, M.(2012). Visual Methods in Psychology : Using and Interpreting Images in Qualitative Research. *Psychology of Women Quarterly*,36, 247.
- Daniels, H. (2001). *Vygotsky and Pedagogy*. London: Falmer.
- Danemark, B., Ekstrom, M., & Jacobsen, L. (2002). *Explaining Society. Critical realism in the social sciences*. London: Routledge.
- Davies, S.M. (2009). *The potential of a stratified ontology for developing materials in community based coastal marine environmental education processes*. Unpublished master's thesis, Rhodes University, Grahamstown.
- Dean, K., Joseph, J., Roberts, J., Wight, C. (2006). *Realism, Philosophy and Social Science*. Basingstoke and New York: Palgrave Macmillan.
- Dewey, J. (1938). *Experience and education*. New York: Macmillan.
- Dieleman,H.,(2012). Organizational learning for resilient cities, through realizing eco-cultural innovations. *Journal of Cleaner Production, Special volume on Advancing Sustainable Urban Transformation*. Elsevier publishers.
- Dillon, J.,Morris, M., O'Donnell, L., Reid, A., Rickinson, M., & Scott, W. (2005). *Engaging and Learning with the Outdoors. Final report of the outdoor classroom in a rural context action research project*. National Foundation for Education Research Project (UK): OCR.
- Eamer, J.(2006). *Keep it simple and be relevant: the first ten years of the Arctic Borderlands Ecological knowledge Co-op*. Washington DC: Island Press.
- Eklöf, J.S, Torre-Castro, M., Nilsson, C., Rönnbäck, P. (2006). How do seaweed farms influence local fishery catches in a seagrass-dominated setting in Chwaka Bay, Zanzibar? *Aquatic Living Resources*, 19, 137-147.
- English, S. Wilkinson, C., & Baker, V. (Eds.). (1994). *Survey Manual for Tropical Marine Resources. ASEAN Australian Marine Science Project: Living Coastal Resources*. Townville: Australian Institute of Marine Science.
- English, S., Wilkinson, C., & Baker, V. (Eds.). (1997). *Survey Manual for Tropical Marine resources* (2nd Ed.). AIMS. Townville: Australia.
- Ellison, A.M. (2000). Mangrove restoration: Do we know enough? *Restoration Ecology*, 8, 219-229.

- Ellen, R. (2004). From ethno-science to science, or "What the indigenous knowledge debate tells us about how scientists define their project", *Journal of Cognition and Culture*, 4, 409-50.
- Ellen, R., Parkes, P., & Bicker, A. (Eds.) (2000). *Introduction in Indigenous Environmental Knowledge and its Transformations*. Amsterdam: Harwood.
- Elzinga, C.L., Salzer, D.W., Willoughby, J., W., & Gibbs, J.P. (2001). *Monitoring Plant and Animal Populations*. Oxford: Blackwell science.
- Encyclopaedia of Earth. www.eoearth.org/article/Mangrove_ecology?topic. Retrieved on 15th January 2013 .
- Engeström, Y (2001). Expansive Learning at Work: toward an activity theoretical reconceptualization. *Journal of Education and Work*, 14, 1-156.
- Eriksen, P. & Woodley, E. (2005). *Using multiple knowledge systems: Benefits and challenges; millennium ecosystem assessment, multiscale assessments*, 4, 85-117. Washington DC: Island Press.
- Fabricius, C., & Koch, E. (2004). *Rights, resources and rural development: community-based natural resource management in Southern Africa*. Earthscan: London, UK.
- Faunce, C., H., & Serafy J.E. (2006). Mangroves as fish habitat: 50 years of field studies. *Marine Ecology*, 318, 18).
- Fernandez-Gimenez, M. E., Ballard, H. L., & Sturtevant V. E. (2008). Adaptive management and social learning in collaborative and community-based monitoring: A study of five community-based forestry organizations in the western USA. *Ecology and Society*, 13, 2-4.
- Fisher, J.A. (2001). The demise of fieldwork as an integral part of science education in United Kingdom schools: a victim of cultural change and political pressure? *Pedagogy, Culture & Society*, 9, 75-96.
- Flyvberg (2006), B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, 12, 219-245.
- Food and Agriculture Organisation of the United Nations (2007). *The world's mangroves 1980-2005. A thematic study prepared in the framework of the Global Forest Resource Assessment*. Rome: FAO.
- Foucault, M. (1983). The Subject and Power. In H. Dreyfus & P. Rabinow, (Eds.). *Michel Foucault: Beyond structuralism and hermeneutics*. Chicago: University of Chicago Press.
- Fox, N. (1998). How to use Observations in a Research Project. Sheffield: Trent Focus Group.

- Fraser, E.D.G., Dougill, A.J., Mabee, W.E., Reed, M., & McAlpine, P. (2005). Bottom up and top down: Analysis of participatory processes for sustainability indicator identification as pathways to community empowerment and sustainable environmental management. *Journal of Environmental Management*, 78, 114-127.
- Fritz, K. (2008). *Ethical Issues in Qualitative Research*. Bloomberg: Johns Hopkins University.
- Gadgil, M., Berkes, F., & Folke, C. (1993). Indigenous knowledge for biodiversity conservation. *Ambio*, 22, 151-156.
- Gallop, G. (1997) *Indicators and Their Use*. Information for Decision Making in Sustainability Indicators: A Report on the Project on Indicators of Sustainable Development. Chichester: John Wiley.
- Gerring, J. (2007). *Case Study Research: Principles and Practices*. Cambridge: Cambridge University Press.
- Gilbert, G. (Ed.) (2008). *Researching Social Life*. (3rd ed.). London: Sage.
- Glahn, C., Specht, M., & Koper, R. (2007). *Creating new learning experiences on global scale*. Berlin: Springer.
- Glasser, H. (2007). Minding the gap: the role of social learning in linking our stated desire for a more sustainable world to our everyday actions and policies. In Wals, A.E.J. (Ed.) *Social Learning towards a Sustainable World. Principles, Perspectives, and Praxis* (pp.35-62). Wageningen: Wageningen Publishers.
- Goffredo, S., Pensa, F., Neri, P., & Orlandi, A. (2010). Unite research with what citizens do for fun: recreational monitoring of marine biodiversity. *Ecological Applications*, 20, 70-87.
- Goldman, M. (2007) Tracking wildebeest, locating knowledge: Maasai and conservation biology understandings of wildebeest behaviour in Northern Tanzania. *Environment Planning D*, 25:31-307.
- Hallowell, N., Lawton, J., & Gregory, S. (Eds.). (2005). *Reflections on research: The realities of doing research in the social sciences*. Berkshire: Open University Press.
- Hammersley, M., & Atkinson, P. (2007). *Ethnography: Principles in practice* (3rd ed.). London: Routledge.
- Hammond, L., Austin, K., Orcutt, S., & Rosso, J. (2001). *How people learn: Introduction to learning theories*. Stanford: Stanford University.
- Hartwig, M. (Ed.) (2007). *Dictionary of Critical Realism*. London: Routledge.
- Haverkort, B., & Reijntjes (2010). Diversities of Knowledge communities, their worldviews and sciences: On the challenges of their co-evolution. In S. Subramanian, & B.

- Pisupati, (Eds.). *Traditional Knowledge in Policy and Practice: Approaches to development and human well-being*, pp. 12-13.
- Hazzan, O. (1999). Reducing abstraction level when learning abstract algebra concepts. *Educational Studies in Mathematics*, 40, 71-90.
- Heaslip, R. (2008). Monitoring salmon aquaculture waste: the contribution of First Nation's rights, knowledge and practices in British Columbia. *Marine Policy*, 32, 988-96.
- Henry, S., G., & Feters, M.,D. (2012). Video elicitation interviews: a qualitative research method for investigating physician-patient interactions. *Ann Fam Med*, 10, 118-25.
- Hergenhahn, B.R., & Olson, M.H. (2001). *An introduction to theories of learning*. (6th ed.). Upper Saddle River: Prentice Hall.
- Hill, D., Fasham, M., Tucker, G., Shewry, M. & Shaw, P.(Eds.) (2005). *Handbook of biodiversity methods: Survey, evaluation and monitoring*. New York: Cambridge University Press.
- Hodgson, E.W., Stanley, C.A., Roe, A., H., & Downey, D. (2010). *African Honey Bees*. Logan: Utah State University.
- Hoppers, C., A.,O. (Ed) (2002). *Indigenous knowledge and integration of knowledge systems: Towards a philosophy of articulation*. Claremont: New Africa Books.
- Howell, K. (2013) *An introduction to the Philosophy of Methodology*. Los Angeles: Sage.
- Ibanez, A.L. & Benitez, O.G.(2004). Climate variability and spawning migrations of the striped mullet and white mullet in the north-western area of the Gulf of Mexico. *Journal of Fish Biology*, 65, 822-831.
- Jackson, B., (1997). *Designing Projects and Project Evaluations Using The Logical Framework Approach*. IUCN .
- Jickling, B. & Wals, A.E.J. (2008). Globalisation and environmental education: Looking beyond sustainable development. *Journal of Curriculum Studies*, 40, 1-21.
- Johannes, R. E., M. M. R., Freeman, & R. J. Hamilton. (2000). Ignore fishers' knowledge and miss the boat. *Fish and Fisheries*, 1, :257–71.
- Julius, A. (2005). *Monitoring Programme for resource condition, environmental and biological parameters for Mnazi-Bay Ruvuma Estuary Marine Park (MBREMP) Tanzania*. Research Report submitted for the requirement of United Nations University Fisheries Training Programme.
- Kathiresan, K., & Bingham, B.L. (2001). Biology of mangroves and mangrove ecosystems. *Advances in Marine Biology*, 40, 81-251.

- Kawulich, B.B. (2005). Participant Observation as a Data Collection Method. *Qualitative Social Research*, 43, 1-28.
- Keen, M., Brown, V.A., & Dyball, R. (Eds.). (2005). *Social Learning in Environmental Management. Towards a sustainable future*. London: EarthScan.
- Kemmis, S. & Smith, T.J. (Eds.). (2008). *Enabling Praxis*. Challenges for education. Rotterdam: SensePublishers.
- Kinondoni Integrated Coastal Area Management Programme. (2003). *Annual Progress Report*. Dar es Salaam: SSPA.
- Kinondoni Integrated Coastal Area Management Programme. (2004). *Phase One - Final Report*. Dar es Salaam.
- Kinondoni Integrated Monitoring Plan (KIMP). (2005). Dar es Salaam: FAST, University of Dar es Salaam.
- Kofinas, G. P. & McPherson, F. (2002) Community contributions to ecological monitoring: knowledge co-production in the U.S.- Canada Arctic Borderlands. In I. Krupnik & D. Jolly, (eds.). *The earth is faster now*, (pp. 54-91) (. Fairbanks Arctic Research Consortium of the United States.
- Kofinas, G., Lyver, P., Russels, D., White, R., Nelson, A., & Flanders, N. (2003). Towards a protocol for community monitoring of caribou body condition. *Rangifer*, Special Issue, 14, 43-52.
- Kolb, D.A. (1984). *Experiential learning: Experience as the source of learning and development*. New Jersey: Prentice Hall.
- Krishnaswamy, A. 2004. Participatory Research: Strategies and Tools. Practitioner: *Newsletter of the National Network of Forest Practitioners*, 22, 17-22.
- Krueger, R. A. (2000). *Focus Groups. A practical Guide for Applied Research*. (2nd Ed.). Thousand Oaks: Sage.
- Kuhn, Annette 1996 "Remembrance,". Women Writing on Photography from the 1850s to the Present. In Heron, L., & Williams, V. (eds) 'Illuminations'. (Durham, NC: Duke University Press). pp. 471-78.
- Lebel, L., Grothmann, T., & Siebenhuner, B. (2010). The role of social learning in addictiveness: Insights from water management. *International Environmental Agreements: Politics, Law and Economics*, 10, 333-353.
- Letherby, G., Scott, J., & Williams, M (2013). *Objectivity and Subjectivity in Social Research*. London : Sage.

- Laird, S. (Ed.) (2002). *Biodiversity and Traditional Knowledge*. London: Earthscan.
- Lave, J., & Wenger, E., (1991). *Situated Learning: Legitimate Peripheral Participation*. Cambridge: Cambridge University Press.
- Lotz-Sisitka, H.(2002). Weaving Cloths: Research Design in Contexts of Transformation. *Canadian Journal of Environmental Education*,7, 2-101.
- Lotz-Sisitka, H.B. (Ed.). (2012). *(Re) views on Social Learning Literature: A Monograph for Social learning Researchers in natural resources management and environmental education*. Grahamstown/Howick: Environmental Learning Research Centre, Rhodes University/EEASA/SADC REEP.
- Makaramba, R.,V. & Kweka, O.L. (1999). *Tanzania Coastal Management Partnership: Institutional and Policy Matrix*. Dar es Salaam: TCMP.
- May, T., & Perry, P. (2011). *Social research and reflexivity : Content, consequence and context*. London : Sage.
- Maxwell, J.A.(2012) *A realist approach for qualitative research*. Los Angeles: Sage.
- Martinez, M.A, Sauleda, N., & Guenter, H.L .(2001). Metaphors as blueprints of thinking about teaching and learning. *Teaching and Teacher Education*, 17, 965-977.
- Masara, C. (2010). *Learning commercial beekeeping: Two cases of social learning in southern African community natural resources management contexts*. Unpublished master's thesis, Rhodes University, Grahamstown.
- McDonald, M., Arragutainaq,L, & Novaling , Z (1997) *Voices from the Bay: Voices from the Bay: Traditional Ecological Knowledge of Inuit and Cree in the Hudson Bay Bioregion*. Ottawa: Canadian Arctic Resources Committee and Municipality of Sanikiluaq.
- Medin, D., Atran,S.,(2008), *The Native Mind and the Cultural Construction of Nature*. Massachusetts: Massachusetts Institute of Technology.
- Michel, D., & Sticklor, R.(2012). (Eds.). *Indian ocean rising: Maritime security and policy challenges*. Washington DC: STIMSON.
- Miettinen, R. (2000). The concept of experiential learning and John Dewey's theory of reflective thought and action. *International Journal of Lifelong Education*, 19, 54-72.
- Mingers, J. (2006). *Contemporary systems thinking. Realising system thinking; knowledge and action in management sciences*. New York: Springer.
- Mingers, J. (2011). *The contribution of Systemic thought to Critical Realism*. Sheffield: Equinox Publishers Ltd.

- Miller, N. & Dollard, J. (1941). *Social learning and imitation*. New Haven: Yale University Press.
- Mitchell, C. (2011). *Doing Visual Research*. London: Sage.
- Moller, H., Berkes, F., Lyver, P.O., & Kislalioglu, M. (2004). Combining science and traditional ecological knowledge : monitoring populations for co-management. *Ecology and Society*, 9, 2-19.
- Morgan, D.L. (2008). Sample. *The SAGE encyclopaedia of qualitative research methods*. Thousand Oaks, CA: Sage.
- Mostert, E., Pahl-Wostl, C., Rees, Y., Searle, B., Tabara, D., & Tippett, J. (2007). Social Learning in European River-Basin Management: Barriers and Fostering Mechanisms from 10 River Basins. *Ecology and Society*, 12, 1-19.
- Mukute, M. (2010). *Exploring and expanding learning processes in sustainable agriculture workplace contexts*: Unpublished doctoral thesis, Rhodes University, Grahamstown.
- Muro, M. & Jeffrey, P. (2008). A critical review of the theory and application of social learning in participatory natural resources management. *Journal of Environmental Planning and Management*, 51, 325-344.
- Nabhan, G. P. (2000b). Interspecific relationships affecting endangered species recognized by O'odham and Comcaac cultures. *Ecological Applications*, 10, 1288-95.
- National Integrated Coastal Environmental Management Strategy (NICEMS). (2003). Dar es Salaam: Tanzania Coastal Management Partnership.
- National Environmental Education and Communication Strategy. (2005-2009). Dar es Salaam: RIHAL'S GENERAL SUPPLIES.
- Nazarea, V.D. (2006). Local knowledge and memory in biodiversity conservation. *Annual Review of Anthropology*, 35, 317-35.
- Newig, J., D. Günther, & C. Pahl-Wostl (2010). Synapses in the network: learning in governance networks in the context of environmental management. *Ecology and Society*, 15, 4-24.
- O'Donoghue, R. & Neluvhalani, E. (2002). Indigenous knowledge and the school curriculum: A review of developing methods and methodological perspectives. In E. Janse van Rensburg, J. Hattingh, H.B. Lotz-Sisitka, & R. O'Donoghue. (Eds.). *EEASA Monograph: Environmental Education, Ethics and Action in Southern Africa*. (pp. 121-134) Pretoria: EEASA/Human Sciences Research Council,.

- O' Donoghue, R. (2003). Indigenous knowledge: Towards learning materials and methodologies that respond to social processes of marginalisation and appropriation in Eastern Southern Africa. *Australian Journal of Environmental Education*, 19, 57-67
- Ollman, B. (2003). *Dance of the dialectic: Steps in Marx's method*. Illinois: University of Illinois Press.
- Packard, J. (2008) 'I'm gonna show you what it's really like out here': The power and limitation of participatory visual methods. *Visual Studies*, 23, 63–77.
- Pahl-Wostil, C., Craps, M., Dewulf, A., Mostert, E., Tabara, D., & Taillieu, T. (2007). Social learning and Water Resources Management. *Ecology and Society*, 12, 2-5.
- Pahl-Wostil, C. (2009). A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change*, 19, 354-365.
- Parlee, B., Manseau, M., & Lutsel K'e Dene First Nation. (2005b). Understanding and communicating about ecological change: Denesoline Indicators of ecosystem health. In F. Berkes, R. Huebert, H. Fast, M. Manseau, & A. Diduck, (Eds.), *Breaking ice: Integrated ocean management in the Canadian North*. Calgary: University of Calgary.
- Patton, M. (1997). *Utilization-Focused Evaluation: The New Century Text*. Thousand Oaks: Sage Publications.
- Pesanayi, T., V. (2008). *Investigating learning interactions influencing farmer's choices of cultivated food plants: A case of Nyanga and Marange Communities of Practice, Manicaland Province, in Zimbabwe*. Unpublished master's thesis, Rhodes University, Grahamstown.
- Pole, C. (2004) *Seeing is believing? Approaches to Visual Research*. Oxford, ELSEVIER Ltd.
- Preston, R.J., Berkes, F. & George, P.J (1995). Perspectives on sustainable development in the Moose River Basin. In: Papers of the 26th Algonquian Conference, pp. 378-93.
- Price, L. (2007). *A transdisciplinary explanatory critique of environmental education; business and industry*. Unpublished doctoral thesis, Rhodes University, Grahamstown.
- Puck, T.G., & Stibbards, A., (2012). Systemic ecological illiteracy? Shedding light on meaning as an act of thought in higher learning. *Environmental Education Research*, 18, 353-373.
- Puri, K. (2001). *Legal protection of traditional knowledge and cultural expressions of indigenous peoples*. Lecture given at Corpus Christ College, Cambridge.

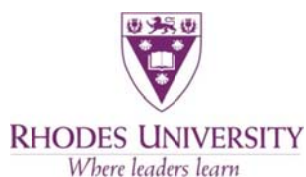
- Reed, M.S., Fraser, E. D. G., & Dougil, A.J. (2006). An adaptive learning process for developing and applying sustainability indicators with local people. *Ecological Economics*, 59, 406-418.
- Reed, M.S., Evely, C.A., Cundill, G., Fazey, I., Glass, J., Laing, A., Newig, J., Parrish, B., Prell, C., Raymond, C. & Stringer, L.C. (2010). What is Social Learning?. *Ecology and Society*, 15(4).
- Reid, W. V., Berkes, F., Wilbanks, T. J., & Capistrano, D. (Eds.) (2006). *Scales and knowledge systems. Concepts and applications in ecosystem management*. Washington: Island Press.
- Richards, L. (2005). *Handling Qualitative Data. A practical guide*. London: Sage.
- Rice, M.A., Mmochi, A.J., Zubieri, L., & Savoie, R.M (2006). Aquaculture in Tanzania. *World Aquaculture*, 37, 50 -57.
- Rice, M., and Pinnegar, S. (2012). Reflection under construction: Using the handbook of reflection and reflective inquiry in practice, *Reflective Practice: International and Multidisciplinary Perspectives*, 13, 821-827.
- Ridder, D., E. Mostert, & H. A. Wolters.(Eds.). (2005). *Learning together to manage together: improving participation in water management*. Osnabrück: University of Osnabrück.
- Robertson, H., A. & McGee, T.,K. (2003). Applying local knowledge: the contribution of oral history to wetland rehabilitation at Kanyapella, Australia. *Journal of Environmental Management*, 69, 275-87.
- Rodela, R. (2011). Social learning and natural resource management : the emergence of three research perspectives . *Ecology and Society*, 16, 30.
- Rodela, R., Cundill, G. & Wals, A. (2012). Methodological underpinnings of social learning research in natural resource management: a review. *Ecological Economics*, 77, 16-26.
- Ruane, J.M. (2005). *Essentials of research methods. A guide to social science research*. Oxford: Blackwell Publishing.
- Rydin, Y., Homan, N., & Wolff, E., (2003). Local Sustainability Indicators. *The International Journal of Justice and Sustainability*, 8, 581-589.
- Säljö, R. (1979). Learning from the learners' perspective. *Higher Education*, 8, 443-451.
- Samoilys M.A. & Kanyange N.W. (2008). *Natural resource dependence, livelihoods and development: Perceptions from Tanga, Tanzania*. IUCN ESARO 2008
- Sayer, A. (1992). *Method in Social Science: A realist Approach*. (2nd ed.), London: Routledge.

- Sayer, A. (2000). *Realism and Social Science*, London: Sage.
- Seale, C. (Ed.) (2005). *Researching Society and Culture*. (2nd Ed.), London: Sage.
- Scheltinga, D.M., Counihan, R., Moss, A., Cox, M., & Bennet, J. (2004). User's Guide to Estuarine, Coastal and Marine Indicators for Regional Natural Resource Management. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management. *Science Daily*, October 2005- Retrieved on 15th January 2013 from www.sciencedaily.com/releases/2005
- Schudel (2013) Examining emergent active learning processes as transformative praxis: The case of the schools and sustainability professional development programme. Unpublished doctoral thesis, Rhodes University, Grahamstown.
- Schlacher, T.A, Lloyd, S., & Wiegand (2010). Use of local ecological knowledge in the management of algal blooms. *Environmental Conservation*, 37, 210-21.
- Scott, D.(2010). *Education, Epistemology and Critical Realism*. London & New York : Routledge.
- Shava, S. (2008). *Indigenous knowledge: A genealogy of representations and applications in developing contexts of environmental education and development in southern Africa*: Unpublished doctoral thesis, Rhodes University, Grahamstown.
- Semesi, A.K. (1989). *The mangrove resources of the Rufiji delta, Tanzania*. Paper presented at a workshop on Marine Sciences in East Africa.[4-16 November]. Institute of Marine Sciences, University of Dar es Salaam.
- Sfard, A.(1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, 27, 4-13.
- Shenton A.K. (2004). Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information*, 22, 63-75.
- Sillitoe, P. (2007) (Ed.). *Local science vs global science . Approaches to indigenous knowledge in international development*. New York: Berghahn Books.
- Southern African Development Community Regional Environmental Programme (SADC REEP). 2012. *Learning Together for a Sustainable Future : 15 years of Swedish-SADC co-operation*. Howick: SADC REEP.
- Stake, R. (1995). *The Art of Case Study Research*. Thousand Oaks, CA: Sage Publications.
- Stanczak, G.C. (2007) (Ed) *Visual Research Methods*. Image, Society, and Representation. California: Sage.

- Stetsenko, A. (2008). From relational ontology to transformative activist stance on development and learning : expanding Vygotsky's CHAT project. *Cult Stud of Sci Educ*, 3, 471- 491.
- Sullivan, B., L., Wood, C.,L., & Iliff, M,J.(2009). eBird: a citizen-based bird observation network in the biological sciences. *Biological Conservation*. 142, 82-92.
- Steyaert, P., Barzman, M., Billaud, J.P., Brives, H., Hubert, B., Ollivier, G., & Roche, B. (2007). The role of knowledge and research in facilitating social learning among stakeholders in the French Atlantic coastal wetlands. *Environmental Science & Policy*,10, 537-550.
- Talbot, F. & Wilkinson, C.(2001). *Coral reefs, mangroves and sea-grasses: A source book for managers*. Australian Institute of Marine Science.
- Tanga Coastal Zone Conservation and Development Programme (TCZCDP): *Annual Progress Report, 1st April 2004 - 31st March 2005*.
- Tanzania Coastal Management Partnership – TCMP. (1998). Proceedings of the scientific meeting on marine and coastal ecosystem risk assessment. *An approach for linking Science to Integrated Coastal Management*. Zanzibar: TCMP & IMS.
- The Western Indian Ocean Marine Science Association (WIOMSA). Monitoring mangroves and sea grasses in Marine Protected Areas. A Toolkit for Western Indian Ocean:www.wiomsa.org/mpatoolkit/Themessheers/G4_Monitoring Accessed in January, 2011.
- Thomas, G. & James, D. (2006). Re-inventing grounded theory: some questions about theory, ground and discovery. *British Educational Research Journal*, 32, 6, 767-795.
- Thorsen C., A., & DeVore, S., (2012). *Analysing reflection on/for action: A new approach, reflective Practice: International and Multidisciplinary Perspectives*. London: Routledge.
- Turnbull,D.(2000). *Masons, tricksters and cartographers: Comparative studies in the sociology of scientific and indigenous knowledge*. Amsterdam: Harwood Academic.
- Vershuren, P & Doorewaard, H. (2010). *Designing a Research Project*. (2nd Ed.). Den Haag: Eleven International Publishing.
- Vieira, M.B, & Runciman, D.(2008). *Representation*. Cambridge: Polity Press.
- Virkkunen, J., & Ahonen, H., (2011) "Supporting expansive learning through theoretical-genetic reflection in the Change Laboratory", *Journal of Organizational Change Management*, Vol. 24, 229 – 243.
- Wagner, G.M., Mgya, Y.D., Akwilapo, F.D., Ngowo, R.G., Sekadende, B.C., Allen, A., Zollet, E.A. & Mackentley, N. (2001). Restoration of coral reef and mangrove ecosystems at

- Kunduchi and Mbweni, Dar es Salaam with community participation. In Richmond, M.D. & Francis, J. (Eds.), *Marine Science Development in Tanzania and Eastern Africa*, 2001, pp. 467-488. Dar es Salaam: University of Dar es Salaam.
- Wagner, G.M. (2005). Participatory monitoring of changes in coastal and marine biodiversity. *Indian Journal of Marine Sciences*, 34(1),136-146.
- Wals, A.E.J. (Ed.) (2007). *Social learning towards a sustainable world*. Wageningen: Wageningen Academic Publishers.
- Wals, A.E.J., Van der Hoeven,N., & Blanken, H. (2009). *The acoustics of social learning: designing learning processes that contribute to a more sustainable world*. Wageningen : Wageningen Academic Publishers.
- Wals, A.E.J.(2010).Message in a Bottle: Learning our way out of unsustainability. Wageningen: *Inaugural lecture upon taking up the post of Extraordinary Professor of Social Learning and Sustainable Development at Wageningen University*. Wageningen University.
- Wavey, R.(1993). International workshop on indigenous knowledge and community-based resource management: Key note address. In *Traditional Ecological Knowledge: Concepts and Cases*. (pp.11-16). Ottawa: Canadian Museum of Nature / International Development Research Centre..
- Webb, J. (2009). *Understanding Representation*. London: Sage.
- Webler,T.,Kastenholz,H.,& Renn,O.(1995). Public participation in impact assessment: a social learning perspective. *Environmental Impact Assessment Review*, 1, 443-463.
- Wenger,E. (1998). *Communities of Practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.
- Wertsch ,J.V. (1985). *Vygotsky and the Social formation of Mind*. Cambridge, MA: Harvard University Press.
- Wilkinson, D. (2000). (Ed.). *The researcher's toolkit. The complete guide to practitioner research*. London: RoutledgeFarmer.
- Yin, R.K. (2003) *Case Study Research Design and Methods*. (3rd ed.). London: Sage.

Appendix 1: Letter of introduction from Rhodes University



The Deputy Principal - Academic
Dar es Salaam University College of Education (DUCE) Dar es Salaam,
Tanzania

14 November, 2011

Dear Deputy Principal (Administration),

RE: PHD RESEARCH: Daniel Sabai

This letter serves to confirm that Daniel Sabai is a full-time PhD scholar at Rhodes University in South Africa (student number: 11S7154), based at the Environmental Learning Research Centre, and supervised by Professors Heila Lotz-Sisitka and Rob O'Donoghue in a study that seeks to understand the processes of abstraction, conceptualization and representation of Traditional Ecological Knowledge (TEK) and their potential contribution to the development of coastal management indicators that are less reified and more contextually congruent.

Mr. Saibai's PhD proposal was approved by the Higher Degrees Committee in the beginning of November, 2011 and is now ready to start his field work in Mkinga District from 1st December this year to 31st May 2012, with possible follow-ups in the following year (2013).

Kindly assist him to secure necessary research permits for his field work as per attached study framework.

Should you have any further queries regarding this student's study, please don't hesitate to contact the Environmental Learning Research Centre at +27 46 603 8390.

Trusting all is in order.

Kind regards,

Sashay Armstrong

Research Programme Administrator Environmental Learning Research Centre
Education Department Rhodes University Grahamstown sashay.armstrong@ru.ac.za



Appendix 2: Research permit from University of Dar es Salaam



UNIVERSITY OF DAR-ES-SALAAM

OFFICE OF THE VICE-CHANCELLOR
P.O. BOX 35091 ♦ DAR ES SALAAM ♦ TANZANIA

Ref. No: AB3/3(B)
Date: 16th December, 2011
To: The Regional Administrative Secretary,
Tanga Region.

UNIVERSITY STAFF AND STUDENTS RESEARCH CLEARANCE

The purpose of this letter is to introduce to you **Mr. Daniel Sabai** who is a bonafide member of staff of the University of Dar es Salaam and who is at the moment conducting research. Our staff members and students undertake research activities every year especially during the long vacation.

In accordance with a government circular letter Ref. No.MPEC/R/10/1 dated 4th July, 1980 the Vice-Chancellor was empowered to issue research clearances to the staff and students of the University of Dar es Salaam on behalf of the government and the Tanzania Commission for Science and Technology, a successor organization to UTAFITI.

I therefore request you to grant the above-mentioned member of our University community any help that may facilitate him to achieve research objectives. What is required is your permission for him to see and talk to the leaders and members of your institutions in connection with his research.

The title of the research in question is **"Analysing the Significance of Abstraction, Conceptualization, and Representation of Traditional Ecological Knowledge in the Eastern Coast of Tanzania: An approach Towards Developing Indicators for Monitoring Mangrove and Fisheries Resources"**.

The period for which this permission has been granted is from **December, 2011** to **December, 2012** and will cover the following areas/offices: **Mkinga District.**

Should some of these areas/offices be restricted, you are requested to kindly advise him as to which alternative areas/offices could be visited. In case you may require further information, please contact the Directorate of Research, Tel. 2410500-8 Ext. 2087 or 2410743.


Prof. Rwekaza S. Mukandala
VICE-CHANCELLOR

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Appendix 3: Summary of Representations from two Focus Groups held in Moa and Boma between January and March 2012.

Section A: Mangroves

Common or shared understanding of mangroves in the area:

- Mangrove are homes for fisheries
- They are hiding place for juvenile fishes
- They are special spawning areas for fisheries
- They provide food for a variety of fisheries like mullet fish and mangrove based fisheries
- They control erosion
- They are used for boat making and construction purposes
- They provide security against predators

Common mangrove species in the study area:

- Mpia- *Sonneratia alba* (green mangroves found near the shoreline, most fishes feed on its roundish small fruits in the rainy season)
- Mkoko- *Rhizophora mucronata* (dominant species found in muddy-fine sediments. The species locate themselves behind *Mpia* species and are therefore safe from direct ocean waves. The term 'mkoko' is also generally applied to other mangrove species in the study area).
- Msinzi - *Bruguiera gymnorrhiza* (have large leaves and are found in intertidal areas that contain fresh water and sea water characteristics)
- Mkomafi- *Xylocarpus granatum* (bears brown/green fruits with rough barks. They have round fruits bigger than those that are found in other species. These species are located in the intertidal areas that have sea and fresh water in the study area.).
- Mkandaa - *Ceriops tagal* (evergreen plants with clustered twigs found in well drained soils.).
- Mkandaa-dume - *Lumnitzera racemosa* (green plants found in landward areas of high salinity at Moa and Boma. The plant is widely used for boat making)
- Mchu - *Avicennia marina* (tend to separate itself from other species by growing close to terrestrial plants. They are common and fast growing)

Past and present condition of mangrove resources in the area:

In the Past:

- Clearance of mangroves for charcoal, salt-making, and selling, and building
- Clearance of mangrove-barks for 'colourants' making.
- Some species destructed due to dynamite blasts
- Fishers digging out roots in search of baits
- Wild animals digging out roots to feed on earthworms
- Not managed as now

- Monitoring by using scientific indicators

At Present:

- Restoration of mangroves by groups of restorers
- Transplanting activities
- More species than before
- Incidental clearance
- Roots still dug out by fishers in search of baits
- Wild animals still digging out roots in search of earth worms
- Good physical appearance on mangroves
- Good looking canopy
- Fewer gaps or bare areas due to transplanting activities
- Monitoring still there but involving few individuals.

Common threats to mangroves:

- Clearance for charcoal making, salt-pans, boat making, and building
- Plastic waste from residential and commercial areas (which trap young plants and eventually kill them)
- Dynamite fishing
- Sometimes invasive species disturb some plants
- Wild animals dig out mangrove roots
- Fishers also dig-out the roots in search of baits (earth worms)

Indicators of poor mangroves health:

- When there is an observed decrease of seedlings in the mangrove forest
- When the soil is rocky or reddish in colour
- Presence of bare spaces in the forest
- When there plenty of yellow leaves (in reasons other than seasonal shading)
- When there are signs of digging around plant roots in search of fishing-baits.
- When there are indications of destructive fishing practices in the mangroves
- When plants appear dormant (limited growth)

Indicators of good health:

- When the soil is rich, muddy, and not rocky
- When leaves are green, and there are more young leaves coming out
- When tree barks are thick around the stem and some other parts
- When roots are not damaged
- When there no plant stumps in the mangrove area

Indicators of poor mangroves health:

- When the soil is hard (not soft enough to allow penetration of roots)
- When the species are not dry
- When leaves appear yellow in times other than seasonal shading
- When the plant appear dormant (not increasing in size)
- When there is increased number of crawling/ creeping creatures

- When plant barks are damaged
- When roots are damaged or dug out

Indicators of good health:

- Good and soft soil that allows penetration of roots
- When leaves appear green most of the time
- When roots are not dug out
- When barks are not damaged
- When the mangrove species increases in size
- When there are no signs of erosion in the mangroves
- When the stem looks healthy

SECTION B: FISHERS' REPRESENTATIONS

Fishing trends:

- More use of traditional fishing in the past than now
- Common use of traditional fishing gears such as malema/madema, mishipi, mikuki (spear), locally made nets and hooks in the past than now
- Emerging modern fishing gears and expanding industry which pose threats to traditional fishing
- Modern fishing gears catch every kind of fish and observed to be unsustainable as compared to traditional fishing methods. Some species are believed to have disappeared or declined as compared to the past. These include, *Unga* (mangrove red-snappers), *Midu*, and *Tembo*.
- Dynamite fishing is also a threat (it destroys everything including nursery grounds, and juvenile fishes.
- There is a decline in fish size now as compared to the past. Most of fisheries caught are small in size and have less weight than those caught in the past.

Common species in the mangroves:

SN	Species: Local name	Availability or presence in the mangrove	Features/characteristics as described by fishers
1.	Paramamba	Pays regular visits	Found in abundance during rainy season as water tend to be cooler in the mangrove
2.	Unga	Permanent	Uses mangrove as nursery &, feeding ground
3.	Chewa	Permanent	As unga, no.2
4.	Dizi	Permanent	As unga, no.2
5.	Chaa	Permanent	As unga, no.2
6.	Mkunga	Permanent	As unga, no.2
7.	Kikotwe	Temporary	Pays regular visits at night in search for food
8.	Chafi	Temporary	As kikotwe, no.7
9.	Tembo	Permanent	Uses mangrove as nursery &, feeding ground
10	Ngogo	Permanent	As tembo, no.9
11	Mkizi	Pays regular visits	caught in abundance during rainy season as water tend to be cooler in the mangrove
12	Midu	Permanent	As unga no.2
13	Kigunda	Permanent	As unga no.2
14	Kisumba	At juvenile stage	Leaves mangroves at post-juvenile stage
15	Funda	Permanent	As unga no.2

Fish interactions in the mangroves:

- Fish interactions are determined by seasons (in the northerly monsoon there are more fisheries in the mangroves as the water is warm than in the southerly monsoon which attracts cold).
- Mullet fish (characterised by limping or jumping while swimming) and other fisheries that are not permanently residing in the mangroves tend to visit mangroves in large companies in the rainy season than other seasons of the year.

- Mangrove attract such species for many reasons, first, the temperature seems to be optimal in the mangroves than the ocean, secondly, some mangrove fruits like *Mpia* shed their fruits at that time of the year and visiting fisheries feed on those fruits.
- Juvenile fishes spend their early months in the mangroves from the spawning season, and they feed, learn to swim, and hide against predators. Most of these are released to the ocean after three months to start independent life. They start approaching the ocean by swimming in the low waters, and slowly advance to high waters.

Swahili description of fish interactions:

Wakati wa Kaskazi samaki wengi wanatembelea koko kwa kuwa wakati huo joto linakuwa jingi baharini. Samaki wanavuliwa kwa misimu maalum; kuna wanaovuliwa mwezi wa nne majira ya baridi kama vile kolekole na wengine mfano mkizi wanavuliwa saana nyakati za majira ya mvua hasa kokoni (wanakokwenda kutafuta chakula, mapumziko, na kujificha kutokana na maadui). Mikoko inatumika kama mazalia na makuzi ya samaki. Samaki wadogo hutumia maeneo ya mikoko kama makuzi kwa takribani miezi 3, na baada ya hapo huanza kusogelea maji ya pima mbili, tatu, na baade baharini. Mabadiliko ya pepo yanaweza kusababisha kuwepo kwa samaki baharini/kokoni au kupungua kwa samaki.

Samaki wengi wanaotembelea koko si-wakazi wa humo, ila huenda kutafuta chakula mfano matunda ya mpia yaliooza, wadudu, na samaki wadogo. Baadhi pia wanakwenda kutaga kokoni. Mikizi wengi wanaingia kokoni majira ya mvua.

Threats to fisheries

- Dynamite fishing (uvuvi wa baruti)
- The use of poison in fishing (utupa)
- Advancing modern fishing industries
- Mangrove clearance (which implies that fisheries nursery grounds are destroyed).

Observable fish behaviours/ changes overtime:

- Declining fish catch
- Declining fish size
- Disappearance of some species
- Juvenile and adult fishes have generated more fear of humans than in the past due to dynamite blasts

Indicators of good fish health status:

- Inspecting the fish to see if there are any wounds, scars, or bruises, or hanging hooks around the neck, or in the stomach. If the fish is free from such threats then I will consider it as being healthy.

- Observing the fish-air bladder to see if it is damaged or not. Any damages suggest that it has been fished out using dynamite and is therefore not healthy.
- A healthy fish can physically be identified by looking at its body parts. If some parts such as the tail, an eye, and etcetera are missing, then that fish cannot be considered to be healthy.
- Observing the shape and body fats. If the fish is too skinny and dormant then I will rule out that it is not healthy.
- If there are many fishers in the area one may easily conclude that there is fish decline or such decline is likely to come.
- Inspection of the colour of gills. Red colour suggests that the fish is healthy while brownish and pale indicate bad health.
- Inspecting fish eyes to see what colour are they. Brown and pale colours will suggest that the fish is not healthy.

Appendix 4: Open-ended questionnaire for capturing traditional ecological knowledge on mangrove ecosystem in Mkinga District.

Target Participants: Mangrove restorers with 10 years' experience in restoration practices.

Section 1: Self-introduction and request to participate in the research process:

I am a full-time PhD scholar at Rhodes University in South Africa, based at the Environmental Learning Research Centre, and supervised by Professors Heila Lotz-Sisitka and Rob O'Donoghue (all from Rhodes University). I would wish to carry out a study that intends to make an input to improvement of social learning processes in the coastal environment, as a reliable way of safeguarding the integrity of coastal resources particularly mangroves and fisheries, and have selected Mkinga District as a study area. Kindly feel free to participate, ask questions, and share your experience, knowledge or information with me.

Section 2: Personal Particulars

(a) Name of the participant.....

(b) Age..... (Optional) (c) Sex.....

(d) Locality/ Site/ Village

Section 3: Mangrove related questions:

3.1 Restorer's understand of the mangrove ecosystem:

1. When did you first settle here, and what are you involved in, on daily basis?
2. What do you know about mangroves?
3. Which mangrove species do you know and how are these distributed over the coastal area?
4. How would you describe the past and present *condition* of mangroves in your area?
5. What would you consider to be common *threats* that occur in the mangrove ecosystem?
6. What kinds of changes are apparent in the mangrove system now as opposed to the past?
7. How would you identify a healthy mangrove species from unhealthy one; and what would you cite as determinants of good health versus poor health?.

Appendix 5: Open-ended questionnaire for capturing traditional ecological knowledge on mangrove-based fisheries in Mkinga District.

Target Participants: Fishers with at least 15 years' experience.

Section 1: Self-introduction and request to participate in the research process:

I am a full-time PhD scholar at Rhodes University in South Africa, based at the Environmental Learning Research Centre, and supervised by Professors Heila Lotz-Sisitka and Rob O'Donoghue (all from Rhodes University). I would wish to carry out a study that intends to make an input to improvement of social learning processes in the coastal environment, as a reliable way of safeguarding the integrity of coastal resources particularly mangroves and fisheries, and have selected Mkinga District as a study area. Kindly feel free to participate, ask questions, and share your experience, knowledge or information with me.

Section 2: Personal Particulars

(a) Name of the participant.....

(b) Age..... (Optional) (c) Sex.....

(d) Locality/ Site/ Village

Section 3: Fisheries related questions:

3.1 Fishers' understand of the mangrove-based fisheries:

1. When did you first settle here, and what are you involved in, on daily basis?
2. How would you describe the trend(s) of traditional fishing in the mangrove area?
3. Which fish species would you identify as being 'common' in the mangroves?
4. How would you describe fish-interactions in the mangroves?
5. What kind of threats would you identify as being common to fisheries that use mangroves as habitats; what particular fish species are involved?
6. What would you describe as being observable changes in fisheries in terms of their behaviour, size, breeding grounds, and movement?
7. What are visible characteristics that enable you to rule out that the changes you have identified occurred or not?
8. How would you identify a healthy fish from unhealthy one? And what would you identify as determinants of good versus poor health?

Appendix 6: Open-ended questionnaire for capturing data on historical background of fisheries & mangroves ecosystem in Mkinga District

Target Participants: Local Elders (retired fishers & mangrove users who have lived in the study area for at least 30 yrs.)

Section 1: Self-introduction and request to participate in the research process:

I am a full-time PhD scholar at Rhodes University in South Africa, based at the Environmental Learning Research Centre, and supervised by Professors Heila Lotz-Sisitka and Rob O'Donoghue (all from Rhodes University). I would wish to carry out a study that intends to make an input to improvement of social learning processes in the coastal environment, as a reliable way of safeguarding the integrity of coastal resources particularly mangroves and fisheries, and have selected Mkinga District as a study area. Kindly feel free to participate, ask questions, and share your experience, knowledge or information with me.

Section 2: Questions on the historical background of mangroves:

1. When did you first settle here, and what are you involved in, on daily basis?
2. How would you describe mangroves?
3. Which mangrove species do you know and how are these distributed over the coastal area?
4. How would you describe the past and present *condition* of mangroves in your area?
5. What would you consider to be common *threats* that occur in the mangrove ecosystem?
6. What kinds of *changes* are apparent in the mangrove system now as opposed to the past?
7. How would you identify a healthy mangrove species from unhealthy one; and what would you cite as determinants of good health versus poor health?

1. Questions on history of fishing in the mangroves:

1. How would you describe the trend(s) of traditional fishing in the mangrove area?
2. Which fish species would you identify as being 'common' in the mangroves?
3. How would you describe fish-interactions in the mangroves?
4. What kind of threats would you identify as being common to the fisheries in the mangrove; what particular fish species are involved?
5. What would you describe as being observable changes in fisheries resources in terms of their behaviour, size, breeding grounds, and movement?
6. What are visible characteristics that enable you to rule out that the changes you have identified occurred or not?
7. How would you identify a healthy fish from unhealthy one?

Appendix 7: Questionnaire for guiding Focus Group Discussions in the process of verifying individual representations about mangroves in Mkinga District.

Target Participants: Mangrove restorers who participated in in-depth interviews at individual level.

Section 1: Self-introduction and request to participate in the research process:

I am a full-time PhD scholar at Rhodes University in South Africa, based at the Environmental Learning Research Centre, and supervised by Professors Heila Lotz-Sisitka and Rob O'Donoghue (all from Rhodes University). I would wish to carry out a study that intends to make an input to improvement of social learning processes in the coastal environment, as a reliable way of safeguarding the integrity of coastal resources particularly mangroves and fisheries, and have selected Mkinga District as a study area. Kindly feel free to participate, ask questions, and share your experience, knowledge or information with me.

Session introduction: Most of the participants that are here are familiar to me because we met during individual in-depth interviews which took place in the mangrove area. **We are meeting here once again not to repeat what we covered in the previous session, but to expand traditional ecological experiences. This session may also remind us of what might have been over-looked or forgotten during individual sessions and give us a clearer picture of the mangrove ecosystem. I will therefore ask the same questions that were asked during in-depth interviews as an opportunity for the participants to add, adjust, or expand anything that you might have regarding the mangrove ecosystem. Please feel free to put up your hand and I will give you an opportunity to contribute and share what you have.**

Section 2: Knowledge and experiences about mangroves

1. What would you consider to be the common or shared understanding of the mangrove ecosystem in this area?
2. Which mangrove species are known to people and how are these distributed over the coastal area?
3. How would you describe the past and present *condition* of mangroves in your area?
4. What would you consider to be common *threats* that occur in the mangrove ecosystem?
5. What kinds of *changes* are apparent in the mangrove system now as opposed to the past?
6. How would you identify a healthy mangrove species from unhealthy one; and what would you cite as determinants of good health versus poor health?

Appendix 8: Questionnaire for guiding Focus Group Discussions in the process of verifying individual representations about mangrove-based fishing in Mkinga District.

Target Participants: Fishers who participated in in-depth interviews at individual level.

Section 1: Self-introduction and request to participate in the research process:

I am a full-time PhD scholar at Rhodes University in South Africa, based at the Environmental Learning Research Centre, and supervised by Professors Heila Lotz-Sisitka and Rob O'Donoghue (all from Rhodes University). I would wish to carry out a study that intends to make an input to improvement of social learning processes in the coastal environment, as a reliable way of safeguarding the integrity of coastal resources particularly mangroves and fisheries, and have selected Mkinga District as a study area. Kindly feel free to participate, ask questions, and share your experience, knowledge or information with me.

Session introduction: Most of the participants that are here are familiar to me because we met during individual in-depth interviews which took place in the fish-landing sites. **We are meeting here once again not to repeat what we covered in the previous session, but to expand traditional ecological experiences about fisheries resources.** This session may also remind us of what might have been overlooked or forgotten during individual sessions and give us a clearer picture of the mangrove-based fisheries. I will therefore ask the same questions that were asked during in-depth interviews as an opportunity for the participants to add, adjust, or expand anything that you might have regarding fisheries. Please feel free to put up your hand and I will give you an opportunity to contribute and share what you have.

Section 2: Knowledge and experiences about mangrove-based fisheries

1. How would you describe the trend(s) of traditional fishing in the mangrove area?
2. Which fish species would you identify as being 'common' in the mangroves?
3. How would you describe fish-interactions in the mangroves?
4. What kind of threats would you identify as being common to the fisheries in the mangrove; what particular fish species are involved?
5. What would you describe as being observable changes in fisheries resources in terms of their behaviour, size, breeding grounds, and movement?
6. What are visible characteristics that enable you to rule out that the changes you have identified occurred or not?
7. How would you identify a healthy fish from unhealthy one?

Appendix 9: In-depth interviews with local elders:

Location of interview: Boma

Involved participant: 1E BKII

Specialisation: Retired fisher and mangrove user.

Number of years in fishing: 30

Daniel : Thank you elder for agreeing to take part in this interview.

1EBKII: You are most welcome.

Daniel: When did you first settle here?

1EBKII: My parents moved to this area when I was young; I have ever since lived here.

Daniel: How would you describe mangroves?

1EBKII: Mangroves harbour a variety of living things including fishes. They are grounds for fish-spawning. They protect the coast from erosion by blocking strong waves.

Daniel: Which living things in particular?

Crabs, different earth worm species, Jelly fishes, Lung fishes, Mullet fishes, and tiny fish species locally called 'Mazumburu'. Mullet fishes enter mangrove areas in abundance during rainy season. Paramamba species also spend much of their time in there.

Daniel: Which mangrove species do you know and how are these distributed over the coastal area?

*Our forest harbours nearly 8 mangrove species but I am familiar with 6 of them. These are arranged in an orderly manner from the shoreline to the area that boarder human settlements. The species that border the water mark is known as mpia (*Sonneratia alba*); thereafter, you will see mkoko (*Rhizophora mucronata*),mkandaa (*Ceriops tagal*), mkomafi (*Xylocarpus granatum*), msinzi (*Bruguiera gymnorrhiza*), and mchwi (*Avicennia marina*).*

Daniel: Which of the species you have identified is dominant and why?

*1EBKII: Mkoko (*Rhizophora mucronata*) are dominant species; they are dominant because they grow faster than other species, and are not directly exposed to ocean waves. Their seeds are therefore not carried away by waves as it is the case with other species. This makes them dominant. Mkoko (singular) (mikoko-plural) are located in muddy areas which favour mangrove growth. Their seeds hang head-long up to maturity level, and when wind blow or other factors shake the plant, the seed fall and its sharp age sticks to muddy soils and grow.*

Daniel: And which species would you consider to be rare, and why?

*1EBKII: Mkandaa species (*Ceriops tagal*) are likely to be rare, as these are mostly cleared for construction at household level. There is also an increasing demand for Mchwi, Mpia, and Mkomafi as either material for boat making or scaffolds for the same.*

Daniel: How would you describe the past and present condition of mangroves in your area?

- 1EBKII: *The forest status has declined significantly. Many years ago, mangrove species were of good height, very thicker than now and straight, you can hardly now find well-nourished species as before.*
- Daniel: *What would you establish as being the cause for the decline?*
- 1EBKII: *The emergence of salt-making stand to be the main cause but also other uses at household and commercial levels. Besides, in the past, the government had special two representatives in every locality who were carrying out surveillance and regular patrols. Their presence generated some kind of fear and respect to the mangrove ecology. Now the officers are no longer visiting our locality or ward; most of responsibilities are being carried out by local environmental committees, which I believe, are not effective for that particular role.*
- Daniel: *How would you identify healthy mangroves from those which are not? And what would you present as evidences that particular mangrove species are healthy?*
- 1EBKII: *You look at different parts of the plant such as leaves, branches, stem, and roots. If there is any change from normal to abnormal then you know that there is a problem.*
- Daniel: *Have there been any changes in the fisheries that use mangroves as habitats?*
- 1EBKII: *There is a decline in fish catch now than in the past. The decline results from unsustainable practices that are carried out near mangrove sites such as dynamite fishing and the use of poison in fishing (utupa). This tends to affect every fish because it destroys adult and juvenile fishes and their habitats. Mullet fishes and Paramamba species are the most affected whenever such illegal form of fishing is practiced.*
- Daniel: *Do you know any of the species that have disappeared as a result of unsustainable fishing?*
- 1EBKII: *Yes but most of them are not mangrove based species. Fishes like 'Mbono' have almost disappeared but those are not mangrove-based. They live in Cora reefs. Mangrove crabs have also declined significantly.*
- Daniel: *Do you have any other observations regarding fish dynamics or behavioural changes?*
- 1EBKII: *Yes, especially fish size. In the past fishers would fish big fishes. Most of fisheries that are caught now are small in size, probably due to unsustainable fishing. As for fish behaviour, mullet fisheries tend to jump up in and out the water. One of the experienced fisher told me that when they behave like that, they are trying to regulate their body temperature especially when water temperature levels exceed the optimal condition that such fisheries require. Fishes are like people; we also feel temperature and look for places where we can cool ourselves.*
- Daniel: *How would you distinguish a healthy fish from the one which is not healthy?*
- 1EBKII: *You look at the size, body morphology, abdominal area whether there is any damage or not.*

Appendix 10: In-depth interviews with mangrove restorers:

Location of interview: Moa

Involved participant: 1MMNII

Specialisation: mangrove restorer

Number of years in restoration activities: 10

Daniel: Welcome to the interview as agreed.

1MMNII: Thank you.

Daniel: How would you describe mangroves?

1MMNII: Mangroves are hiding sites for marine creatures, and special resorts. They are nurseries for fisheries, and can widely control erosion along the ocean shores resulting from heavy and speedy waves.

Daniel: How would you describe the current status of mangroves in your area?

1MMNII: I can see the difference between the mangrove forest that I saw some years back and the current one. The previous mangrove status was bad due to human induced threats. In the past, we cleared the forest for charcoal making, construction purposes, but are no longer engaged in such destructive practices which increase pressure to the mangroves. We are now focusing on restoration. Initially, we did not have any form of organised group work as it is the case now; people would operate individually and this was the time when a lot of mangroves were being cleared. But after sometimes Tanga coastal zone programme invited us to several seminars, those who participated helped the rest of us to organise ourselves as a team.

Daniel: How do you arrive at establishing whether a particular mangrove forest is in a good or bad condition?

1MMNI: Well, you look at how thick the general forest is, including foliage. If there are very few gaps in it then you know that it is doing well. You may also examine specific mangrove species especially their leaves, stems, and the surrounding environment. If leaves of a particular mangrove species turn into yellow while those of other plants remain green then you know that there is problem. For example, the plant you are standing close too, has unstable roots; someone might have cut them and I can tell that the plant can't last longer.

Daniel: How would one differentiate transplanted mangroves from those that have grown naturally?

1MMNI: Transplanted mangrove species take much longer time to grow than species that grow naturally. Naturally grown species always do better. Besides, species that are transplanted tend to appear in straight lines while naturally grown ones appear in a random form.

Daniel: So, if species that grow on their own tend to do better than those that are transplanted, why are you then encouraging transplanting?

1MMNI: Transplanting is mainly aimed at covering specific gaps within the mangrove forest regardless of whether the concerned location has good soils or not. Naturally growing plants are selective. They only grow in areas that favour their growth.

Appendix 11: In-depth interviews with mangrove-based fishers:

Location of interview: Moa

Involved participant: 11FMII:

Specialisation: Fisher

Number of years in fishing: 45

Daniel: Well come to the interview.

11FMII: Naam [Yeah]

Daniel: How would you describe fishing trends in the mangrove area?

11FMII: Fishing in the past was mainly done using traditional fishing gears such as malema/ madema, tando, uzio, mishipi, mshipi wa mkononi and nyavu, we have stopped using some of the gears due to absence of some fish species in the mangroves.

Daniel: Well, I will come back to the 'absence' of some species but would you please mention specific kinds of fisheries that use mangroves as habitats and describe their life in general?

11FMII: Mangrove-based fisheries include; Unga, Chewa, Mkizi, dome, and Tembo, but there are other species such as Madizi and Kolekole that just visit mangroves sites during high water tides and retreat to the ocean at low tides. Mangroves are homes for juvenile fisheries, prawns, and many minute creatures. These leave in special holes and under stone shelters before advancing to the ocean. Some live in muddy areas beneath mangrove roots such as Mkizi, Dome, Chaa, and Kikotwe. More fisheries enter mangroves areas in the rain season, than any other time of the year. Paramamba, Unga, and Chachi are among common species that enter mangroves water during that time. Some of these species remain in the mangroves in special holes and areas that allow them to hide until the end of the rain season.

Daniel: I can see that you are carrying some fish species; do you have any mangrove-based species there?

11FMII: Yes, I have Chewa, and Midu or Mwidu; all these use mangroves as habitats.

Daniel: What are the main characteristics of mangrove based-fisheries?

11FMII: Mangrove fisheries share this common feature; they all use mangroves as places that offer opportunities for food and shelter. Some juvenile fish use them for protection against their predators.

Daniel: Do you know how fish spawning occur?

11FMII: Fish do lay eggs under stony sites in the mangroves, thereafter, juvenile fisheries are hatched. They stay in the mangroves for some few months and start swimming towards the ocean. Their kind of swimming is very slow and it depends with the level of water. As water increases, they advance slowly until they are able to swim properly.

Daniel: How would you compare the kind of fisheries you saw in the past 30 years and those that you see now?

- 11FMII: *There were more mangrove based fisheries in the past than now. The number has gone down probably due to increased fishing activities in our area. In the past, one could fish between 3000-4000 species using a mere traditional gear. That can hardly happen now. Another reason for declining fisheries could be the use of dynamite and poisons by some fishers.*
- Daniel: *You mentioned earlier about the disappearance of some mangrove based fish species, which species in particular would you site as having disappeared and why?*
- 11FMII I: *Paramamba species which used to be abundant is now either rare or has disappeared in some places. I suspect that the newly introduced modern fishing gears commonly known as "Ring-nets" are the cause. These have also affected deep-water fisheries and even those which used to retire to the mangroves during rain seasons.*
- Daniel: *How would you identify a healthy fish from unhealthy one?*
- 11FMII *It is physically easier to identify unhealthy fish. You look if the airbladder is intact or not. You also check is there are any wounds, scars, hanging pieces of hooks or injuries or if there some missing body parts.*

Appendix 12: In-depth interviews with mangrove-based fishers:

Location of interview: Moa

Involved participant: 9FMII:

Specialisation: Fisher

Number of years in fishing: 50 +

Daniel: Welcome to the interview.

9FMNII Thank you.

Daniel: I can see that you are holding some fishes; would you please identify and describe them?

9FMNII: This particular species is called Mwidu; you can find it in stony areas within the mangrove ecology, and in nearby shallow water areas. The second species is known as Unga (Mangrove red snapper); they are dominant in the mangrove ecology. The last one is called Mkizi (Mullet fish); these kinds of species spend much of their time in the mangroves and may retire to nearby much deeper areas.

Daniel: Do you know any other mangrove species beside those?

9FMNII: There are other species that are mangrove-based but are not here with me; these include Chewa and dome. The later tend to burry itself in muddy areas during low tide, and comes up during the high tide. It is like lung fish but it looks like a sea turtle if you have ever seen one.

Daniel: What is the difference between the fishes you are holding now and the species you saw or caught in the last 30 years?

9FMNII: These species are not in abundance anymore as in the past. There are a lot of modern fishing gears in place that affect the situation, and probably seasonal changes might also have contributed to the decline of fisheries. Our fore-fathers used traditional fishing gears which were generally much friendly than the ones we see now.

Daniel: Why do you think traditional fishing gears are important than those used in the modern fishing industry?

9FMNII Traditional fishing gears allow reproduction of fish and some species could grow up to the level that only three people could manage to carry them into the fishing vessel. When we grew up, that's the kind of fishing knowledge we got introduced to. Currently, the fishing industry is focusing on quick gains. It appears superior over traditional forms of fishing. Even the size of fish is different now from the past. There are more much smaller fisheries due to what I have said. In the past, there were particular species that were huge but are no longer available.

Daniel: Would you please mention their names?

9FMNII: I remember one species called Kyolwe with large scales throughout its body. This likewise, could not be lifted-up with one or two people. Kambisi was another white coloured species that would grow to almost the same level as Kyolwe. You see now, gears are made specifically for certain kind of fisheries, with much higher catching precision, so how can we still have the same situation as before?

Daniel: How would you distinguish a healthy fish from unhealthy one?

9FMNII: You open the gill covers and inspect whether the gills are red or brownish. If they look whitish, brownish or pale then that particular fish is not healthy. You can also press it to see if it bounces back. If not, you know that there is a problem. Lastly you can see its size or length and tell whether it has been dormant or not.

Appendix 13: Feedback from the experiential learning practice (cycle):

Leaner's feedback after participating in the Experiential Learning Cycle (see Chapter 6):

- *Deciding what image should I capture was a big challenge to me. I spent sometimes speechless like someone who is 'stammering', but later went on with the practice. I ended up taking two photographs; one depicting good health of mangrove species and another indicating poor health status-24MMII. (See plate 6.7 and 6.8)*
 - *The task went on very well because I was able to capture a photo of a fish called 'Chewa'(Redmouth grouper). I like the photo because it was well taken. I did not experience any worries during the task. My intention was to make those who have never seen that kind of fish to reflect its uniqueness in terms of ability to stay alive for up to three hours after it has been fished out from the ocean-13M/FMII. (See plate 6.10)*
I deliberately focused the camera to the area which is affected by invasive species so that I may be in a better position to explain the photographic image of my choice There was no visual difference between the image that I captured and the real situation on ground. They all appeared the same-13M/FMII. (see plate 6.3).
1. *This picture shows a mangrove plant called 'Mkoko' (Rhizophora mucronata); this is a stem, these are branches, and these are leaves. Some leaves in this image look damaged as you can see, some parts of the plant generally look good. This branch in particular, is not good. There are signs of insects underneath the plant, but also the soil around it is dug out, not by humans but possibly by wild animals -1MMNII.(see plate 6.1).*
 2. *I took a picture of Rhizophora mucronata species (Mkoko) because it helps in protecting the coast, used for boat making and also as habitat for fisheries. This particular species grow well in good soils and poorly in sandy soils. You can detect that the health of the plant is poor when its leaves start changing from green to reddish/yellowish. This photo reveals that the plant I have taken is generally healthy, though some leaves display minor attacks from insects- 2M/FMNII.(see plate 6.2)*
 3. *I took a photo of 'Mkoko' (Rhizophora mucronata). This image shows several species, their roots, stems, branches, and leaves. I opted for this particular species because it is 'common' in the mangrove ecosystem. This photo indicates that captured species are not healthy because they are located in poor soils. Mangroves do well in muddy soils but not in sandy areas like this-20 MMII. (See plate 6.6)*
 4. *When the facilitator asked me to describe the image I had taken, and he himself turned into a listener, I found myself stuck. I am not used to talking myself; I wished to be asked more questions. When we had interviews in the mangroves, I explained everything, but this one was somehow new for me-19MMII. (See plate 6.5)*

5. *Photograph taking is new to us, when you interviewed me in the mangroves it was easier to respond than today. I found myself in a new experience, and even running short of words-17MMII. (Views based on plate 6.4)*
6. *I opted for the image that indicates a threatened 'Mchwi' (Avicennia marina) species. This kind of threat is human induced since some branches were cut down by a sharp material -24MMII.(See plate 6.7)*
7. *I opted to take a photographic image of Mpia plant (Sonneratia alba) because this particular species is more threatened than other mangrove species. This plant is a victim of invasive species as you can see at the top. This is an indicator that this particular plant is not healthy. That's why there are some signs of 'drying' from the top-13M/FMII. (See plate 6.3).*
8. *I started fishing 25 years ago. I also opted for 'Chewa' species because I know well its life and habitat. This fish lives in-shore near rocky areas, and prefers visiting mangroves sites, and hiding in holes in there. This kind of fish does not suffocate easily once it is fished-out. Unlike other fishes which die shortly when taken out of water, it may take up to 3 hours long being alive. I took this photo in anticipation that it would look good, and people would like it. The quantity of 'Chewa' is currently dwindling, and fishers can only fish them if they set traps in their habitats. I also took this photo to show people who have never seen this type of fish before- 13M/FMII*
9. *The photo I have taken displays the image of 'Koe' fish. This fish visits mangroves occasionally in search for food specifically micro-insects, and also for spawning purposes. Such occasional visits are in most cases beneficial to this fish. Its original habitat is 'under reef areas' but all this depend on the maturity stage or level. Juvenile species spent much of their time in mangroves and are released to in-shore water when they are able to swim and feed properly. This picture looks clear and good. I took it for reasons of its attraction or good looking nature of the fish itself- 2/MFMNII (see plate 6.9)*

Appendix 14: The Experiential Learning Intervention Workshop (ELIW):

Procedures and feedback (see Chapter 7):

Goal: Planned to allow learners (participants) to mirror the two frameworks of indicators according to the order of the RRREI(C) model and develop an integrated framework which would be used as a tool for engaging workshop participants in the fourth stage of the Experiential Learning Cycle (testing or active implementation)

Target group: Mangrove restorers, fishers, local elders, and mangrove scientists.

Location: Moa (South):

Date: 18-19/09/2012.

Workshop time (8.00 am to 5.30 pm)

Workshop procedures & activities:

1. Opening the workshop
2. Self-introduction and researcher's appreciation of the turn-up.
3. Describing the goal or overall objective: The facilitator/researcher introduced the overall workshop objective (goal) and urged workshop participants (mangrove restorers, fishers, local elders, and local marine scientists (representatives) to actively use workshop sessions to meet the intended goal.
4. The Experiential Learning Intervention Workshop (ELIW) was used as a platform for identifying key attributes that form the two frameworks of indicators and analysing them deeper in different sessions according to the order of the RRREI(C) model in order to reduce 'complexity' that surrounds their systemic nature and pave the way towards knowledge integration.
5. The workshop was divided into four main sessions. The first session focused on assessing the level of familiarity and comprehension of attributes that constituted the framework of scientific indicators for monitoring mangrove species and mangrove-based fisheries respectively. This created a space for workshop participants to explain the extent to which the scientific framework of indicators which had been in use from the early 1990s was familiar to them. It was during this session that **resolution** of the scientific attributes (identifying and describing them was done as per the RRREIC model. The researcher listed down all the scientific attributes and the participants were asked to indicate which ones were familiar to them and which ones were not, and also give reasons for the answers they had given.
6. The second session was spent in tracing the relational aspects or linking the attributes to their relevant methods and techniques that are proposed in the scientific monitoring plan (identified during the first session). This session was planned to make the participants 'understand' the connection between the indicators/ attributes and methods, and be able to make contributions in the integration process. This session served as a **re-description** stage (see Bhaskar (2010); where discussed components

of the phenomenon are analysed deeper either comparatively or in a relational manner to allow outcomes or emergences.

7. Deeper involvement of the participants in the RRREI(C) model started continued in the third session which focused on in-depth discussions and descriptions of the attributes/indicators and methods/techniques that constituted the scientific framework; followed by discussions on the traditional ecological knowledge framework. This created a space for workshop participants to dialogue with the local coastal and marine scientists on the relevance of the scientific attributes/ indicators to the local context (the study area). Such active dialogues and suggestions suggested that the participants were now 'in charge' of the process they were going through, and of the awaiting 'integration' task. It was during this session that other stages of the RRREI(C) such as Retrodiction, Elimination, Identification and Correction were reached; yielding input that appears in sections (7.4.3-7.9) were . Most of the descriptions for specific attributes or indicators; especially those that emerged from traditional ecological knowledge (see section 7.4.3.2, F: a-j; and section 7.4.3.4, L: 1-12) were captured during data collection stage but had to be affirmed by Experiential Learning Intervention Workshop participants. It should however, be noted that more time was spent on discussing the scientific framework of indicators than the TEK one, since the latter had just been developed by most of those who were participating in the workshop and carefully thought through, to reflect contextual realities on ground, and it just required input from those who did not take part in their development (i.e. marine scientists and few local individuals).
8. The fourth session was spent to integrate the two frameworks of indicators based on the needs and requirements identified during the second and third sessions. This session was extended in the following day to accommodate testing of the new framework (in the afternoon) and in the following day, where also a feedback session on the 'testing exercise' was carried out. Testing of the indicators was also an extension of the fourth stage of experiential learning cycle.
 - A: Comparing the two frameworks:
 9. Those indicators were for the educated. You could count two or three individuals who could at least use them. But these ones are simple because you just observe and record what you have observed-1MMNII.
 10. The former indicators were not easy; I was unable to use them as compared to these ones- 17MMII;
 11. One could hardly understand that framework of knowledge; this one is clear- 22MMFG.
 - B: Feedback from the indicator testing exercise
 12. We tested all indicators and recorded the required information as seen in this sheet. We did not face any difficulties. Every member participated effectively in the exercise-leader group A.

13. We went to the eastern part of the forest and read through the indicators before testing. The indicators are easy than those in the old framework. We recorded the required information in the sheet-leader group B.
14. We successfully tested the indicators though there were some signs of high tide, we did not finish all the indicators but what we did was successful, there was no problem-leader group C.
15. As we were testing the new indicators, we found them to be simple and easier than the old ones. They are straight forward and can be done in a very short time. All group members played a role in the testing- 5MMNFG.
16. We found out that it is not easier to measure all levels of plant growth by 'pima'. One 'pima' is reached when you stretch both hands. Half 'pima' is one hand. You know that mangroves grow very gradual; sometimes to an inch level. We need to bring-in the 'metre' to help in catching different levels of length, up to at least a centimetre level-5MMNFG.

Appendix 15: Blank consent form (English)

Consent Form for participating in the study that seeks to understand processes of abstraction, conceptualisation and representation of Traditional Ecological Knowledge (TEK) and their potential contribution to the development of coastal management indicators that are less reified and more contextually and culturally congruent.

Please tick the appropriate boxes

Yes No

Taking Part

I have clearly understood the purpose of the study. ☐ ☐

I have been given the opportunity to ask questions about the study. ☐ ☐

I agree to take part in the study. Taking part in the study will include being interviewed, recorded (audio or video), and taking of still photos. ☐ ☐

I understand that my taking part is voluntary; I can withdraw from the study at any time and I do not have to give any reasons for why I no longer want to take part. ☐ ☐

Use of the information I provide for this project only

I understand my personal details such as phone number and address will not be revealed to people outside the study project. ☐ ☐

I understand that my words may be quoted in publications, reports, web pages, and other research outputs. ☐ ☐

*Please choose **one** of the following two options:*

I would like my real name used in the above ☐

I would **not** like my real name to be used in the above. ☐

Use of the information I provide beyond this project

I agree for the data I provide to be archived by Rhodes University, University of Dar es Salaam, and any other institutions that may be willing to use the study findings for purposes of learning and community development. ☐ ☐

I understand that other genuine researchers will have access to this data only if they agree to preserve the confidentiality of the information as requested in this form. ☐ ☐

I understand that other genuine researchers may use my words in publications, reports, web pages, and other research outputs, only if they agree to preserve the confidentiality of the information as requested in this form. ☐ ☐

So we can use the information you provide legally

I agree to assign the copyright I hold in any materials related to this study to [Daniel Sabai]

☐☐

Name of participant [printed] Signature _____
Date

Researcher [printed] Signature _____
Date

Project contact details for further information: Names, phone, email and addresses.

Appendix 16: Filled-in- consent form (Swahili)

FGD

Fomu ya kuridhia kushiriki katika utafiti unaolenga kupata ufahamu wa asili kuhusu mikoko na samaki wanaoitumia kama mazalia, makuzi na makazi. Utafiti huu utasaidia kuandaa viashiria vya kutambua mikoko yenye afya nzuri na iliyoathirika.

Tafadhali weka tiki katika kiboma husika: 'ND' ina simama badala ya Ndiyo na 'HA' badala ya Hapana. ND HA

Kushiriki katika zoezi

Nimeelewa vema madhumuni ya utafiti husika. ☒ ☐

Nimepewa nafasi kuuliza maswali kuhusu utafiti husika. ☒ ☐

Nakubali kushiriki katika utafiti uliotajwa hapo juu. Wakati wa kushiriki katika utafiti, natambua kuwa uwekaji wa kumbukumbu mfano picha za video na mnato utahitajika. ☒ ☐

Nimekubali kushiriki katika zoezi hili kwa hiari yangu; ninaweza kujitoa katika utafiti huu wakati wowote ule nitakapoamua kufanya hivyo bila kulazimika kutoa sababu au maelezo. ☒ ☐

Anuani, simu, na vielelezo binafsi

Ninaelewa kuwa vielelezo binafsi kama vile simu, anuani nk havita tolewa kwa watu wasiohusika na utafiti huu. ☒ ☐

Ninaridhia kuwa maelezo nitakayoyatoa wakati wa utafiti yanaweza kuandikwa katika vijarida, ripoti mtandao au kuchapishwa bila tatizo. ☒ ☐

Tafadhali chagua moja kati ya haya yafuatayo:

Jina langu halisi litumike katika utafiti huu. ☒ ☐
Litumike jina mbadala (la uwakilishi tu). ☐

Kutumia taarifa nilizozitoa nje ya Mkinga

Ninaridhia kuwa taarifa nitakazozitoa kuhusu mikoko zinaweza kusomwa na kuhifadhiwa na taasisi nyingine kama vile Chuokikuu cha Dar es salaam, Chuokikuu cha Rhodes, na vyuo vingine vinavyojihusisha na masuala ya maendeleo ya fukwe au maeneo yanayohusiana. ☒ ☐

Natambua kuwa taasisi zinazojihusisha na tafiti zinaweza kutumia maelezo ya utafiti huu iwapo zitazingatia masharti binafsi niliyoyapendekeza hapo juu. ☒ ☐

Natambua kuwa yeyote atakaye taka kutumia maelezo niliyoyatoa katika majarida, ripoti, mtandao nk atazingatia masharti niliyoyatoa hapo awali (juu). ☒ ☐

Naridhia kuwa maelezo nitakayoyatoa wakati wa utafiti yatafanikisha mkakati wa kuandaa rasimu ya viashiria vitakavyo saidia kutambua afya ya mikoko, na natambua kuwa mhusika mkuu na mwandishi wa ripoti katika zoezi hilo atakuwa ndugu Daniel Sabai ☒ ☐

MAKATA MASAMBO 13/1/2012
Jina la anayeshiriki [herufi kubwa] Sahihi (juu) Tarehe
DANIEL SABAI 13/01/2012
Mtafiti [herufi kubwa] Sahihi Tarehe

Taarifa zaidi kwa ajili ya mawasiliano:

1. Kijiji/Kata/Mtaa MQA
2. Simu 0765 060800

Appendix 17: Signed participants' registration sheet; mangrove FGD-Moa

Orodha ya Mahudhuro ya FGD Group Discussion
13/01/2012 eneo la Moa - Mikoko

Jina la mshiriki	anaketoke	Saliti
1. RAMBAZO ABD MOHA	MOA	
2. SHEHA HASI FAKI	KISIRU	
3. REHEMA OMARI	MOA	
4. HASINA MASSA	MOA	
5. SAANA SULEIMAN	KISIRU	
6. MARIAMA ABASI	MOA	
7. AMBASSA GUNDA	MOA	
8. MAKATA MASHAMBO	MOA	
9. JUMA KHAMIS	MOA	
10. MBWANA NGANZI	MOA	
11. ZHARIK. M. OMARI	MOA	Z.M. OMARI
12. Rehema Juma	Kijini	
13. Fatuma Kamba	Kijini	

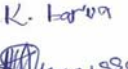
Appendix 18: Signed participants' registration sheet; fishers' FGD-Moa

MATHUBURIO FGD - FISHERS			
<u>Jina</u>		<u>Unakotoka</u>	<u>Sahili</u>
1. Halfani Mbaraka		Moa	
2. Dole Faki		Kijini	✓
3. Ali Hamdu		Boma - Subuku	✓
4. Abdala Kitapa		Kijini	✓
5. Juma Hamis		Moa	✓
6. Hamza Ali		Kijini	✓
7. Nyundo Shime		Boma Mkimbani	✓
8. Bakari Kitaps		Kijini	✓
9. Seudey Rashidi		Kich/Miba	✓
10. Mkidadi Kidumbo	- Moa		✓
11. Mabuki Rajabu	- Moa		✓
12.			
13			

Appendix 19: Signed participants' registration sheet; mangrove –Boma:

MAHUDHURIO YA KIKAO CHA 'FGD' ENEO LA BOMA.

TAREHE YA MAHUDHURIO - 16/01/2012 - Mikoko.

<u>Jina la mshiriki</u>	<u>Anakotoka</u>	<u>Sahihi.</u>
1. FOLEMI MAFANGA	BOMA KICHAKAMIBA	
2. HASANI SIYA	BOMA KICHAKAMIBA	
3. MAFANGA MBARUKU	BOMA KICHAKAMIBA	- M.M. 
4. KIJOLI BARUA	BOMA KICHAKAMIBA	K. Lora 
5. KIPITU MUSSA	BOMA KICHAKAMIBA	
6. MWADONGBA SADI	BOMA - SUBUTUNI	
7. MOHAMEDI IADI	BOMA SUBUTUNI	
8. HASSANI IBRAHIMU, K.	BOMA SUBUTUNI	
9. NYUNDO O. SHIME	B/KICHAKAMIBA	

Appendix 20: Indicator testing sheet: Group A.

KUNDA 'A'

Date 18/9/2012 No.

VIASHIRIA.

1. UDONGO UKO KWENYE HALI NZURI
UREFU WA MTI UMEENG'EZEKA HADIFI-15
RANGI YA MAJANI NI KIJANI
2. MIZIZI IMEENDA CHINI
HAIKUFUKULIWA
3. VICHIPUKIZI VIPO
4. MATAWI YAMENAWIRIKA VIZURI
5. MASHINA YAMESTAWI NA KUENG'EZEKA
WENE
6. WADUDU WAHARIBIFY-WAPO-TONDO KONO²
7. MAMBO YA HATARI YAPO
UKATAJI MITI HOLELA KWA MATUMIZI
8. MINEA VAMIZI - IPO KWA WINGI
9. KOKO LIMEFUGA VIZURI

Appendix 21: Indicator testing sheet: Group B.

18/9/2012 Date No.

KIKUNDI (B)

WASHIRIKI:- NYUNDO SHIME
MAFANYA MBARUKU
MWANINGU RASHIDI
FATUMA KAMBA
ASINA MASA

ENED TULIKO CHAGUA LIMETIGAWA
SEHEMU 2. - UPANDE WA JUU NA
UPANDE WA CHINI.

VIASHIRIA:

1. UDONGO - UPANDE WA JUU UDONGO
WAKE SI MIZURI LAHNI UPANDE WA CHINI
UDONGO WAKE NI MIZURI
- MITI YA UPANDE WA JUU SI
MIZURI IMEDHOFU
- MITI YA UPANDE WA CHINI NI
MIZURI

(1)

Appendix 22: Indicator testing sheet: Group C (i).

KUNDI C (i)

Date 18/09/2012 No.

MIZIZI:

- MIZIZI YA UPANDE WA CHINI
IMEZAMA KWENYE UDDONGO VIZURI

VISISI - KWENYE ENEO LA CHINI
UNA VISISI VINGI KUASHIRIA UIMARA
WA MITI.

NATAWI: NI MAZURI YANACHIPUKIA
VIZURI BAADA YA KUKATWA KWA
MATUMIZI MBALI MBALI.

MASHINA: KWA ILE MITI ILIYOKATWA
NAMYESHESHA KWA MASHINA JAKE
JALIKUWA IMARA.

WABUDE: KWENYE ENEO HILI
WAPANA WADGDU WATHARIBFU.

UKATAJI: KUMEFANYIKA UKATAJI
MWDNGI WA MATARUMA HUSASAN
KWA MITI ANA YA MIPYA

(i)

Appendix 23: Indicator testing sheet: Group C (ii).

SHEHA (KUMAC) (ii)

Date 18-09-12 No. E (ii)

1. UDOLO

UDOLO WA ENED HILI NI NZURI KWA MPYA ISIPOKUA
KWA MIKOKO SID ENED ZURI.

a) UREFU WA MPYA KUONYE, ENED HILI NI NZURI LAHA
b) RANWI YA MAGANI NI LAHI (NZURI) (KISANI)

(2) MIZIZI - MIZIZI JAKE YOTE INAHALINZURI

3. VICHIPUKIZI - HAMINA

4. MWAWI - YAMEPINDA NA MENTINE JAMENYA
KA.

5. SHINSA - YAMEKATWA, NA LINA MABUU

6. WADUWI WA HARIBIFU. WAPO (MAPANJA).

7. UKATAJI WA MITI, MOTO WA TAKATAKA
(UKATAJI WA MITI UPD)

8. MIMBA VAMIZI - IPO KWA WIPU.

9. KOKOLIMEFURU? - ENED DOLO LIMEFURU NA
ENED LIKOWAZI!

Appendix 24: List of participants who took part in the indicator testing exercise:

WALIOSHIRIKI KUPIMA ATHARI ZA MIKOKO HATUA YA MAJARIBIO YA VIASHIRIA VIPYA.		
Date 18/09/2012		No.
MAHUDHURIO: JINA	MAKAZI	SAHITI
1. Juma KHAMIS	MOA	J. Khamis
2. ZITAKILI M. OMARI	MOA	Z. M. OMARI
3. MAFA NYA MBARUKU	BOMA	M. MBARUKU
4. AKIDA Saidi Kufu	MOA	A. Kufu
5. Nchimbi Emicko	ZMO-TANGA-SINDERO	N. Emicko
6. NYUNDO OMARI SHIME	BOMA	N. Shime
7. DONALD M. MNYAGI	ZMO-TANGA	D. M. MNYAGI
8. REHEMA OMARI	MOA	R. OMARI
9. HASINA MASSA	MOA	H. MASSA
10. SHEHA HAJI	KISIRU-NDUMBANI	S. HAJI
11. HAMZA ALI	II - II	H. ALI
12. MWAWINGU RASHID	MOA	M. RASHID
13. AMBASA GUNDA	MOA	A. GUNDA
14. REHEMA J. ALI	NDUMBANI	R. ALI
15. FATUMA KAMBA	II II	F. KAMBA
16. SADA SULEIMAN		S. SULEIMAN
17.		

Appendix 25: Scientific methodologies and techniques for monitoring mangroves based on English et.al 1994 (source KIMP, 2005, p. 10)

2.21. Mangroves

The Transect Line Permanent Plots Method (English *et al.*, 1994) will be used to assess mangroves and the quadrat method will be used for benthic epi-macrofauna.

In the first method, plots (each 5 x 5 m) will be taken randomly along transects perpendicular to vegetation types and will be marked so that they can be re-examined every monitoring session. GPS readings of each plot will also be recorded.

Within each plot, all mangroves will be identified to species level (using Kiswahili names known to the villagers) and counted according to three maturity categories: seedling (< 1 m in height), sapling (height > 1 m, girth < 4 cm) and tree (girth > 4 cm). The girth at breast height (GBH, standardized at 1.3 m above ground) will be recorded for all trees and saplings. Stumps will also be counted and the girth of each at 15 cm above ground will be measured, as an indication of cutting pressure. In most cases, the species of the stumps can also be discerned. Data on mangrove vegetation will be recorded using the data sheet shown in Appendix C.5.

The GBH measurements will be used to calculate basal area of mangroves, which is one of the best measures of mangrove abundance and is generally proportional to canopy cover. It is also one of the best indicators of ecosystem health and maturity. Moreover, when calculated by species, basal area indicates the importance or dominance of each species in a given site. Notes will be taken on the occurrence of die-backs, recording the number of mangrove trees, saplings and seedlings affected and the possible causes if determined.

To assess benthic epi-macrofauna, within each permanent mangrove plot, quadrats (each 0.25 x 0.25 m), will be placed in 4 random locations on the substratum. However, before placing the quadrats, crabs were counted at some distance, in an estimated quadrat area. After placing the quadrat, other organisms will be counted within the quadrat according to Kiswahili names known by the villagers. The number of holes of crabs and tubes of polychaetes, etc. will also be counted per quadrat. Data on macrofauna will be recorded using the data sheet shown in Appendix C.6.

On-going threats to mangrove forests will be recorded using the data sheet shown in Appendix C.7.

Appendix 26: Scientific methodologies and techniques for monitoring mangroves based on English et.al 1997 (source: WIOMSA-see list of acronyms)

Monitored attributes and methods:

Community Structure and Biomass:

The Transect Line Plot (TLP) is the basic approach and involves at least three transect lines perpendicular to the shore, in two sites at each location. Along each transect, three randomly located plots (usually 10 x 10m) are staked out, and their positions recorded with GPS. The species, position, height (using a tool called a hypsometer) and girth of each tree (including stumps) in each plot are recorded and the trees are tagged. This takes time, but need only be repeated every 2-3 years. A simpler method, that can involve local communities, uses a greater number of 5 x 5m plots over a wider area, recording samples of trees in each plot.

Primary Productivity:

Leaf area is correlated with total photosynthesis and thus primary productivity and mangrove 'health'. The 'leaf area index' is measured using a portable light meter with an underwater quantum sensor (for protection from corrosion) and a clinometer to measure solar zenith angle. The method is quick and reliable.

Leaf litter production:

This is sensitive to many environmental factors, and can be measured using suspended net traps to catch falling leaves that are dried and weighed.

Soil characteristics:

The productivity and structure of forests are influenced by the soil. Monitoring soil changes requires collecting 5-10 samples from each location with a D-section corer, and measuring: Redox potential (Eh) (extent to which soils are conducive to microbial decomposition and thus nutrient production) and acidity/alkalinity (pH) (influences chemical transformation of nutrients), with a pH/Milli-voltmeter, preferably on site. Soil salinity (determines growth and zonation) with a refractometer. Temperature at a depth of 10 cm. Grain size (proportions of gravel, sand and mud determine soil permeability) using the time consuming particle size fractionation method or the simpler hydrometer method.

Area coverage:

Aerial or satellite images (e.g. LANDSAT MSS, SPOT-XS) can be useful for monitoring changes, but ground-truthing using TLP methods, is essential to determine mangrove health and other information needed for management (see case study)

