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ENHANCING COMMUNITY STEWARDSHIP TOWARDS AQUATIC ECOSYSTEM HEALTH IN GHANA: (A CASE STUDY OF ADA COASTAL ENVIRONMENT)

BY

LLOYD LARBI

(ID.NO. 10105362)

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DECLARATION

With respect to other people's works, which have been duly acknowledged, this thesis is the result of research work undertaken by **Lloyd Larbi** of the Institute for Environment and Sanitation Studies, University of Ghana under supervision; and that no part of it has been presented for another degree elsewhere.

Signed..

Date.......17/10/2018...................

Lloyd Larbi

(PhD Candidate)

Signed..

Date......17/10/2018.................

Prof. Kwasi Appeaning Addo

(Principal Supervisor)

Signed...............................

Date.....10/10/2018.......................

Dr Adelina Mensah

(Co Supervisor)

Signed.............................

Date.......12/10/2018..................

Dr Daniel Nukpezah

(Co Supervisor)

Sign.......................................

Date 5/10/18

Prof. Dr. Ingo Mose

(Co Supervisor)

CARL VON OSSIETZKY universität OLDENBURG
FAKULTÄT V Institut für Biologie- und Umweltwissenschaften
AG Angewandte Geographie und Umweltplanung
Prof. Dr. Ingo Mose

ABSTRACT

Coastal zones are considered as one of the productive zones of the world. With diverse ecosystems, they provide humankind with immense ecological services. However, coastal aquatic ecosystems have been increasingly threatened as a result of population growth and increasing rate of economic development. To address this issue, there is the need to reshape attitude and practices in the current rate of development, for the mutual benefit of aquatic ecosystems and human societies. This study evaluated the ecological health of the aquatic ecosystems in the coastal area of Ada in Ghana and designed a non-formal educational model to enhance community stewardship. Participatory methods (including household questionnaire, focus group discussions and key informant interviews) described the activities of community members and their perception of the impacts on the aquatic ecosystems. Results from an ecological survey revealed that landuse is poor in over 70% of the sampled aquatic ecosystems. The levels of phosphate (1.29mg/l) and nitrate (2.73mg/l) are comparatively higher than the natural background levels of 0.02mg/l and 0.23mg/l for phosphate and nitrate respectively. The high levels of phosphate and nitrate could be detrimental to plant and animal life. Population and economic pressure was identified as the major issue of aquatic ecosystems. Based on various educational concepts and series of local consultations, an ecosystem stewardship educational model for the local communities is proposed. The model integrates three essential dimensions; knowledge of the local environment, developing skills through practical strategies and promoting sustainable values. Application guidelines are also developed focusing on the non-formal sector of society. The practice of ecosystem stewardship was exemplified in the coastal communities of the study area to demonstrate the application of the educational model and its guidelines.

DEDICATION

I dedicate this research to my father Mr. Edward Larbi, because of his tireless effort in always wanting to see me become the best I can be. He encouraged and supported me through it all.

To my siblings - Leslie, Harry, Miriam and Laurel. You have made me a better person because of your support, love and sacrifices.

"The Lord God took the man and put him in the Garden of Eden to work it and keep it ". – Genesis 2:15

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LIST OF ABBREVIATIONS

AEDA	Ada East District Assembly
AEE	Association of Experiential Education
BOD	Biological Oxygen Demand
CBOs	Community Based Organisations
CERSGIS	Centre for Remote Sensing and Geographic Information Services
COD	Chemical Oxygen Demand
D/A	District Assembly
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
FBOs	Faith Based Organisations
GSS	Ghana Statistical Service
ICZM	Integrated Coastal Zone Management
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
MEA	Millennium Ecosystem Assessment
NCCF	North Carolina Coastal Federation
NGOs	Non-Governmental Organisations
PCB	Polychlorinated Biphenyl
PEB	Pro Environmental Behaviour
R/C	Roman Catholic
ESEM	Ecosystem Stewardship Educational Model
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organisation
VBN	Value-Belief-Norm
WHO	World Health Organisation
WQI	Water Quality Index

CHAPTER ONE

INTRODUCTION

1.0 Introduction to chapter

The first chapter gives a background to the study. It discusses the global environmental change and highlights the need for stewardship in the management of aquatic ecosystems. The study objectives and justification are presented following the problem definition. Limitations and the organisation of the study are provided lastly.

1.1 Background of the Study

1.1.1 Global environmental change, aquatic ecosystems and stewardship

The earth is undergoing rapid environmental changes which are posing major threats to aquatic ecosystems (Sih et al., 2011; Tilman & Lehman, 2001). Lakes and ponds over the years in many parts of the world are reported to be drying (Malhi et al., 2008). Rivers and streams are in danger of drying out as a result of decline in precipitation (Barlow & Clarke, 2017; Poff et al., 2002). Increases in water temperatures due to global warming are expected to alter important ecological activities and the geographic distribution of aquatic species. Studies by Trucco et al. (2012) also highlights that climate change is likely to further burden freshwater and coastal aquatic systems. Medlock et al. (2012) and Dale et al. (2001) report of changes in seasonal patterns of precipitation and runoffs. These changes are influencing hydrologic characteristics of aquatic systems, affecting species composition and ecosystem efficiency. According to the Intergovernmental Panel on Climate Change (IPCC, 2014), future emission scenario SRES A2, more than half of the permafrost would have been melted by the year 2100 (Lawrence et al., 2012; Stendel & Christensen, 2002). Aquatic ecosystems are likely to be affected, because these systems are sturdily influenced by snowmelt and warming. Inundation of coastal zones due to sea level rise threatens the biological components of the ecosystems (Appeaning Addo et al., 2011). Dawson et al. (2011) emphasize that climate change is predicted to become a major threat to biodiversity in the 21st century and effective solutions have proved difficult to devise.

The economic driven activities of humans have been recognised as the driving factors of rapid ecosystem change all over the world. Scientific researchers have described the trend of human use of natural resources as exploitative, unsustainable and the rate continues to increase over the years (Chapin et al., 2010; Tilman and Lehman, 2001; Vitousek et al., 1997). Close to half of land surface has been transformed by human action (Mikkelsen and Langhelle, 2008). Since the beginning of the Industrial Revolution, carbon dioxide concentration has increased by 30 percent in the atmosphere. Humans have also fixed more atmospheric nitrogen than the combined effect from other sources (Jones, 2014). Humans have overexploited more than half of all accessible surface freshwaters in the world. Several activities of humans in the past have caused the extinction of many important species around the globe. For example, about one-quarter of the bird species on Earth have been driven to extinction (Mooney et al., 2009; Vitousek et al., 1997). Macbeth and Topiltzin (2014) highlight the extinction of 200 rare species of Cichlid fishes after the introduction of Nile perch intentionally into the Lake Victoria in eastern Africa. Atlantic whales and walrus have become endangered as a result of over exploitation by whalers on the Atlantic Ocean (Romeo et al., 2015; Bockstoce and Burns, 1993). Igben and Ohiembor (2015) reported that current unsustainable developments and lumbering activities are taking over the freshwater swamp forest in many parts of Nigeria. In Ghana, unsustainable activities of small-scale gold miners have polluted major sources of water rendering several aquatic ecosystems lifeless (Kessey & Arko, 2013). The polluted water is also a threat to human health as community inhabitants rely on these water sources for their household activities. Vitousek et al. (1997) show a conceptual model which illustrates how humans directly and indirectly impacts on the earth system (Appendix A1).

Ecological change has an influence on the culture of the people associated with the ecosystems. According to Chapin and Knapp (2015), humans have long been co-adapting with their ecosystems, with similarities between human cultural distributions over the globe and the types of ecosystems found in those regions. Studies on the current global change, for example the Millennium Ecosystem Assessment report highlight the inclusion of people as part of the ecosystems because human action could influence ecosystems negatively or in a positive manner (MEA, 2005). The rapid global change has been described as a phenomenon which has been fronted by human actions and in order to live through time there is the need for humans to begin thinking about the ways to co-adapt with the current rate of change and also adopt interventions to arrest adverse changes. Ecosystem services support the well-being of humans and the positive response by humans to keep the ecosystems in good structure and functioning will provide a wealth of benefits to both humankind and nature.

The 21st century has embraced the concept of sustainability as the solution to absolving the world of its environmental and economic crises (Mensah & Castro, 2004). Under this concept, people have been described as part of the socio-ecological system (Appendix A2 shows the role of humans in the socio-ecological system). Human actions together with other biotic and abiotic factors in a sustainable manner have been regarded as complex integrated networks which make the earth liveable. In recent times, perhaps in the advent of the industrial age, the trend of exploitation of natural resource by humans has been considered unprecedented leading to diverse forms of pollution. The rate of exploitation could lead to an unsustainable world. In other words, if the present rate of human impacts on the environment continues it has been predicted by environmental models that the natural thresholds in which biotic and abiotic systems structure and function will break down (Renaud et al., 2013) and the resilience of the earth could not be restored any longer. For example, the Commonwealth Scientific and Industrial Research Organization General Circulation Models (CSIRO)_MK2_GS GCM projects significant impacts on biotic factors especially in the tropics by the year 2100 as a result of sea level rise (Appeaning et al., 2011). The rate at which humans are exploiting the resources in ecosystems calls for a sense of responsibility on the part of the individual.

Current methods of regulations, policies and laws aimed at resource management, play a vital role in governance. However, the impact continues to lessen which is partly attributed to the rising human population and the need to provide and meet everyone's satisfaction. In this system of competitive environment, there has been the urgent need to raise awareness of stewardship which will drive the individual's beliefs, values, action skills, behaviours and intentions to act in a positive manner towards the ecosystems. Ecosystem stewardship refers to actively shaping of pathways of social and ecological change for the benefit of ecosystems and society (Chapin et al., 2015). As the governing structures continue to play their role, stewardship will set the bottom-up approach to re-shape the attitude and actions of individual to build healthy and resilient ecosystems for humankind.

It has been suggested by the United Nations Conference on Environment and Development (UNCED) that, implementation of ``sustainable development" should be based on local-level solutions derived from community initiatives (Leach et al., 1999). There are significant opportunities if the stewardship framework and actions are taken now for future management of natural resources (Diaz et al., 2006). In a more localized setting as an example, Diaz et al. (2006) reports that the aboriginal people living in the coastal area of Nunavut in Canada benefitted from developing iron ore and also ensure that mitigation requirements are met to reduce harm to the environment. The communities collect tax on revenues of the extraction and have negotiated an impacts-and-benefits agreement with local inhabitants concerning employment, education and a Community Development Fund.

1.1.2 Education in Integrated Coastal Zone Management (ICZM)

The coastal zone is the geomorphologic area on either side of the seashore. The interaction between the marine and land parts occur in the form of complex ecological and resource systems made up of biotic and abiotic components coexisting and interacting with human communities and relevant socio-economic activities (Gambino et al., 2016; Rochette, 2010). Aquatic ecosystems are vital components of the coastal environment. In addition to being essential providers to biodiversity and ecological productivity, they also provide a variety of services for human populations. Examples include water for domestic use and for irrigation purposes, recreational opportunities and habitat for economically important fisheries (Poff, 2002). Many aquatic ecosystems in the coastal areas of the world have been impacted by human actions (Gedan et al., 2009; Vitousek, 1997). This may be through sewage pollution of the coastal water and environments, contamination from oil spills and production leakages, pollution from mining and industrial activities and solid waste contamination.

In many parts of the world, the concept of ICZM has been acknowledged as a central concept in the management of coastal zones and the marine environments (Portman et al., 2012).

This management approach includes initiatives and interventions that promote environmentally sustainable development of coastal areas. It acknowledges the interrelationships that exist among coastal or ocean uses and their potential impacts on the natural environments. It overcomes the fragmentation inherent in the sectoral management approach (Cicin-Sain et al., 2000). ICZM maximizes the benefits provided by the coastal zone and minimizes the conflicts and detrimental effects of activities on social, cultural and environmental resources (Linden and Lundin, 1996).

Education in ICZM has been recognized as an important avenue for improving coastal zones (Garriga, 2010). Education cuts across almost all issues whenever there is the need to solve problems in the coastal areas. Whether it is an issue of fisheries, development, tourism, waste management, spillage, conservation of resources in the coastal area, one major solution is the need to educate people to improve conditions. Education is essential because people get to understand the limits of the resources that are being affected and in the long-term changes behaviour to do the right thing. The issue about coastal education is the kind of educational material being projected to make an impact in the different communities we have (Schmidt, 2008).

Studies by Galli et al., (2014) and Steffen et al. (2015) indicated that awareness should be promoted to sensitise humans to recognize the need and be involved to maintain ecosystems integrity. The action of involving people to act in a responsible manner towards the ecosystems has the potential to maximise the services derived by both nature and society. The approach to keep these two components in a mutual relationship is to promote and enhance the concept of stewardship in current times in the process of natural resources management.

1.2 Problem Definition

Aquatic ecosystems in the coastal zone have been severely impacted as a result of the intense human activities. These natural sites are highly productive but rapid population growth and developmental activities continue to degrade the quality of these ecosystems. The eastern coast of Ghana is described as an economic, ecological and residential area. The coast provides a source of living to many people living in the area. Typical among them are fishers and farmers (Ada East District Report, 2013). The coastal zone is endowed with different kinds of aquatic ecosystems providing several habitats to diverse species of flora and fauna. Mangrove vegetation span the banks of rivers, streams and in the beach providing ecological services to humans and also serving as home to many wildlife including marine turtles, birds, crocodiles and monkeys.

It has been reported in both local and international media that the eastern coast of Ghana is undergoing significant changes due to human actions. For example, Deutsche Welle TV EcoAfrica series (15.10.2016) reports the degrading ecosystems in the eastern coast of Ghana. These coastal aquatic ecosystems are at risk to succumbing to adverse effects of increasing demands of a growing population. According to the Ada East District report (2013), garbage, typically plastic is piling up at the beach. It is disposed indiscriminately and others are washed up from the sea by the tide. Watershed zones are undergoing rapid changes due to land use and landcover changes. Commercial and residential developments are replacing once forested areas and other natural habitats. Inhabitants in the coastal communities defecate along the beaches making the coast unpleasant (Ada East District Report, 2013). Water pollution, sea level rise and habitat degradation threaten the resources and attributes of the aquatic ecosystems.

Raising community awareness of coastal ecosystems conservation has been by simplified educational messages with no structured model for the non-formal approach. Sensitisation programmes have always focused on the small community groups which do not create the intended purposes, which is to appreciate the need to conserve the natural environment. Coastal education should therefore be holistic (Kannen, 2004), involving community members and the local authorities who make policies and decisions. It must also be structured according to the indigenous ecosystems found in the local environment (Mensah and Amoah, 2013).

1.3 Objective of the Study

The primary objective of this project is to evaluate the ecological health of the aquatic ecosystems in the coastal area of Ada in the eastern coast of Ghana and design a non-formal educational model. This will identify appropriate behaviour to protect and maintain the qualities of the coastal environments through sustainable practices by the community members. The study will provide information for managing the coastal zone and also strengthen stewardship of community members along the Ada Coastal area in Ghana.

The specific objectives are:

1. Investigate issues and local knowledge pertaining to the coastal aquatic ecosystems.
2. Assess the health of aquatic ecosystems and the community structure.
3. Design and test an ecological educational model to strengthen community stewardship.

1.4 Justification of the Study

Effective coastal zone management requires an informed community with understanding of the implication of their actions. Effective education programmes are critical to fostering action and change for improving coastal management (Wortman et al., 2006). In most coastal areas in Ghana, especially in the Ada coastal area, environmental education programmes have targeted basic and secondary students. However, important members like community inhabitants and different business or socio-economic groups, for example are being missed or inadequately reached. There is the need for further research in the area of knowing how to engage these audiences and how to adapt traditional strategies to diverse communities and cultures. An extensive perspective on environmental education is provided by Siemer (2001) which reveals that much more research is needed to understand the effectiveness of various educational strategies. Zint (2013) informs that although there is much knowledge about promoting change in environmental knowledge, skills, attitudes, behaviours, and other factors, this knowledge has not necessarily been applied to aquatic stewardship education.

A number of local government and non-government organisations have developed coastal management education programmes targeting a range of stakeholders within the Ada coastal area in Ghana. However, most of these programmes do not have the requisite framework for sustainability and lack the indigenous knowledge of the local environment. Whilst these programmes may be successful in reaching their target groups, the question is: How effective are these programmes in strengthening stewardship of community members towards improving aquatic ecosystems health and sustainable management of the coast?

This project aims to address this question through a situational analysis of aquatic ecosystems and current coastal management education within the Ada coastal area in the eastern coast of Ghana. It will improve the effectiveness of coastal management education by creating an educational model with a focus on sustainability and knowledge of the indigenous environment.

The research is important in contributing to coastal environmental education. The study stimulates and complements scientific research on effective ways to promote sustainability education especially in the coastal areas of Ghana. It offers a better understanding of the values and threats of the aquatic ecosystems to community members and all stakeholders for an informed decision-making process. The study provides information on the current health status of the aquatic ecosystems in the Ada coastal area. Data from the study could be depended upon for effective decision making in coastal ecosystems management in Ada. An educational model is designed which could be used to strengthen communities' stewardship of aquatic ecosystems. This educational resource will assist educators, environmental NGOs and individuals who wish to promote the conservation of the coastal ecosystems through education.

1.5 Limitation of the Study

The limitations of this study include:

a) Geographical expanse, inadequate financial resources and time constraints reduced the chances of contacting more respondents for the key informant survey.

b) The study also involved the perception of residents on the knowledge, attitude and practice in relation to the prevention of aquatic ecosystem degradation. Data was collected from individuals who are self-reporting their perceptions. It is therefore likely that respondents will try to please the researcher.

These limitations were mitigated through purposive sample selection, pretesting and careful scrutiny of the parameters of measurement.

1.6 Organisation of the Study

The study is structured into six main chapters. The first chapter introduced the study in terms of its rationale, the problem definition, research objectives, justification, limitations of the study and how the thesis is organised. Chapter Two reviews both conceptual and theoretical literature related to ecosystem stewardship and environmental education, coastal ecosystems, ecosystem health, coastal management and stewardship approach. In Chapter Three, the methodology employed in the study is discussed. It describes the study area and sampling locations. The target population, the research instrument and data collection procedures are outlined. Chapter Four presents the results of the study which are presented in three sections (issues pertaining to the aquatic ecosystems, aquatic ecosystem health and ESEM and application). Chapter Five discusses the results of the study. The conclusions drawn from the study results and recommendations based on the conclusions are presented in Chapter Six.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

In this chapter, literature related to the study was reviewed in four main sections. The first describes the concepts of the major components of the study. This includes ecosystem stewardship and environmental education. The second section reviews related works to coastal ecosystems from global to local perspective. The third reviews relevant literature which is in connection to the influence of biotic and abiotic components of ecosystem health. The chapter concludes with a review of approaches in coastal management and ecosystem stewardship proposed by various authors.

2.1 Ecosystem Stewardship and Environmental Education

2.1.1 The Concept of Ecosystem Stewardship

The word stewardship calls attention to the concept of "guarding" in natural resource management and the terminology dates from the 15th century (Berkes, 2008). It is an ethic which is deeply rooted in philosophical and religious traditions of many cultures, including both western society and indigenous people (Berkes, 2008). The concept acknowledges that people are members of nature's household and therefore must bear the responsibility for its care (Chapin et al., 2015). It recognizes the interdependence and linkages between people and nature.

The current concept of ecosystem stewardship has been described by Chapin et al. (2015) as actively shaping of pathways of social and ecological change for the benefit of ecosystems and society. Chapin et al. (2009) highlights three key features of stewardship. These are active interventions, shaping change and a system of people as part of nature. Active interventions have been explained as taking measures to control challenges posed by the current global environmental change. This may include policies that could be used to control pollution in the environment or arrest the challenge of unsustainable harvesting of resources from the ecosystems. These interventions may also include eliminating or reducing products and services which have adverse impact on the environment to keep ecosystems healthy. Measures may also be put in place to control patronization of unsustainable product or avoided right from the inception before they become very difficult to abolish from society.

Shaping change involves society adapting to trends which may be regarded as uncontrollable. For example, warming global temperature is predicted to continue rising in the 21st century even if current emission of greenhouse gases is halted (IPCC, 2001). Therefore, the challenge is to find adaptation strategies to contain the unpreventable changes. Escalating trends of natural hazards need to be managed in ways to reduce the risk of disaster.

The last feature describes a system of people as part of nature with a dual goal effect for both ecosystems and societal well-being. In this regard, humans are not separated from the ecosystems around them but are seen to be components of the system and both are managed together for their mutual gain. Figure 1 below shows the concept which emphasizes on the interdependence of people and nature in a holistic perspective. According to Chapin et al. (2010) this concept is described in the social-ecological system where the interactions between human actions and the ecosystems influence each other. Recognizing these interlinkages and their interdependencies call for the sense of respect for nature on the side of the humans, to ensure that proper measures are taken to preserve ecosystems as the well-being of humankind depends on critical services provided by the various processes in the ecosystems.

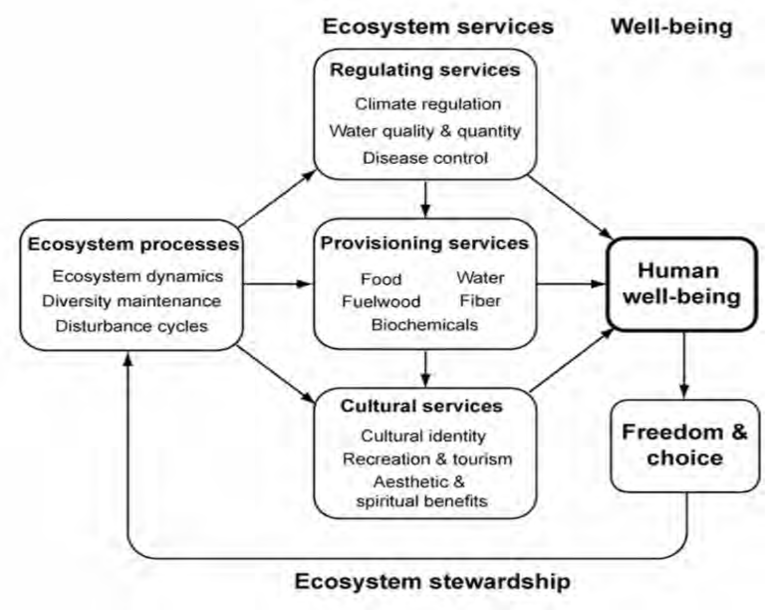

Figure 1: Ecosystem stewardship approach (Source: Chapin et al., 2009)

A co-adaptation relationship existing between humans and the ecosystems respect the socio-cultural integrity of society. Different societies around the world have co-evolved with different ecoregions of the world (Chapin et al., 2010). Therefore, conservation measures that drive society from interacting with their ecosystem, especially obtaining the services provided by ecosystems could be described as a separation of humans from nature which deprives both components of maximizing the dynamic interactions for a full biotic potential. This approach of natural resources management is however, regarded not the best.

The stewardship approach is an environmentally responsible behaviour that involves an interactive relationship between human beings and their dynamic environment. Azizan and Nabsiah (2012) described the stewardship approach as a method which integrates science, ethics and praxis; recognizes a dynamic and changing Earth, maintains biosphere systems that are working well; works to restore degraded systems to previous levels of performance; compensates for altered systems and system behaviour to restore sustainability.

2.1.2 The Goals of Ecosystem Stewardship

In an ecological perspective, ecosystem stewardship has been described as a framework to direct ecosystem management for better ecological and societal outcomes (Chapin et al., 2010). In a broad sense, stewardship adopts management strategies to enhance both human wellbeing (Chapin et al., 2009) and biodiversity conservation (Rands et al., 2010).

Humans have contributed significantly to the decline of conditions required to support conservation. Enhancing ecosystem stewardship can provide practical guidance for society to improve these conditions. It is a mutual strategy which addresses the acute challenges currently facing conservation biologists. The stewardship concept integrates the intimate interdependence of social and ecological processes, the rapid rates of change, uncertainties in outcomes and the distinct possibility of irreversible transformations (Chapin et al., 2011). With these challenges and building on the social-ecological foundations of conservation science, Chapin et al. (2011), explains the ecosystem stewardship as a framework which is interconnected that a change in any one component of the system will cause subsequent changes throughout the system.

The ultimate strategy for implementing ecosystem stewardship is to reduce or reverse the impact of preventable changes which has been the focus of current conservation efforts and adapt to changes that cannot be prevented. The concept also shapes future changes, often through transformation to enhance the intricate network of different species.

2.1.3 Key Elements of Ecosystem Stewardship

The concept of ecosystem stewardship approach presents three key elements.

- The dual goal effect (ecosystem resilience and human wellbeing)
- Integration of ecological and social processes across scales
- Emphasis on actions that shape the future

The twin goals of ecosystem stewardship are ecosystem resilience and human well-being which recognize the dynamic interplay between people and the rest of nature. Neither of these goals is likely to be achieved in the absence of the other. Human wellbeing is described as the quality of life, reflecting basic material needs, safety and security, freedom and choice, good social relations, and capacity of people to realize their potential through actions that are creative or improve society (Chapin et al., 2009). Current conservation practices often focus on the conservation of species and their habitat neglecting the wellbeing of associated human communities. The ecosystem stewardship concept promotes strategies aiming to manage the ecosystem as an integrated whole involving both inputs and outputs.

In the aspect of integrating ecological and social processes, the ecosystem stewardship approach is guided by sustainability and resilience principles that have both ethical and scientific foundations (MEA, 2005). The approach advocates for strategies that use the environment and resources to meet the needs of the present without compromising the future (Kates et al., 2005). Sustainability thus addresses the long-term maintenance of future options, not constancy but flexibility of opportunities. Resilience fosters this flexibility by maintaining the capacity of a system to absorb perturbations and shocks and maintains its structure and function, including both ecosystem properties and human livelihoods, rather than specifying particular outcomes (Folke, 2006).

The last element of the stewardship concept seeks to promote actions that shape the future: Given the difficulty or impossibility of restoring the past under conditions of rapid environmental change drivers (e.g., climate warming, globalization of trade), stewardship focuses on fostering a desirable future rather than re-creating historical conditions (Chapin et al., 2009). Ecosystem stewardship as a strategy for conservation seeks to build on rather than replace the historical strengths of conservation science. Although conservation goals are broad and diverse, there has been substantial conservation effort focused on the protection of individual species to reduce their likelihood of extinction.

Ecosystem stewardship seeks to identify thresholds of irreversible change and advocates transformation of those pathways that are reducing ecosystem resilience and human wellbeing, while facilitating transformations that increase the likelihood of escape from undesirable traps (Leenhardt et al., 2015). Stewardship builds on a long history of conceptual developments in conservation science at species-to-landscape scales with additional focus on social-ecological feedbacks and threshold dynamics at multiple scales that influence conservation opportunities at times of rapid and uncertain change (Leenhardt et al., 2015).

2.1.4 The framework for Ecosystem Stewardship Educational Model (ESEM)

The earth is home to all living things (Rolston, 2012). Human activities together with other biotic and abiotic processes are interconnected together affecting and influencing each other (Wai & Bojei, 2015). The ultimate goal of these processes is to keep the whole earth system in harmony making it livable. Humans depend on the bounty of the earth to thrive and when the system fails human existence will be threatened. Therefore, there is a responsible need of humans to take care of the earth.

Stewardship involves ethics in the sense of personal responsibility, behaviour based on respect for the earth and responsibility to the future generations (Flowers, 2007). This urgent call is a responsibility on all individuals to take care of the environment, use resource wisely and efficiently (Chapin et al., 2010). The implication is a self–obligatory limit on personal consumption and also adjusting own beliefs, habits and values (Chapin et al., 2010).

In stewardship education, the internalized stewardship ethics and skills needed to make desirable choice and take environmentally responsible action are developed in a designed process. Successful stewardship education programmes are designed to influence beliefs, values, intention, actions skills and behaviour with respect to the environmental issues at a particular location. Variables that should be addressed in stewardship educational programmes have been categorized into three; the entry level, ownership level and empowerment level variables. Entry-level variables are good forecasts of behaviour or ones that appear to be related to good citizenship (CRC, 2014). They include environmental sensitivity and knowledge about ecology (Siemer, 2001). Ownership level variables identify with environmental issues; individuals create a sense of ownership of the problem or issue in their environment (Siemer, 2001). They include a deep understanding of the issues and personal commitment and identification with the issue. Flowers (2007) explains that empowerment variables provide humans a sense that they can make changes and provide solutions to important environmental challenges especially in their communities. Such factors include perceived skill in using environmental action strategies and skills, knowledge of action strategies, an internal locus of control, and the purpose to act (Zint, 2013). A successful stewardship programme therefore requires a sound conceptual framework which integrates all three variables and is evaluated. Flowers (2007) emphasized that behavioural changes are possible, but there is the need to build on past programme evaluations and experience in order to achieve them. It is also advocated that assessment of stewardship programmes need to be regularly included in programme organisation (Flowers, 2007).

The designed process for the stewardship education programmes is a sequential learning experience which takes place over a longer timeframe and also involves both settings of the formal and non-formal with support from social environment (Wortman et al., 2006). To be more operative and structured, programmes should be run with presenter training workshops which adequately prepare presenters for effective work particularly in the non-formal setting. Flowers (2007) call attention to the fact that excellent programmes and materials may exist but most educators are usually unaware of these products or may not have the necessary service training to utilize them.

The non-formal programmes should be planned to involve families, peer groups and community groups in a system which is defined suitable to the local environment. Vitousek (1997) discussed the uniqueness of aquatic stewardship education programmes that may achieve desirable changes in environmentally responsible behaviour. Changes in both individual and community level factors are needed to encourage and sustain stewardship commitment over time (Vitousek, 1997). Educational programmes that include some type of practical, hands-on activities are more effective at establishing responsible environmental behaviours than those that do not (NCCF, 2000).

Environmentalists seek to provide the needed knowledge and actions to society in order to keep and maintain healthy ecosystems. Different disciplines are working in an integrated approach with environmentalist with the aim of bringing solutions to challenges faced in current times or as projected. It is imperative that attention is drawn to stewardship where individuals are also empowered to know about the functioning and structure of the ecosystems particularly those in their immediate environment or in connection to their livelihoods. The stewardship concept also advocates empowering individuals to provide remedies to basic challenges that could escalate into major threats in the environments. The idea of stewardship does not necessarily put measures in place to stop humans from exploiting the ecosystems. However, the human attitude of abuse to the ecosystem's services is re-shaped in the idea of sustainability. In this effect man exploits the ecosystem in the sphere of environmental resilience, economic gains and social integrity.

The framework below (Figure 2) seeks to build an environmental educational approach which is founded on stewardship. The focus is to enhance stewardship of community members to improve the health of the different aquatic ecosystems using coastal zone as case study. Figure 2 defines enhanced stewardship in the perspective of knowledge, skills and values. These three factors function together to enhance the individual's intention to act in a positive manner towards the environment. In the dimension of knowledge, the framework seeks to build the knowledge of ecosystem structure and functioning of community members. North Carolina Coastal Federation (NCCF, 2000) stated that critics of environmental education claim that it is an attempt to overwhelm people with inaccurate and biased information about the future of our planet. An educational framework, which allows members to investigate their indigenous ecosystems, will bring them to their own conclusions about the view of the ecosystem health. Hungerford and Volk (1990), states that when people are allowed to study what is around them or in their local environment, they appreciate what is being imparted. Also, a study from Chapin et al. (2010) indicates that people have long been co-adapting with their local environments and ecosystems. There is the sense of intimacy that keeps people to their localities and in that effect, it is likely people will relate and appreciate knowledge of their immediate environment.

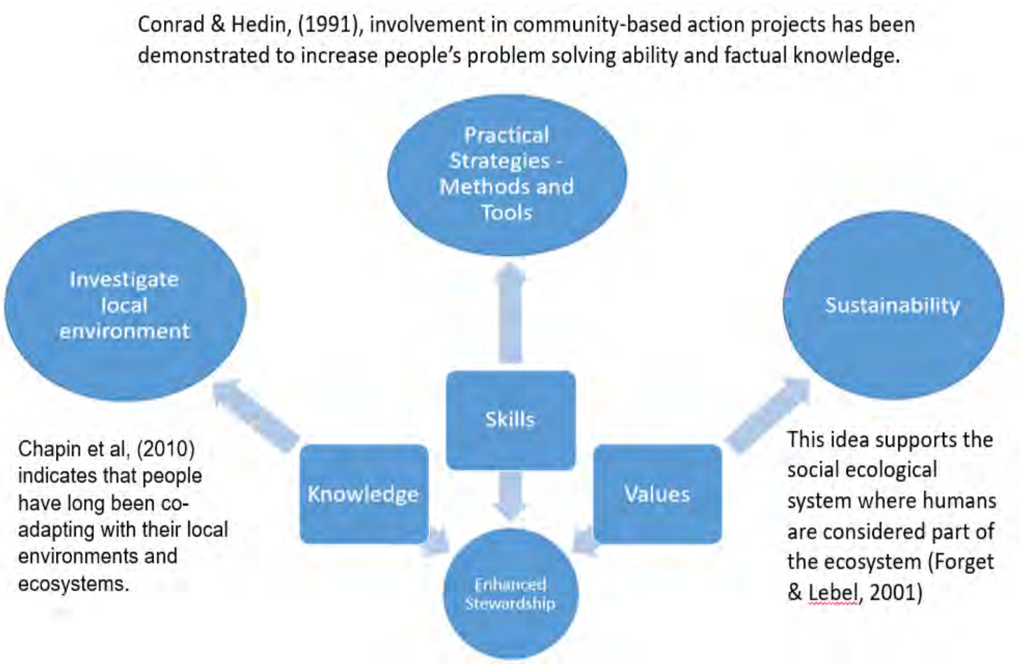

Figure 2: Conceptual framework for environmental stewardship education

According to Pomerantz (1991) most environmental approaches give information about the consequences of human action without teaching the solutions that inhabitants can take to curb these challenges. Hungerford and Volk (1990) reveals in a study that this approach usually makes members feel helpless and they are unwilling to act to bring about the necessary change. In the direction of skills, the above framework seeks to adopt the strategy of involving inhabitants in practical or hands-on activities to contribute in alleviating challenges in the ecosystems found in their communities. The approach integrates innovative methods and tools in the educational process. Demonstrated studies by Conrad and Hedin, (1991), have proven that involvement in community-based action projects increases people's problem-solving ability and factual knowledge. When people are made to have a practical feel of the natural environment and engaged in activities in the process of managing ecosystems, they are willing to participate in the preservation of these natural sites. This supports a growing movement in environmental education that provides people with a more balanced view of the environment by focusing on environmental solutions in addition to problems.

The last arm of the proposed stewardship approach focuses on promoting the values of sustainability (Berkes & Ross, 2013). This arm builds on the three pillars of sustainability which are economic growth, environment and the societal integrity (Moldan et al., 2012). This idea supports the social ecological system where humans are considered part of the ecosystem (Forget & Lebel, 2001) and our actions also contribute to sustain the ecosystem. Therefore, there is the need to ensure that people sustainably use the resources in their ecosystem to make a living. Educational approaches stemming from this approach hopes to trigger the community members' intention to act in a more responsible manner towards the ecosystems. In the long term, stewardship becomes more effective and a norm in communities which will build and maintain resilient ecosystems.

2.2 Coastal Ecosystems (Global and Local Perspective)

2.2.1 The Value of the Coastal Zone and Coastal Ecosystems

The coastal zones are regarded as the most productive zones in the world (Moser et al., 2012). About 40% of the world's population lives in the 5% of the world's land area located within 100 km of the coastline and growth is continuing (Moser et al., 2012). These areas are usually active zones of economic, ecological and social interactions. Various economic activities take place as a result of the greater number of people residing in the area. Some direct livelihoods in the coast include fishing, farming, aquaculture and trading. Coastal environments provide several resources for the survival of humans. Examples include fertile land, fishing, mangrove forests, marine and terrestrial biodiversity, scenic beauty, marine resources, meeting point of flora and fauna of fresh and saline water; salt fields, and minerals: Quartzes and Zircon, Uranium etc.; and easy transportation and sailing facilities (Rahman and Rahman, 2015).

Food in the form of fisheries catch is a major provisional service of the coast. This has been an important service because more than a billion people worldwide rely on fish as their main or sole source of protein (Moffitt & Cajas-Cano, 2014). According to Pauly et al., (2002), fishing dates back at least 40,000 years and fish now contributes 15% of average animal protein consumption to three billion people worldwide. For example, China has been noted for the highest consumption and growth in fish availability (Pauly et al., 2002), owing to the dramatic expansion in its fish production (Mallory, 2013). Trade of fish and seafood products has increased together with growth in global seafood production (Tveterås et al., 2012; Gagern & Van den Bergh, 2013). For the past decade, Thailand has been the leading exporter of shrimp and shrimp products to the world market and the income generated contributes substantially to the Thai economy (Tanticharoen et al., 2008; Newton et al., 2012).

There are more than one million people employed directly or indirectly by the industry (Bell et al., 2015). Moffitt and Cajas-Cano (2014) highlights that the fishing industry provided direct employment to 38 million people, with a further 162 million people indirectly involved in the fisheries industry worldwide. Worldwide, several fishery industrial productions are located in the coastal environments providing a direct source of employment to coastal inhabitants. Globally, small-scale fisheries (SSF) provide livelihoods to millions of coastal inhabitants (Moffitt & Cajas-Cano, 2014; Chuenpagdee et al., 2012). Other coastal resources have also generated several opportunities for other businesses especially at the smaller scale level (Teh & Sumaila, 2013). These include fish trading and other related materials, equipment and facilities for fishing (Tveterås et al., 2012).

Other extensive employment generation sectors in the coastal environment include tourism, energy and construction activities (Tveterås et al., 2012). In tourism alone, the potential to extend the season of enterprises, form joint-ventures with communities and tap into the market is very promising in terms of potential to generate employment. Mariculture has the potential to generate investment and employment in rural communities and it is seen as an opportunity for coastal populations (Tveterås et al., 2012).

Although the coastal area is not suitable in terms of farming activities, people in the urban area close to the coast resort to planting vegetable crops which are known to provide basic income to smaller household communities (GSS, 2014). Vegetable farming along the coastal areas of Ghana dates back to the colonial times in the sixteenth century (Danso et al., 2014). Farmers have been planting crops like lettuce, onions, cauliflower and cabbage. This is partly because of the easy access to water for irrigation and nutrients in the coastal zones (Danso et al., 2014).

Other provisioning services from the coastal ecosystems include curios and ornamentals for aquarium trade, building materials for boats and house construction. Pharmaceutical products and other biological resources are obtained from the exploration of biodiversity (Pereira & Cooper, 2006). The coastal areas are regarded as sacred and used for cultural and spiritual purposes by many coastal dwellers. Traditional knowledge has become an integral part of the dynamics of island and coastal ecosystems. Coastal tourism is one of the fastest growing sectors of global tourism and is an essential component of the economies of many small island nations (Halkos & Matsiori, 2012). Much of the economic value of coral reefs is generated from nature-based and dive tourism, with net benefits estimated at nearly 30 billion dollars annually (UNEP, 2006). The coastal areas serve as areas of research due to diverse habitats in the area. Several evidences which guided major scientific knowledge and ancient historic events were discovered in the coastal environments.

Supporting services are derived from the wide range of habitats in the coastal ecosystems (McLean et al., 2001). Estuaries, mangroves, lagoons, seagrasses and wetlands are habitats serving as nurseries for both inshore and offshore fish and other species. The life cycle of fish, shellfish and migratory birds are supported by habitats such as beaches, dunes, saltmarshes, estuaries and mudflats which are located in the coastal zone (McLean et al., 2001). Coastal ecosystems play a key role in photosynthesis and productivity. Through mixing nutrient from upstream and tidal sources, estuaries are one of the most fertile aquatic systems in the coastal environments. The attractiveness of the coast has resulted in excessively rapid expansion of economic activity, settlements, urban centres and tourist resorts. As a result, it is usually common to find people migrating to the coastal regions in both developed and developing countries (Small & Nicholls, 2003).

2.2.2 Increasing Human Utilization of the Coastal Zone

Coastal zones have been exploited intensively by humans since time immemorial and the rate of exploitation continues to increase rapidly as man advances in technology (Rahman & Rahman, 2015; Moser et al., 2012). According to the theories of evolution, land creatures originated from the water and the coast has served as the first habitat of accommodation for these creatures (Schoch, 2009). The dynamism of ecosystems has changed these organisms and their environment with time leading to diverse forms of modifications. For humans, early civilisations thrived along waterbodies such as the Nile, Tigris and Euphrates in ancient Mesopotamia, Indus in India, and Huang He in China (Danquah et al., 2011). This is attributed to the enormous importance of water for human development. Artefacts show evidence that early humans first occupied coastal areas and exploited near-shore zones with locally manufactured tools (Walter et al., 2000). Hunting and farming with locally manufactured tools were the main activities exploiting resources. These simple tools have developed through time to highly sophisticated machineries (Walter et al., 2000) which are capable of causing great harm to ecosystems without necessary checks.

The trend of urbanisation and industrialisation continues to increase rapidly in the 21st century with the coastal zones of the world hosting more of the world's big industries (Vikas & Dwarakish, 2015). These areas have been economically active zones generating employment in several sectors of economic development. The increasing trends have negative repercussions on the coastal ecosystems if sustainable measures are not in place. Coastal population growth in many of the world's deltas, barrier islands and estuaries has led to widespread conversion of natural coastal landscapes to agriculture, aquaculture, silviculture, as well as industrial and residential uses (UNDP, 2007; Pendleton et al., 2012). Rapid urbanization in the coastal zone for example enlargement of natural coastal inlets and dredging of waterways for navigation, port facilities, and pipelines exacerbate saltwater intrusion into surface and ground waters. In a study 50% of salt marshes, 35% of mangroves, 30% of coral reefs, and 29% of seagrasses have been degraded worldwide (UNEP 2006; Waycott et al., 2009).

Many ecosystems around the world have faced similar challenges as a result of increasing human utilization of the coastal zone (Moser et al., 2012). In many developed countries, rapid industrialization in the coastal zone has led to vast removal of the vegetative cover which has also cascaded into the loss of habitats of diverse species of organisms. It is also recorded that water pollution as a result of industrial waste release into drains destroy many breeding grounds of species. Increasing shoreline retreat and risk of flooding of coastal cities in Thailand, India, Vietnam and the United States have been attributed to degradation of coastal ecosystems by human activities, illustrating a widespread trend (UNEP, 2006; Huitric et al., 2002).

The direct impacts of human activities on the coastal zone have been more significant over the past century than impacts that can be directly attributed to observed climate change (Dadson et al., 2016; Balica et al., 2012). Drainage of coastal wetlands, deforestation, discharge of sewage, fertilizers and contaminants into coastal waters are some of the major direct impacts of human activities. Extractive activities may include sand mining and hydrocarbon production, harvests of fisheries and other living resources, introductions of invasive species and construction of seawalls and other structures (Balica et al., 2012). Channelization, damming and diversions of coastal waterways are engineering activities which harden the coast, change circulation patterns and alter freshwater, sediment and nutrient delivery. Soft engineering solutions, such as beach nourishment and foredune construction may also directly or indirectly alter the natural systems (Parry et al., 2007).

Ecosystem services on the coast are often disrupted by human activities (Moser et al., 2012). For example, tropical and subtropical mangrove forests and temperate saltmarshes provide goods and services (they accumulate and transform nutrients, attenuate waves and storms, bind sediments and support rich ecological communities), which are reduced by large-scale ecosystem conversion for agriculture, industrial and urban development, and aquaculture (Farley & Costanza, 2010). Ecosystem services make significant contributions to human welfare. Some are essential and have no substitutes, and almost all are becoming increasingly scarce (Farley & Costanza, 2010).

2.2.3 Pollution of Coastal Zones and Ecosystems

The natural affiliation to live within the coastal environment has been a catalyst that continues to draw more people to the coastal area. Increasing population comes with it increasing waste and pollution of the ecosystems if no sustainable planning measures are put in place. The coastal zones are turning into waste zones in many developing countries due to lack of funds for effective treatment of waste (Chua & Garces, 1992). These zones have been used as the dumping sites of untreated waste water, air and land pollutants which continue to degrade many ecosystems. Creel (2003) has noted increasing population, urbanization and industrialization as the key drivers of these issues at the coastal zone. In a study by Bhat and Pandit (2014), widespread deterioration in water quality of inland aquatic systems has been reported due to rapid development of industries, agriculture and urban sprawl over the last decade.

Islam and Tanaka (2004) indicated that the history of aquatic environmental pollution goes back to the very beginning of the history of human civilization but did not receive much awareness until a threshold level was reached with adverse consequences on the ecosystems and living organisms. The tonnes of waste within the coastal area affect ecosystems and gradually affect the services they offer to mankind. Usually these wastes may have their source from the industrial and domestic activities within the coastal zone. Also, wastes from neighbouring regions may be washed and carried offshore to the coast and the ecosystems.

Land erosion is a major driver of coastal land pollution. Sediments and pollutants from runoff can affect estuaries, shores and marine life. Increased sediments and pollutants may originate from land-use practices many hundreds of kilometres away. These pollutants usually emanate in portions of catchments far from the coast and may end up in aquatic ecosystems affecting biotic components and functioning (Farley & Costanza, 2010). Agricultural activities such as deforestation, chemical use and poor cropping or grazing practices can cause increased erosion, turbidity and high nutrient levels in estuaries and coastal waters. Excessive sediment flow place stress on components of coastal ecosystems, such as seagrasses, inshore invertebrates, fishes of commercial and recreational value and other species. Elevated nutrients from runoff can also cause eutrophication and the harmful growth of algae. These pollutants in the ecosystems may end up in a vicious cycle affecting humans. For example, recently research has proven that chemical pollutants, such as DDT and PCBs, mimic sex hormones and interfere with the human body's reproductive and developmental functions (Engelking, 2008).

Ecosystem services have been reported to be on a decline as a result of the negative impact of human population growth and industrial developments which release waste into ecosystems (Vanbergen, 2013). The waste in the coastal areas is gradually affecting the fishery population because many breeding grounds have been affected. In many parts of the tropics, mangrove swamps are cleared to make room for shrimp farms, removing habitats that are important breeding grounds for fish (Burnie, 2008). In many parts of the world, disposal of pollutants continues to be a serious challenge in ecosystems affecting several species of fauna and flora in the coast. Reports of pollution in the coastal environments have been reported in many countries in Africa. In Ghana, untreated sewage which is directly released into the streams, rivers and lakes has led to the decline in the water quality within the coastal area. Reports indicate rising health implications especially of water borne diseases in the environs during the rainy seasons because of the runoffs.

Pollution makes streams, lakes and coastal waters unpleasant to look at, to smell and to swim in (Hart, 2008). In some urban areas in Ghana, coastal inhabitants continue to report of the increasing polluted air within the area as a result of the huge deposit of domestic and industrial waste in the neighbourhood. Leachate from the dump sites seep through eroded channels and find their way into the homes of people. These are also reported to contaminate food and water which pose health threat to the community members. In Ghana, pollution of the coastal area and the ecosystems is not different of what is happening in other parts of the world. A rising trend of the loss of vegetative cover within the coastal zones has been a serious threat to ecosystems. The situation is aggravated by erosion which eventually washes off nutrients rendering the land bare. This has a knock-on effect on productivity affecting provisioning services of the ecosystems and also reduction in crop yield (Rochman et al., 2013).

Another serious challenge along the beaches of Ghana is the menace of plastic waste. Plastics, classified as non-biodegradable are carried along from the inland zones through running waters and end up in the coastal areas. These are known to have detrimental effects on ecosystems. The biological components are affected in diverse ways by the plastic menace. There are a significant number of scientific studies indicating that plastics choke many birds in the coastal area. Rochman et al., (2013) reported in a study that several animals wrongly pick these plastic pellets as food and may end up killing them as they cannot be digested in the digestive tracts. Browne et al., (2013), highlights inadequate products, waste management and policy are struggling to prevent plastic waste from infiltrating ecosystems. These plastics sometimes contain element which become poisonous as they get dissolved in water and may affect species of plants and animals in diverse ways especially causing mutations in their genetic make-up. According to a study by Browne et al., (2013), microplastics in the habitats accumulate and transfer pollutants such as nonylphenol, phenanthrene and addictive chemicals into the gut tissues of invertebrates causing some biological effects.

Plastics indiscriminately disposed of and scattered out in the beach zones reduces the aesthetic value of the coastal area. In a study by Davenport and Davenport (2006), coastal tourism started in the 19th century and has increased in non-linear fashion ever since, stimulated by a combination of developments in transport technology and rising prosperity. The aesthetic nature of the coastal ecosystems contributes billions of dollars to the coastal countries gains through tourism and however unclean coastal environments in effect, are a loss of revenue to the state. If the aesthetic nature of the coastal ecosystems is well maintained, it creates livelihood opportunities for inhabitants and also more revenue is generated through tourism.

2.2.4 Pollution from Land and Marine Sources

Current studies suggested sanitation issues as the major challenge of pollution from the land into the coastal zone in developing countries. These have been sourced from industries and households and carried along by water ways into the coastal environments. Constituents of the land-based pollutants include plastics, paper products, metals, glass product, chemicals and hazardous wastes. Marine sources include seaweeds from offshore zones which may be carried along by the sea waves into the coastal zones. Other marine based pollutants may result from discharges from neighbouring countries which may be carried along by ocean waves and travel across oceans to settle in the coastal areas of other countries. Nor and Obbard (2014) reports of the mangrove ecosystems around Singapore which is been affected by marine debris carried along by ocean currents and deposited at the coastal zones. This is usually a challenge as the source of such waste is difficult to determine and manage especially when no one is responsible.

Land developments also have implications for the quality of water in streams and lakes. Poorly managed land leads to excess nutrients coming into water and these nutrients contribute to the growth of toxic and noxious organisms in estuaries. Stewardship in this relation focuses on how to allow developments in a more environmentally sound manner so as to meet the need of the society and also not to destroy ecosystems. There is the need for healthy aquatic ecosystems because without them inhabitants will not enjoy the recreational benefits of the ecosystems such as swimming, fishing etc. no clean water to drink and also habitats for various organisms would be destroyed. Land developments and use should be undertaken in an environmentally sound manner to protect aquatic ecosystems.

2.2.5 Conservation of Coastal Natural Resources

Due to the high productive nature of the coastal areas in terms of resources, several measures have to be taken by humans to conserve the natural resources. There are also people in every community, indigenous or not, who do not follow an ethic of respect for nature, regardless of professed norms. Such people may negatively modify habitats in ecosystems or over-exploit local resources for short-term profit, convenience, sport, or as insurance against future scarcity. A typical example is the extinction of Pleistocene megafauna which was caused by overharvesting (Lorenzen et al., 2011; Meltofte, 2013).

In current times, access to new technology for hunting or motorized transport, for example, may increase harvest efficiency and the likelihood of overharvest (Meltofte et al., 2013). Analogously, socio-economic changes may alter lifestyles and the traditional interactions between people and the animals they harvest. In some cases, fewer people engage in subsistence harvest than in earlier times. This may reduce harvest pressure, but may also make these individuals less aware of or less committed to traditional rules that self-regulate harvest.

Over the years, sectoral methods used to conserve individual agenda have been known to create conflicts among the stakeholders. Cicin-Sain and Belfiore (2005) indicates that if managed in isolation, coastal areas are vulnerable to natural resource development and exploitation. The various stakeholders of the coastal areas may have different approaches for the conservation of their direct resource use in the coastal environment. This may not be favourable to other stakeholders of the same resource leading to conflicts in the area. In a report by Meliadou et al. (2012), the North Lebanon coastal area faced several conflicts as a result of sectoral managements. Round table discussions were organised for the Municipalities of the area and the main coastal productive sectors (tourism, industry, fisheries, and agriculture) where the participants drew cognitive maps. Analysis of the maps showed a large number of factors perceived as affecting the current situation of the coast. Notable among them was intersectoral interactions. In effect, sectoral approach for the management of the coastal zone has not been the best due to the integrated nature of the coastal processes.

In recent years, the concept of integrated coastal zone management (ICZM) has been described as the best strategy in managing issues regarded to the coast areas. The approach integrates all the stakeholders and finds common solutions for their challenges. ICZM has been applied in many coastal areas around the world. It is considered as the most appropriate tool to achieve sustainable coastal development (Gariga & Losada, 2010). Cicin-Sain and Belfiore (2005) concludes that protection of coastal areas including species, habitats, landscapes and seascapes should be integrated into spatial development strategies for larger areas under the umbrella of ICZM. In a review by Portman et al., (2012) the adoption of ICZM is known to have improved the coexistence of stakeholders in the coastal zone of eight countries investigated. The concept emphasizes integration across sectors, levels of government, uses, stakeholders and the spatial and temporal scale therefore minimizing the conflicting issues in a consensus.

The adoption of integrated approach in the coastal management also enhances the positive gains of stakeholders. This is partly attributed to the understanding which now exists among the parties with respect to their objectives of development and the need to also maintain the integrity of the coastal ecosystems. The usual way of prevention or keeping coastal inhabitants away from harnessing resources has been thought of as not the best practice. It has been concluded by Curtin and Prellezo (2010) that to understand ecosystem-based management one must consider ecosystems as complex adaptive systems which can show changes at higher levels from actions and processes occurring at lower levels. Recognising that humans are part of these complex adaptive systems is vital in that their actions along with other processes can lead to transformations in ecosystem functioning.

A conservation ethic can be supported through a wide range of actions, including culture camps, school environmental programmes, cultural events that support a community sense of place, and dialogue and partnerships with scientists that engage local people in conservation discussions, research, actions, and meaningful roles in co-management (Chapin et al., 2015).

Freese and Trauger, (2000) also highlights that for people who do not subscribe to a conservation ethic, regulations are important to protect species that are most vulnerable to human actions. These include actions impacting species that are long-lived and reproduce slowly. In general, if populations of most species are stable or increasing, then conservation can focus on specific groups and habitats. Usually species and habitats which are most vulnerable to transformational changes in their environment are considered (Meltofte et al., 2013).

2.2.6 The Coastal Zone of Ghana

Amlalo (2006) describes the coastline of Ghana which stretches for approximately 550km with a generally a low-lying area of not more than 200m above sea level. The major economic activity along the coastal zone of Ghana is fishing (Otoo et al., 2006). Other activities of economic importance that occur in the zone include agriculture, transportation, salt production, oil and gas exploration, sand and stone winning, recreational and industrial developments (Olympio & Amos-Abanyie, 2013). The coastal zone is also currently used for the disposal of industrial and municipal wastes which disrupts the natural ecology of several aquatic systems (Boadi & Kuitunen, 2002). This activity raises a lot of environmental concerns and therefore needs urgent attention.

Environmental degradation of coastal areas has been identified as a key issue in Ghana's coastal Environment (Hewawasam, 1998). Poverty in the coastal area is also widespread combined with ailing human health and rapid urbanization (Amlalo, 2006). Poverty and environmental degradation are described as major factors which potentially contribute to a vicious circle that inhibits human development in the coastal areas of Ghana (Amlalo, 2006). He further explained seven main environmental issues identified in the marine and coastal environment theme. These are specified as domestic sanitation, fisheries degradation, wetland & mangrove degradation, industrial pollution of water resources in the coastal zone, coastal erosion, Biodiversity loss and aquatic weed encroachment (Amlalo, 2006).

2.2.7 Current Challenges in the Coastal Areas of Ghana

Studies by Jonah (2014) indicate that there is lack of proper management interventions and poor monitoring systems to understand what is really happening in the coastal ecosystems of Ghana. One crucial thing about the coastal area is that, the number of people moving into and settling in the coast keep increasing (Moller-Jensen & Knudsen, 2008). The situation is partly attributed to economic gains particularly fishing and tourism (Otoo et al., 2006). The coastal area has a number of attractions which make it a desirable place for many people. People like the beaches and they move to live there. These activities are increasing human footprint along the coast of Ghana (Olympio & Amos-Abanyie, 2013). This is evident in the study location, Ada coastal community in the eastern coast of Ghana.

The increasing rate of human activities on ecosystems without proper management measures comes with negative multiple effects which eventually lead to ecosystem degradation: a threat to human health, loss of biodiversity, new diseases among organisms, hypoxia, harmful algal blooms, siltation and reduced water quality (Ansari et al., 2010). A study by Lawson et al., (2015) highlights the major environmental challenges along the coast of Ghana to be open defecation, pollution, poor waste management and the use of unsustainable fishing methods. If the authorities and users of the coastal resources fail to recognize the limits of the stress laid on the resources in the ecosystems, they will be degraded beyond restoration and the biggest impact will fall on humans particularly the local inhabitants whose livelihoods depend on the services of the ecosystem.

Currently, the impacts of sea level rise and poor sanitation are common observable environmental challenges in the Ada coastal zone (Otoo et al., 2006). Many structures and properties have been eroded by the rising sea level. According to the Ada East District, coastal erosion has been undertaken by the Government of Ghana, under the Ada Coastal and Volta Estuary Defense Project. Work is progressively steady and it is expected that, the project will solve the increasing loss of beaches to the sea, estimated to be 2.5 metres per annum (AEDA, 2016).

The challenge now is to tackle the issue of excessive pollution of the environment with waste which affects coastal ecosystems (AEDA, 2016). A recent environmental impact assessment conducted by Dredging International revealed that the environmental management is poor in the District. Most of the corridors of the plains are highly engulfed with filth especially with materials such as sachet rubbers, polythene bags and other plastic and metallic materials which are not easily degradable. Excessive livestock grazing and the indiscriminate felling of trees have rendered most parts of the coastal area bare. This is gradually causing damage to the coastal aquatic ecosystems (AEDA, 2016).

The coastal communities of Ada are rich ecological zones. The value of these ecosystems is not being appreciated and used for the benefit of both man and nature especially on the part of local inhabitants. Though local authorities are doing their best to protect coastal ecosystems, more work is needed to enhance community stewardship to improve ecosystems. The situation could be improved by building the knowledge base of community members with the indigenous coastal ecosystems through practical approaches and also promoting sustainable resource exploitation in the coastal area.

2.3 Influence of Biotic and Abiotic Components on Ecosystem Health

2.3.1 Concept of Ecosystem Health

The ecosystem can be regarded being similar to an organism, in which different components of the system are organized in a certain order and closely linked to each other by metabolic processes (Costanza & Mageau, 1999). The basic components of an ecosystem are the biological, chemical and physical components of the environment (Thom and O'Rourke, 2005). Ecosystems are however complex systems composed of various subsystems and factors. For example, air, water and green areas in natural subsystem, industrial production and currency communication in economic subsystem, human living and culture exchange in social subsystem. How well these components are organized and interact reflects how well the ecosystem functions. In a healthy ecosystem, the various components interact well, each metabolic procedure moves smoothly and the whole system functions well (Myers et al., 2013).

There is now abundant evidence that many human dominated ecosystems, including various biophysical systems at regional and global levels, have become highly stressed and dysfunctional (Rapport et al., 1998). Rapid deterioration of the world's major ecosystems has intensified the need for effective environmental monitoring and the development of operational indicators of ecosystem health. The concept of ecosystem health is a way to assess the holistic operations and development potential of ecosystems.

Ecosystem health is usually defined in terms of non-appearance of pathological signs in a particular ecosystem. For example, lakes, ponds and rivers are healthy if they show no signs of diseased condition such contamination, loss of aquatic species or algal blooms (Rapport et al., 2001).

Ecosystem health has been defined by Costanza et al. (1992) as healthy and free from 'distress syndrome' if it is stable and sustainable or if it is active and maintains its organization and autonomy overtime and is resilient to stress. In broad sense, healthy ecosystems have the capacity of maintaining biological and social functions helping to achieve reasonable and sustainable human goals of society. The combined effect of ecosystem health is about sustaining communities, economic opportunities as well as human and biotic health.

Definitions of ecosystem health have been closely allied with the concepts of stress ecology which define health in terms of 'system vigor, organization and resilience, as well as the absence of signs of ecosystem distress (Rapport et al., 1999). The definition also includes the presence of essential functions and key attributes that sustain life systems. Vigor or productivity has been described as the capacity of the natural system to sustain the growth and reproduction of living things (Costanza & Mageau, 1999). The vigor of a system is simply a measure of its activity, metabolism or primary productivity. Examples include gross primary productivity in ecological systems and gross national product in economic systems. Organization is the capacity of the natural system to support different living organisms and the complex interactions that sustain them (Costanza & Mageau, 1999). For example, dissolve oxygen concentrations in a natural environment is described as one of the best and most immediate indicators of ecosystem's health because oxygen is needed to support animal and plant life (Costa & Hughes, 2012). Resilience of the natural system is the capacity to withstand perturbations (Costanza & Mageau, 1999). In this effect the natural system is able to rebound after disturbances such as floods, fire and storms. In natural terms, these attributes have been defined to explain the concept of ecosystem health. A healthy ecosystem is one that is sustainable (Arthington et al., 2010). It has the ability to maintain its structure (organization) and function (vigor) over time in the face of external stress (resilience).

2.3.2 Socio-Economic and Human Health Dimensions of Ecosystem Health

In another dimension, the concept of ecosystem health could be applied to socio-economic and human health (Costanza et al., 1992). The evolving definitions of ecosystem health in this area cover the direct implications of biophysical changes to include the effects on human communities. There is a direct social, economic and human health consequence associated with ecosystem health. In the rural and urban communities, the economic indications of ecosystem health are sustainability livelihoods (Rapport et al., 2001). The human health indications are clearly seen in the vitality of the human community that is part of particular environment (Rapport et al., 2001). According to epidemiological studies, increasing human diseases is being driven by environmental decline. Diseases such as malaria, cholera, dengue fever, bilharzia and many others are all heightened by degraded environments (Rapport et al., 2001). On the other hand, continuous stress from human activities is noted to be most responsible for the transformation of ecosystems from healthy to unhealthy states. Impacts of human activities which may include the release of residual contaminant waste from factories and industries into air, water and soil; the impact of overharvesting and infrastructural developments such as dams, water diversion, road construction, utility corridors and fragmentation of landscapes affect both terrestrial and aquatic ecosystems. Humans may also introduce exotic species into new environment purposefully or unintentionally which may change the structure of the ecosystem. Additional stress may come from the inevitable impact of climate change and the depletion of the ozone layer (Rapport et al., 2001).

A healthy ecosystem is able to buffer against the unpredictable changing of market forces of the society (Rapport, 1998). The system can support a variety of human activities that can be considered as an alternative to maintain the source of income for the human communities which depend on the natural system (Rapport, 1998). Ecosystem health is as much about implementing strategies in environmental management as it is about fostering a new integrative science. The concept is now part of a developing curriculum in schools of public health, faculties of medicine and veterinary colleges. Understanding these phenomena requires a broad integration of knowledge across the social, natural and health sciences. The concept indicators are now employed world-wide (Thom & O'Rourke, 2005). The scientific work has focused on health metrics associated with conservation of biological diversity (Balmford et al., 2005), ecosystem management (Larkin, 1996; Reitkerk et al., 2004), and fisheries management (Pikitch et al., 2004). These studies provide the scientific underpinnings for assessing ecosystem health which emphasize on the mechanisms causing changes (Rapport et al., 1999).

Ecosystem health is thus closely linked to the idea of sustainability which is seen to be a comprehensive, multiscale, dynamic measure of system resilience, organization, and vigor (Thom & O'Rourke, 2005). A healthy ecosystem is one that is sustainable (Costanza and Mageau, 1999). The system not only performs well in terms of structural stability and functional completeness under normal conditions, but it also has a strong ability to adapt and recover when facing change and even threat (Su et al., 2013).

In an aquatic environment, the term water quality could be described as the physical, chemical, biological and aesthetic properties of water that determine its fitness for a variety of uses and for the protection of aquatic ecosystems (Scrimgeour & Wicklum, 1996). However, in a broader perspective, the aquatic ecosystem health is a function of many factors including water quality, community structure and diversity (for example, macroinvertebrates and fish), and the extent and condition of riparian and native vegetation in the Catchment (WRC, 2003). All these factors contribute to the ability of aquatic ecosystems to support and maintain a balanced, integrated, adaptive biological system (Flotemersch et al., 2016). Many of these properties are controlled or influenced by constituents, which are either dissolved or suspended in water (WRC, 2003).

Rapport et al. (2001) describe the cumulative effects of acute and chronic stress which may result in ecosystem distress syndrome. Major signs of the syndrome include: enhanced volatility of fluctuations in component population numbers, reductions in biodiversity, simplification of food webs through elimination of key species, relative depletion of the larger and longer-lived biotic components, declining yields or harvests, increasing disease prevalence within both plant and animal species and increases in dominance by exotic species (Rapport et al., 2001).

2.3.3 Abiotic and Biotic Influence on Aquatic Ecosystem Health

Aquatic ecosystems are described as ecological diverse ecosystems with several physical and biological interactions. However, human activities continue to negatively affect the structure and functioning of these natural sites. For example, wetland ecosystems regarded as one of the productive ecosystems of the world have been increasingly affected by poor water quality due to human activities.

The quality of water in the natural environment depends on various abiotic and biotic constituents and their interaction, which are mostly influenced by the immediate surroundings of the particular region. Industrial waste and the municipal solid waste have emerged as one of the leading causes of pollution of surface water (Patil et al., 2012). Physicochemical parameter study is important to get exact idea about the quality of water. Aftab et al. (2005) studied various Physicochemical parameters and determined higher quantities of electrical conductivity (EC), total dissolve solids (TDS), total suspended solids (TSS), biological oxygen demand (BOD), chemical oxygen demand (COD) and ammonia than permissible limits in water bodies. This was due to the untreated fertilizer effluent which is carried by run-offs. studied the bore well and dug well water samples from highly polluted industrial areas (Pawar et al., 2006). Samples were collected and analysed for physicochemical parameters by adopting the World Health Organisation (WHO) standard methods for examination for water and waste water. The analyzed samples obtained high values, compared with drinking water standards. Dey et al. (2005) studied physio-chemical parameters of water samples drawn from the river Koel, Shankha and Brahmani and concluded that dilution during rainy season decreases the metal concentration level to a considerable extent. Poonkothai and Parvatham (2005) studied Physicochemical and microbiological contents of automobile wastewater. Results indicated higher values than permissible limits which render the waste water unsafe in the natural environment. These research works are important in determining the health of the aquatic ecosystem. They provide information such as sensitive degradation hotspots which will guide the design of awareness creation programmes in order to enhance community stewardship.

A category of physicochemical parameters has been described as key parameters directly related to water quality and ecosystem health (Costa & Hughes, 2012). Major parameters include temperature, salinity, dissolved oxygen, nitrate, phosphate, TDS, conductivity, pH and turbidity. In an aquatic ecosystem, the water temperature controls the rate of all chemical reactions, and affects growth, reproduction and development. Drastic temperature changes can be fatal to the living organisms as it disrupts the physiological processes (Edjere et al., 2016). pH is most important in determining the corrosive nature of water. The lower the pH value, the higher the corrosive nature of water and can cause stress to many aquatic species (Gupta et al., 2009) DO is one of the most important parameters. Its correlation with water parameters gives several direct and indirect information e.g. bacterial activity, photosynthesis, availability of nutrients, stratification etc. (Premlata, 2009). An excess of nitrogen and phosphorous, but especially nitrogen in coastal waters, lead to eutrophication – a state of pollution characterized by high nutrients and sediments input to waterbodies (Ansari et al., 2010). Most of the nitrogen that enters coastal waters is from anthropogenic inputs and is in the form of dissolved inorganic nitrogen such as ammonia, nitrate and nitrite (Premlata, 2009). These inputs originate primarily from wastewater, runoff and atmospheric deposition (Costa & Hughes, 2012). Turbidity measures water clarity or how much the material suspended in the water column decreases light penetration. Suspended material may consist of both inorganic sediment and organic matter such as phytoplankton. High levels of turbidity can result from natural disturbances such as storms, wave action and bottom feeding animals as well as anthropogenic disturbances such as urban runoff, waste discharge, dredging and boating (Costa & Hughes, 2012). Salinity is a key factor especially in intermediary saline aquatic environment like an estuary. It affects the variety and well-being of the various aquatic organisms living in an estuary. Some species of fish spawn in fresh water and live part of their lives at sea. Others do the opposite. Bottom dwelling species such as oysters and crabs may tolerate salinity variations but will decline when there is a wide change in salinity conditions (NCCF, 2000).

Seasonal variation of physicochemical factors is important to consider in ecological assessment because it helps to determine the trend of spatio-temporal changes of important abiotic factors and their effects on the biotic components. A resilient ecosystem is able to function as a waste receptacle, clean and absorb the type and quantity of contaminants in a particular locality and in different seasonal conditions of the year. Ecosystems are sensitive to climatic changes, variations in nutrient content and to the seasons under which they grow. Different ecosystems have their individual life history and this is known to have a close relationship with the kind of environment in which it is found. Thus, to effectively study the health of ecosystems, it is recommended to monitor physicochemical parameters and and biological components as well as investigating the relationship between these two parameters and how they impact on each other (Patil et al., 2012).

Macroinvertebrates are an important food source for many fish. They are also good indicators of ecosystem health, because some species are extremely sensitive to water quality (Yazdian et al., 2014). A lack of macroinvertebrates in what appears to be a healthy ecosystem can indicate the presence of short-term, but disastrous water quality issues, such as extremely hot temperatures. Another criterion for healthy ecosystem is the kind of macrophyte and the environmental quality of the area where they grow naturally. Macrophytes act as a refuge and nursery for juvenile fish and shellfish (Costa & Hughes,

2012) eg Volta clams (*Galatea paradoxa*), many of which are commercially important species in the coastal area of Ada. Attributes of the natural environment of a plant or plant community give an idea of their tolerance limits to various environmental conditions (Yazdian et al., 2014), and of the physical, chemical, and microbiological processes involved in their establishment and development (Iliopoulou-Georgudaki et al., 2003).

In particular, healthy ecosystems capable of serving both ecological and economic functions would require a diversity of macroinvertebrates (Barbosa et al., 2001). Such ecosystems have different plants including annuals, perennials, common and abundant, with a high removal capacity, tolerant to local conditions like climate, pests, and diseases. These plants are usually readily propagated and established within the locality (Pérez-López et al., 2009).

2.4 Coastal Management and the Stewardship Approach

2.4.1 Coastal Zone Management and Environmental Education

The need to protect the coastal environment became a matter of necessity as people clearly understood the increasing degradation of the coastal zones in the early 1960s (Cicin-Sain & Belfiore, 2005). There were serious issues of coastal pollution, killing of endangered species, over-exploitation of resources and damaging of the coastal habitat particularly beaches. This situation created the involvement of coastal researchers to start working on conservation programmes which led to the creation of legislations preventing pollution and habitat destruction of coastal ecosystems (Molnar & Kubiszewski, 2012). Management of the coastal zone may come in different ways. It may come in the form of regulations to control exploitation of resources. This strategy is being adopted by the state of New Jersey in the United States (Molnar & Kubiszewski, 2012). Another way is the focus on education and projects to increase awareness on the need to know the various ecosystems in the coastal environments and protect them.

“Environmental education” is a process that provides learners with awareness and knowledge about the environment and fosters the development of the skills, attitudes and motivations to enable learners to make informed decisions and take responsible actions that incorporate environmental considerations (Flowers, 2007). The ultimate goal or outcome of environmental education is the creation of environmentally literate citizens (Adkins & Simmons, 2002). This is important because solving today's challenging local and global environmental issues and moving society towards sustainability cannot rest only with “experts” but will require the support and active participation of an informed public (Hammerman et al., 2001).

The goal of environmental education is to develop a world population that is aware of, and concerned about, the environment and its associated problems, and which has the knowledge, skills, attitudes, motivations, and commitment to work individually and collectively toward solutions of current problems and the prevention of new ones (Adkins & Simmons, 2002). The basic aim of environmental education is to help individuals and communities understand the complex nature of the natural and the built environments resulting from the interaction of their biological, physical, social, economic, and cultural aspects (Hungerford, et al., 1980). It also requires the acquisition of knowledge, values, attitudes and practical skills to participate in a responsible and effective way in anticipating and solving environmental problems (Adkins & Simmons, 2002).

Effective education programmes also help people to develop positive visions for future of the coast and the ability to participate in change to improve coastal management (Athman & Monroe, 2001). Similarly, capacity building initiatives can help coastal management professionals, community groups and individuals to develop the skills, self-directed leadership and motivation to more effectively manage coastal areas (Wortman et al., 2006). Such programmes go beyond raising awareness about coastal management issues through lectures or printed materials, instead involving people in specific actions and choices, and better on-ground outcomes for the coastal environment (Wortman et al., 2006).

2.4.2 Approaches in Environmental Education

Approaches in environmental education used to be the fact-giving strategy in the past. This has always involved the environmental educators giving out lectures or printed materials during sensitization programmes (Ross, 2001). This approach although contributes to build the knowledge of inhabitants, study assessments indicate that they offer limited space to engaged participants (Wortman et al. 2006). Over the years, this strategy has evolved and developed to include engaging participants in hands-on activities practical activities (Athman & Monroe, 2001). The nature of the previous approach has been in enclosed areas such as classrooms and halls. However, recent methods have been getting participants outside to have a feel of the natural environment. Findings from educational researchers indicate that practical work is effective in terms of developing people's conceptual understanding (Abrahams & Reiss, 2012). Goldenberg, (2001) advice that outdoor adventure education programmes should meet standards of ethics for the care of participants and the environment. New concepts of sustainable learning also focus on environmental education that lay emphasis on addressing environmental challenges and also promotes economic and societal growth (Melkert & Vos, 2010).

The process of environmental education can occur through formal, non-formal, and informal approaches or settings. Formal environmental education is linked with the formal education system and generally takes place in a school context. Study assessments for the formal approach advocate that stewardship education could be integrated with the normal classroom curricula such as science, mathematics, writing and reading skills. This approach stimulates interest of students to learn the basic skills and at the same time acquire the environmental knowledge to become good stewards (McDonnell, 2001). This strategy is more successful if it involves educators who are well informed and trained in environment and stewardship matters. Getting environmental education into the schools could be accomplished by meeting educator's needs for specific topics such as having excellent materials. McDonnell (2001) highlighted innovative educational programmes that could be used as a springboard to encourage educators and their participants. Task-giving activities done in connection with the environmental challenges are expected to develop problem-solving skills and critical thinking. Practical stewardship education gets participants excited as they interact with the natural environment (Siemer, 2001). Getting to become knowledgeable of what is around them makes them more appreciative and therefore enhances the sense of responsibility.

The non-formal environmental education is an organized educational activity outside the formal school system, and includes environmental educational activities or programmes provided by community organizations, youth groups, museums, zoos and nature centres, etc (Siemer, 2001). The informal environmental education is done through the provision of information without an organized educational/institutional structure and typically includes learning about the environment through the media, personal reading, everyday experience and interactions with other people. While all of these approaches are important in contributing to improve conditions in the environment, there is still an issue with development of concepts and strategies to make significant impact as far as community members are concerned (Schmidt, 2008).

Marcinkowski (1998) concludes that to be effective in stewardship education, educators in these programmes need to assume the role of guide and facilitator rather than content provider. He also advocates the use of a programme logic model to organize the programme and identify important linkages for evaluation. For example, an issue and action instruction programme proved to develop investigation and evaluation skills to environmental issues (Decker et al., 2012).

2.4.3 Social Setting and Environmental Stewardship Programmes

Educational programmes designed to change behaviors also should consider the social context surrounding the environmental issues of interest (Hungerford & Volk, 1990). Programme designers should view the desired behavior changes within the context of the worldview shared by those involved with or affected by the issue. Developing programmes that consider the significant social and cultural norms may enhance the likelihood of producing target behaviors in the community served by the programme. In Opdam et al. (2013) study of landscape ecology, he indicates that to produce knowledge relevant to society, it must include considerations of human culture and behavior, extending beyond the natural sciences to synthesize with many other disciplines. Belonging to and identifying with a group is important for an individual's personal development. Researchers have identified group and community as important variables in the development of ethics and values (Hauerwas, 1981). Community can include family, school, ethnic community and groups to which one belongs, (Sichel, 1988). Participants in stewardship programmes transmit their attitudes, beliefs, and values to family, peers and others in the community. Group members positively influence or actually initiate an individual into activities which can encourage or discourage stewardship behaviour.

This suggests that to be most effective, stewardship educational programmes should use small groups, emphasize peer activities, focus on relevant issues and involve action learning. Mentoring, community clubs, and family programmes implemented over the long term may build the kinds of moral communities that will facilitate ethics education (Matthews & Riley, 1995). Stewardship programmes will be most effective in reaching behavioral goals if designed to incorporate parents, families and neighborhood as part of the learning community.

2.4.4 Incentives and Barriers in Environmental Stewardship

Some researchers have found that feedback, rewards, and penalties can produce short-term behaviour change. However, when these consequence conditions are removed, people immediately return to their original behavior patterns where they stop participating in activities to engage them in the process of conserving the ecosystems. Dwyer, et al., (1993) stated the challenge still remains as to find ways to sustain good behavioural change. Feedback, rewards and penalties may have some influence for stewardship education programmes, but they are not likely to produce lasting behaviour change or development of environmental citizenship.

A summary of literature generally found that external strategies, such as financial incentives are effective in changing behavior, though some evidence suggests the change has always been a short-term. Persuasive communications that provided information alone have proven not enough to effect change of behaviour for stewardship. The real interest to stewardship education is the evidence of a strategy for influencing long term behavioral change. The group context of promoting values and norms has also been stressed to be influential in the stewardship effort (Stern et al., 1999).

Stewardship incentives or barriers/constraints may encourage or discourage environmental stewardship actions. Behavioral incentives or barriers may be cultural, psychological, economic, political, or socio-demographic in nature (Dixon et. al., 1995). Constraints have been identified to be intrapersonal, interpersonal or structural. Intrapersonal is defined as not feeling able to perform the behavior, lacking skills or confidence. Interpersonal deals with the situation of not having someone to do the behavior with or having someone who is discouraging people from taking part in the process of change. Structural constraints include lack of time or money, lack of access to a site to perform the behavior. Dixon et al., (1995) highlights additional barriers to include cultural, political or socio-demographic. Environmental educators must therefore seek to understand and identify these constraints and design educational programmes to minimize or even eliminate such barriers.

2.4.5 Coastal Ecosystem Stewardship in Ghana

The coastal zones of Ghana have ecosystems which provide coastal inhabitants with benefits and services making life comfortable in the environment. Through provisioning services, inhabitants derive various kinds of foods, medicines, energy etc, to sustain their livelihoods. The cultural and aesthetic values derived from these natural sites contribute in diverse ways to enhance the socio-cultural lives of the people. For example, ethnic groups may associate themselves with some living organisms which are found in the ecosystems.

Over the years, the customs and traditions of Ghana included laws and regulations that significantly supported the protection of these natural sites (Hens, 2006). These laws are known to have shaped the sense of responsibility among inhabitants for the protection of ecosystems such as forests, rivers, lakes and ponds. The traditional practices helped to preserved nature in the past (Hens, 2006). Several of these traditional customs and regulations are rooted in the concept of "sustainability" which has been described today as the best approach of development (Oktari et al., 2015).

Due to the influx of new religions and much attention on economic development in recent years, the effectiveness of the local traditional laws, customs and regulations have been compromised in managing issues of natural resources conservation (Golo & Yaro, 2013). Perhaps, the approaches usually do not present clear details or logically meanings to recent inhabitants who demand reasoning and explanations into current issues of life. Different belief systems therefore create that environment for people to abuse exploitation of natural resources. This is because the basic traditional principles which serve to bind all inhabitants to conform to management regulations are usually not regarded by the new religions or belief systems (Golo & Yaro, 2013). The situation exemplifies current conditions in the coastal zone of Ghana. Coastal dwellers specifically exploit aquatic ecosystems and resources with the sense of stewardship on the barest minimum.

The management of ecosystems and important natural sites particularly in the coastal areas has gotten to a stage where there is the need to make effective planning and monitoring. The current trends demand presenting more insightful awareness of the consequences of activities in the coastal area to inhabitants (Awuah-Nyamekye, 2013). There is the need to communicate the impacts of coastal processes and human influence on the ecosystems and the possible cascading effects they might have on the future generation in a more clear and acceptable way to the coastal dwellers.

Enhancing stewardship would stimulate the pro-environmental behaviour of individuals, communities and economic stakeholders of the coastal zone, which will sensitize actions to control the negative actions of inhabitants on the aquatic ecosystems. The strategy of protecting the environment through stewardship should be regarded as the way forward (Armsworth et al., 2007). People become more responsible when they are aware of the consequences of their action and also when they are engaged in the process of helping to resolve their own local challenges (Decker et al., 2012).

A study by Lawson et al., (2015) in Ghana highlighted that children and the youth are aware of environmental problems in their local communities and they are also capable of recommending solutions to some of these problems. Environmental education focused on children and youth is a particularly important strategy because it's an opportunity to intervene at a key developmental stage of life and because children can be an important influence on the environmental behaviour of their parents (Flowers, 2007). According to Lawson et al. (2015), engagement and action at the local level are lacking and there is the need to develop more innovative ways to communicate environmental issues with children and the youth

The knowledge about the structure and functioning of the ecosystems where inhabitants live create the sense of appreciation to value the coastal environment and therefore reduce the current rate of human impacts (Kudryavtsev et al., 2012). Poor environmental conditions along the coast of Ghana could eventually cause damage to aquatic ecosystems which will have negative implications on the ecosystem services derived in the coastal environment. It is therefore imperative that environmental experts conduct detail ecological studies in the coastal areas and also design educational resources concerning the indigenous ecosystems. This could contribute to enlighten inhabitants on the values and threats within their coastal environments. It will strengthen stewardship and the need for conservation of aquatic ecosystems in coastal areas of Ghana.

The Earth Stewardship Initiative is a call to ecologists to use the integrative potential of their discipline along with the societal goals of sustainability science to help develop ecologically and societally sound options that enhance ecosystem resilience and human well-being (Chapin et al., 2011). Building an effective stewardship is rooted in the sustainability concept which factors in the individual's quest to develop economically and at the same time taking consideration of the environment.

CHAPTER THREE

MATERIALS AND METHODS

3.0 Introduction

This chapter of the study covers the entire research process. It presents how the whole research work was planned and carried out as a case study. It begins with the description of the study area and the sampling locations. The methodology employed have been described separately for each study objective. It explains the research design, the sources of data, the population, sample size and techniques used in the study. It also describes the data collection instruments and the data analysis technique used for this study.

3.1 Case Study Approach

The study adopted the case study approach which is an acceptable approach worldwide as a research strategy, either as a single case or multiple case study research strategy (Hirschheim et al., 2012). The single case study restricts itself to the study of one particular case or a section within a unit (Hirschheim et al., 2012). In this study, the single case study approach was adopted which focus on the Ada Coastal Environment in Ghana.

3.2 Location of the Study Area

This section provides brief background information on the study area. It presents general information on the coastal zone of Ghana; focusing on the Ada East District where the study area is located. It also provides information on the settings, socio-economic and some physical characteristics of the location and also describes the sampling areas.

3.2.1 General Description of the Coast of Ghana

The coastal zone of Ghana is carved up into three geomorphic units which are western, central and the eastern coasts (Survey Department in Appeaning et al., 2008). This is illustrated in figure 3 below. The western coast extends from the Ghana-Cote d'Ivoire border to the Ankobra river estuary and it is approximately 95km. The western coastal area is characterised by gently sloping sandy beaches with lagoons. The central coast stretches from the Ankobra estuary to Tema which is also about 321km (Ly, 1980). The features of the central coast include rocky headlands and sandbars or spits which enclose lagoons. The east coast extends from Tema to the Ghana-Togo border, about 149km. The eastern coastal area is characterised by sandy shoreline with considerable erosion hotspots along the shoreline (Ly, 1980). The project was undertaken in the Ada coastal communities of the Ada East district which is located in the eastern coast of Ghana. This district was chosen because it is an area in Ghana with diverse aquatic systems. It is also one of the zones classified in the Ramsar jurisdiction because of its ecological importance.

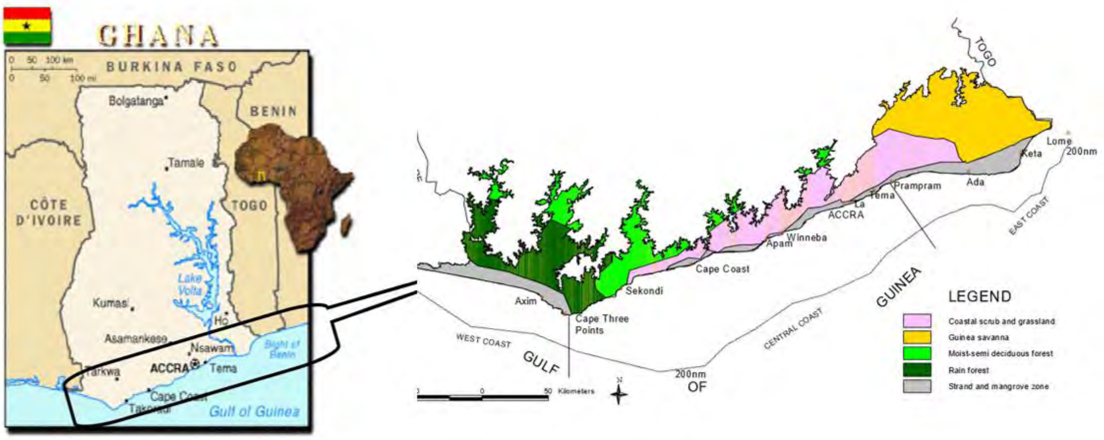

Figure 3: Map of Ghana showing the coastal zone

Source: CERSGIS 2015 *(modified)*

3.2.2 Setting description of the Ada East District

The Ada East District lies in the Greater Accra Region of Ghana and it is about 120km east of Accra, the capital city of Ghana (Figure 4). The district covers a land area of 525 square km and it shares boundary with three other districts namely South Tongu, North Tongu and the Ada West. The major towns in the district are Adafoah, Big Ada and Ada Kasseh which lie in the neighbourhood along the coast. The Population and Housing Census, 2010 places the population of the district at 130,975. The females are 68,801 forming 52.53% and 62,174 are males which forms 47.47% (Ada East District Assembly Report, 2016). Fishing and farming have been the notable occupation of the people of Ada East district. Several fishing activities take place along the Volta River, estuary and the sea. The inhabitants are engaged in the rearing of Tilapia, shrimp farming as well as oyster mining. The peasant farmers are mostly into the cultivation of vegetables such as onions, pepper, tomatoes and root tubers such as cassava (Ada East District Assembly Report, 2013). Vegetables are cultivated on a large scale for commercial purpose. Along the coastal area are hospitality industries which include hotels, guest houses, chalets restaurants and bars. Saloons and retail shops are also springing up in the bigger towns of the District (GSS, 2014). Figure 4 below shows the maps of Ghana and the Ada East District indicating the location of the study area along the coast.

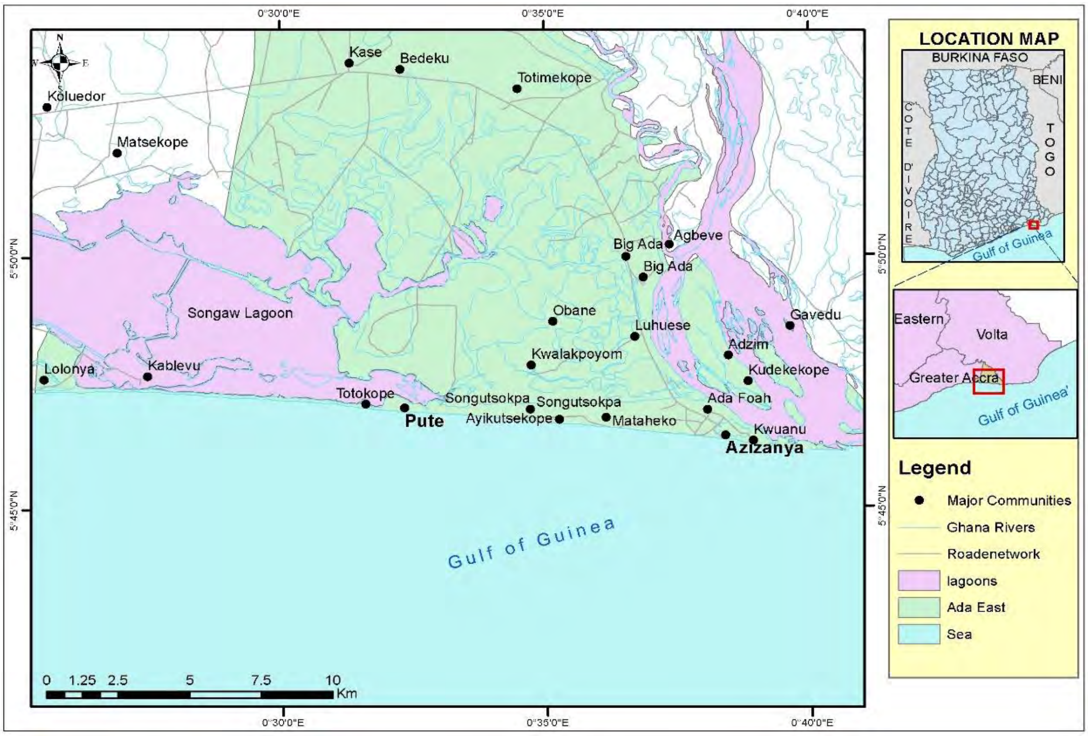

Figure 4: Map of Ghana showing study area

Source: CERSGIS, 2015

3.2.3 Physical Features

3.2.3.1 Relief and Drainage

Ada East district forms part of the Greater Accra plains of Ghana. The plains are characterised by gentle sloping and undulating landscapes with heights less than 60 metres (200 ft) overhead sea level. The Todjeh boulders rising about 240 meters (800 ft.) above sea level are the most striking out relief features in the area (Ada East District Assembly Report, 2016). The Ada East District has a drainage pattern which is branched with several extensions with some of the streams taking their sources from the Volta River. Most of the streams and water bodies spring up into their full capacity in the wet season. However, they are dried in the dry seasons when there are no rains (Ada East District Assembly Report, 2013).

3.2.3.2 Vegetation

Coastal savannah vegetation is the typical type of vegetation found in the inland areas of the district. These are characterised by different species of grasses interspersed with shrubs and trees. There are strands of mangrove vegetations in the coastal area particularly in the coastal islands where the land is salty and waterlogged. Long fringes of coconut trees span the coastal area which gives a scenic view for tourists who visit the area.

3.2.3.3 Minerals and Geology

The Ada East district has large deposits of salt which is a major economic gain to the inhabitants. Inhabitants are engaged in the salt production activities which serve as source of their livelihood. The salt mining industry has generated revenue in the past and the district continues to depend largely on this commodity for its economic growth. The greater portion of the District is underlain by tertiary and recent deposits (GSS, 2014). Along the mouth of the Volta River as well as in the areas surrounding the Songor Lagoon at Pute, there are deposits of recent unconsolidated clay, sand and gravels.

3.2.3.4 Climate

The climate of the Ada East district lies within the hottest regions of the country with average temperatures between 23°C and 28°C all year round (GSS, 2014). However, maximum temperature could reach 33°C especially during very hot seasons. Heavy rainfalls are recorded during the rainy season which falls in the period of March to September. The average rainfall in the region is 750mm (Ada East District Assembly Report, 2016). The coastal areas become very dry in the dry season when there are no rains. Humidity is about 60 percent high, due to the closeness of the sea, the Volta River and other aquatic systems.

Daily evaporation rates range from 5.4 - 6.8 millimeters. The quick crystallization of salt in the coastal area is due to the relatively high temperature (GSS, 2014).

3.2.4 Social and Cultural Structure

3.2.4.1 The origin of the indigenous people

It is believed that the ancestors of the natives of Ada originated from somewhere east of the Volta River in the fourteenth or fifteenth century (Amate, 1999). The descendants of the Dangme-speaking people are the people of Krobo, Osudoku, Shai, Ningo, Kpone and Prampram in Ghana. History reveals that, the place from which the ancestors of the Dangme speaking people migrated from was called Same (Amate, 1999). It is claimed to be located somewhere in the southern Nigeria, or in Dahomey, now known as Benin. After they crossed the Volta River, the indigenous Dangme clans of Ada stayed for some time at a place they called Lorlorvor. From there, they moved on to the Guinea coast to settle in what was then a forest which they named Okorhue (GSS, 2014). Okorli is the collective name given to the descendants of these migrants. This is a name which all of the Ada people now like to identify themselves with. Dangme is the local dialect of the people of Ada (Amate, 1999).

3.2.4.2 The Traditional Political System

The head of the traditional political system of the Ada is the Paramount chief, locally called “Nene Ada”. The next in command is the clan head, also known as “Wetsoyi”. Following is the Chiefs called “Asafoatseme”. Every village is affiliated to a clan and in each of these clans is a sub-chief who is a subject to the Asafoatseme (Ada East District Assembly Report, 2016). There are also smaller communities headed by headmen who preside over the people on behalf of the sub-chiefs.

The Ada tribe was originally made up of eight clans namely; Adibiawe, Dangmebiawe, Lomobiawe, Ohuewem, Tekperbiawe, Korgbor, Kudjragbe and Kabiawe. Kabiawe later divided itself into three separate clans, namely Kabiawe-tsu, Kabiawe-yumu and Kabiawekponor thus summing the total number of clans to ten (GSS, 2014).

3.2.4.3 Festivals

The main festival celebrated by the people of Ada is the Asafotufiami and it is commemorated in the first week of August. The significance of the festival is to serve as a remembrance of the ancestors who fought the war in their pursuit to migrate to their present location. The festival brings all the natives of Ada from far and near for a week-long festivity. There is merry-making and family reunion in which the various aquatic ecosystems play a vital role within the social and cultural settings to make events of the festival complete and fulfilled (GSS, 2014).

3.2.5 Economy

Agriculture drives the economy of the Ada East district. Majority of the population in the coast are rural folks who are engaged in farming and fishing. According to Ghana Statistical Service, 2010 Population and Housing Census, majority of the people in the district (68.3 percent) live in rural setting (GSS, 2014).

3.2.5.1 Agriculture

Farming and fishing related activities are predominant both in the inland and coastal areas in the Ada East district. Farmers in the district mainly adopt irrigation measures to water their vegetable crops. Most cultivated crops in the region are cassava, maize and vegetables like tomatoes, onions, shallots, garden eggs, pepper, carrots, and okra. Fruits such as water melon also feature in abundance during the season to sustain the livelihood of farmers. Fishing, which is another predominant economic activity in the district, is done in the Volta River and the Gulf of Guinea. Fish farming such as Tilapia rearing takes place both in the Volta River and in ponds. Shrimp farming also takes place in ponds and shellfish mining is also commonly done by inhabitants living close to the estuary in the district (GSS, 2014).

3.2.5.2 Tourism and Hospitality

The district is one of the major tourist centres of the country. There are numerous tourist sites which include forts, lagoon, estuary, outstanding beaches along the bank of the Volta River and Gulf of Guinea. The natural areas offer many animals habitats, resting place, feeding and breeding grounds. Holiday makers cruise in ferries and jet skis on the river and estuary. The district has of a number of guesthouses, hotels and restaurants that cater for the needs of the tourism and hospitality industry (Ada East District Assembly Report, 2016).

3.3 Study Area

The study area spans about 45km lengthwise of the Gulf of Guinea in the coastal zone of the Ada East District. The reason for the choice of Ada coastal environment as a case study in this research was because the area is one of the ecological zones in Ghana which is classified as a Ramsar site. The protected zone known as the Songhor Ramsar site contains wetlands which provide natural habitats to diverse species of plants and animals. However, the coastal stretch is described as an open reserve area (Wildlife Division of the Forestry Commission). Even though the coastal zone is protected, inhabitants are allowed to exploit resource provided by the ecosystems for their livelihoods. The whole district is declared a wildlife management area and it is the second largest wetland along the coast of Ghana with different kinds of aquatic systems. Moreover, recent reports by the Ada East District Assembly

(AEDA, 2013) indicated that the coastal aquatic ecosystems are under degradation as a result of environmental pollution. Indiscriminate waste disposal by community members was highlighted as a major issue of concern in the coastal environment. The report called for interventions from Environmental Professional to undertake environmental awareness programmes to enhance community stewardship in the coastal communities. The communities spanning the study sites are listed in table 1 below.

Table 1: Communities along the Ada coastal area

Name of Community	GPS reading	
	Latitude	Longitude
Azizanya	5.766804	0.650024
Kewunor	5.766777	0.650104
Maranatha	5.766756	0.650156
Ayigbo	5.766856	0.633496
Lolonyakope	5.766882	0.633391
Kpodji	5.766829	0.616889
Otrokpe	5.766845	0.616671
Ocanseykope	5.766877	0.600058
Mataheko	5.766926	0.58353
Anyakpor	5.766935	0.583418
Adedetsekope	5.76693	0.56689
Songutsokpa	5.766929	0.566845
Patukope	5.766926	0.566755
Elavanyo	5.76692	0.550265
Pute	5.766933	0.533503

These coastal communities are found on a sandy beach overlooking the Atlantic Ocean (Figure 6). In the socio-economic and environmental context, the area could be described as fishing and farming zone with several creeks and ponds interspersed among settlements.

The major vegetation of the area is coastal savannah with a few scattered trees. There are mangrove vegetations along tributaries of the Volta River on the eastern boundary.

The area is primarily inhabited by those of Ga Dangme ethnicity as well as other smaller ethnic groups (such as Ga and Ewe). From the 2000 population and housing census, 42.9% of the population in the area had never attended school (GSS, 2010) which reflects a low level of literacy in the district. The communities have electricity and telecommunications facilities. Potable water is a problem in the communities as inhabitants depend on boreholes which are turning salty as a result of salt water intrusion.

3.4 Sampling locations

Aquatic ecosystems were located on aerial photographs of the study area and their coordinates were taken with a GPS during ground truthing. These areas were marked as sampling locations. Four of the aquatic ecosystems are located along the coast. Five are near the coast (inland) and another four located on the coastal island. The data was incorporated into GIS software ARCGIS and plotted on aerial photographs to show the clear locations of these ecosystems. Figure 5 shows the sampling locations which are designated S1 to S13 on aerial photograph acquired from the Department of Marine and Fisheries in the University of Ghana. Table 2 indicates the kind of aquatic ecosystem found in each of the sampling areas. Their Geographic positions have also been indicated.

The project engaged pupils from the basic schools and youth groups in five communities in the coastal zone. These communities are Totimekope, Ocanseykope, Anyakpor, Elavanyo and Pute. These communities were chosen because they are the communities with basic schools which serve the entire coastal stretch. The community schools are Totimekope D/A

Basic School, Ocanseykope D/A Basic School, Anyakpor R/C Basic School, Elavanyo D/A Basic School and Pute D/A Basic School. These five schools serve all the fifteen communities along the coastline.

Figure 5: Aerial photograph showing location of sampling sites

Source: Department of Marine and Fisheries, UG *(2015)*

Table 2: Sampled waterways with ecosystems in the coastal communities

Site code	Site description	GPS reading Latitude	Longitude
S1	Upstream of Futue Stream	5.811694	0.613972
S2	Downstream of Futue Stream	5.789139	0.623778
S3	Western bank of the River Volta	5.784417	0.638444
S4	Eastern Bank of the River Volta	5.783403	0.633451
S5	Ditch	5.776833	0.646
S6	Mangrove Swamp	5.783466	0.633462
S7	Intertidal zone	5.775306	0.627361
S8	Pond	5.766782	0.650046
S9	Creek	5.773694	0.654972
S10	Creek	5.772722	0.657861
S11	Lagoon	5.771806	0.660222
S12	Lagoon	5.774925	0.663856
S13	Estuary	5.773222	0.668167

3.5 Research Design

The descriptive research design was used in this study. According to Neuman (2000), the design is a scientific method which involves observing and describing the behavior of a subject without influencing it in any way. Key (1997) also stated ardently that, descriptive design helps to obtain information concerning the current status of a phenomenon to describe "what exists" with respect to conditions or variables in the situation. The main disadvantage of the descriptive design is the trouble of ensuring that, the questions to be answered in a survey are clear and not misrepresenting or misleading (Mathers et al., 2007).

3.6 Methodology

The objectives of the study presented the need to adopt a multifaceted approach. Both qualitative and quantitative data were collected in the study. Questionnaire surveys, Ecological surveys, Focus group discussion; Observations and Key informant interviews were employed to obtain information concerning the issues of the aquatic ecosystems and best approaches to enhance community stewardship. The issues identified and the information gathered from the empirical research with respect to the coastal environment provided an understanding which guided the design of a stewardship educational framework and application guidelines. Pilot educational programmes were then organised to test the effectiveness of the model. Figure 6 shows the schematic diagram of the research design.

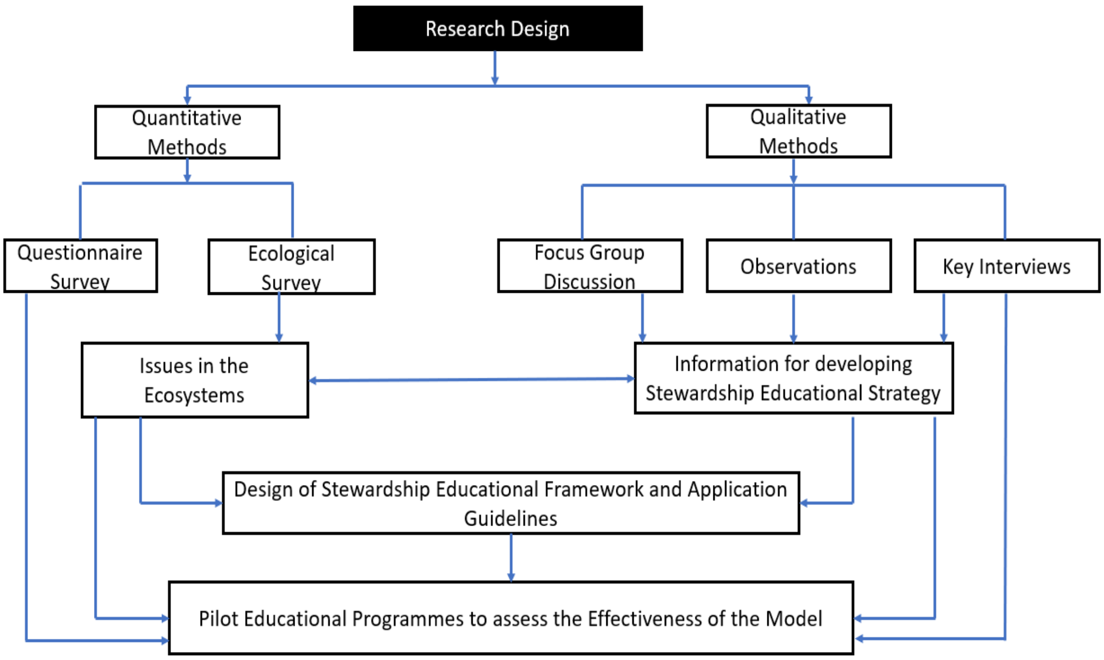

Figure 6: The research method

3.6.1 Focus group discussion for local authorities

A prior notice was given to the local authorities to formally invite official members with a tertiary educational background to a focus group discussion. This was to ensure that higher-level personnel and academics were targeted for an in-depth discussion of the subject matter. The local authority group were members of the Ada East District Assembly, the Wildlife Division of the Forestry Commission and Local Community leaders. These stakeholders were selected because they are directly in-charge of protecting the natural sites of the coastal zone and community development in the district. A total of twelve individuals showed up for the focus group discussion. These individuals comprised five Rangers from the Wildlife Division, five Social workers from the District Assembly and two Community leaders of the coastal area. Discussions were both informal and formal. The informal discussions consisted of general conversations about issues, safety and ways to enhance stewardship of coastal aquatic ecosystems.

The formal questions (Appendix B1) which guided the discussions were generated based on extensive study of literature and expert consultations. Discussions focused on the impact of increasing coastal developments on aquatic ecosystems, the mitigation measures put in place to safeguard the ecosystems and livelihoods, the level of participation from the public, local communities and stakeholder groups on these mitigation measures and what could be done in order to ensure sustainable exploitation of coastal ecosystem resources in Ada. Another section also discussed the need for local authority groups to undergo training to also enrich their knowledge on ways to enhance stewardship within their communities. It identified the best way for community education and appropriate educational resources. The discussions also determined the choice of coastal educational messages, ways of presenting such messages and the most suitable groups to target for coastal education. The discussants were asked to indicate their satisfaction in terms of knowledge and behaviour of community inhabitants with respect to the prevention of ecosystem degradation. They had two options to describe their perception which are: satisfactory and unsatisfactory for knowledge on aquatic ecosystem structure and functioning. For behaviour, discussants chose between a positive or a negative behaviour.

The responses and comments from the focus group discussion contributed to the development of an Ecosystem Stewardship Educational Model (ESEM) was has been described as a co-design approach between the researcher and the stakeholders. The discussions were recorded on audiotapes and transcribed.

3.6.2 Key informants survey for local communities

As part of the research to develop an educational model to enhance stewardship of ecosystems, a Key Informant Survey was undertaken. The main purpose of the survey was to solicit information about the environmental, socio-economic, cultural impacts on aquatic ecosystems, the knowledge on the impacts and conservation practices of the local residents in relation to the prevention of aquatic ecosystems degradation.

Key informants were interviewed using a structured questionnaire (Appendix B2). The use of the questionnaire enables the researcher to get a high proportion of information that is usable. Moreover, it is cost effective since a greater number of respondents can be attended to at the same time. The questionnaire was adapted from a questionnaire portfolio developed by Mensah, (2009) who studied the influence of land use activities on nutrient inputs into upland catchment streams. It contains both open and closed ended questions. The questionnaire was modified to suit the study objectives. It was refined following feedbacks from a pretest on 20 respondents who are community members residing in the coastal area of Ada.

The final questionnaire was divided in four sections. The first section was used to obtain information on the background and demographic characteristics of the respondents. The second section focused on the socio-cultural characteristics. The third section involved questions investigating the environmental characteristics that may affect the health of aquatic ecosystems. The questions in this section were further divided into 16 parts targeting various issues which may affect the health of aquatic ecosystems (Appendix B2). The fourth section looks at the economic and productive systems in the coastal communities and the final section draws attention to inhabitant's knowledge, attitude and conservation practices of coastal aquatic ecosystems.

3.6.2.1 Data Collection Methods

The purposive sampling method was used in the selection of the communities for the survey. This was based on the location of community to aquatic ecosystem and also to ensure that information is gathered from the whole coastal stretch. The convenience sampling technique was employed to select household heads in the study area. This method is a non-probability sampling approach that relies on data collection from population members who are convenient and available for the study. This technique was adopted because it does not waste the time of respondents and also enables a more accurate data collection since respondents are not in a rush to answer the questions. Household heads were targeted for the survey because they could represent the living conditions of the entire household (Bookwalter et al., 2006). Therefore, they are in a good position to provide the required information about the community inhabitants.

Four staff members of the Ada East District Assembly were trained and engaged to assist with the administration of the questionnaires in the local dialects. Some respondents could not read and understand the questions on their own. In all, 203 respondents were engaged in the key informant survey. In every community, the first 13 household heads in proximity who were available were guided through the questionnaire. The sample size was determined at 90 percent confidence level from the number of households in the coastal communities of Adafoah which was estimated to be 1035. According to the GSS (2014), 68.3 percent of the population live in rural setting, mostly located in the coastal zone. It was administered in a face-to-face approach at the residences of the respondents. The survey lasted from February to March, 2016.

3.6.2.2 Data Analysis

Data from the focus group discussions and key informant interviews were analyzed using descriptive statistics in the form of frequencies, percentages and mean. Also graphs, such as pie and bar charts are used to present the results. The purpose was to understand knowledge satisfaction of inhabitants on aquatic ecosystems structure and functioning. The attitude and practices of community inhabitants in relation to the prevention of aquatic ecosystem degradation were also analyzed. A multiple logistic regression analysis was performed to analyzed the significance of the awareness of environment and socioeconomic impacts on the quality of aquatic ecosystems in relation to the demographic characteristics of the respondents.

3.6.3 Ecological survey

The concepts which guided the ecological survey were adapted from generic models including protocols provided by the Coalition for Buzzards Bay (Coalition for Buzzards Bay, 2015) and the North Carolina Coastal Federation (NCCF, 2000). It included standardized parameters required for ecosystem assessments and acceptable levels, concentrations and natural limits for aquatic species as recommended by the World Health Organization (WHO). The NCCF model uses a reference description in relation to the health of the particular aquatic ecosystem. The reference descriptions were in the form of a four-point scale ranging from excellent condition (5), good condition (3), bad condition (1), and very bad condition (0). In this study, the scoring was aided by guidelines based on observed status of ecosystem, human activities or quantitative determination of a parameter in question.

The numeric score graded the condition in the location as assessed by the researcher. The scores were totaled to determine the final score. The maximum score was 35 (5 x 7) and the minimum score was 0 (0 x 7) for each of the three ecological investigations conducted. The final scores ranging from 25 to 35 represented a good ecosystem health whilst scores less than 25 indicated poor ecosystem health (Adapted from NCCF, 2000). Table 3 shows the health index ratings designed for the various ecological investigations (landuse, water quality and habitat quality). Green circle was used to mark areas which fell in the good category and red circle marked areas which fell in the poor category with respect to ecological health.

Table 3: Health indices used to assess the various sampling locations.

Health index rating	Landuse score	Water quality score	Habitat score
Good (G) (green circle)	25 to 35	25 to 35	25 to 35
Poor (P) (red circle)	Less than 25	Less than 25	Less than 25

Adapted from: NCCF, (2000) and Coalition for Buzzards Bay (2015)

3.6.3.1 Landuse investigations

A tape-measure was used to determine the size of buffer zones along waterways at three different places in each sampling location. The average of the three measurements were taken and scored based on the NCCF guideline. Drainage ditches or culverts in waterways were noted around sampling sites and scored. In order to determine whether dirt and pollution are threats for the water in the ecosystems, a test for compaction or hardness of the soil was conducted. A wooden peg was used to test the hardness of the soil. Starting at the edge of the waterway in a straight path, a stop was made at every three metres and the wooden peg was pushed into the ground as far as possible. The depth at which the wooden peg goes into the ground was recorded. The average was computed and scored according to the NCCF guideline. Observational approach was used to figure out if landuse around the waterways is negatively affecting the structure and water quality of the ecosystems. Sampling locations with pipes, culverts or drainage ditches were noted. Their sources and leakages were assessed visually and scored. The percentage of the water that was shaded was estimated and scored. This was so because stable temperature is vital for the survival of many living organisms in the ecosystems. Furthermore, the land type which makes up the watershed in each sampling location was visually assessed and scored based on the NCCF framework. Appendix C presents the scoring guide for the landuse investigation.

3.6.3.2 Water quality investigations

Water quality investigations for ecosystem quality Chemical and Physical parameters of water were measured at the sampling locations to aid in ecosystem quality determination according to the NCCF framework (NCCF, 2000). Water samples were taken at the thirteen different sites using the random grab sampling method. The parameters tested onsite included temperature, dissolved oxygen (DO) and pH with the use of the waterproof handheld instrument, HORIBA Series. Percentage saturation of oxygen, nitrate and phosphate were tested at the Lab. The quantity and type of trash in the ecosystems were visually assessed. These parameters were scored based on the NCCF guidelines (NCCF, 2000). The percentage saturation was calculated to find out how much oxygen each sampling location contains and compared to how much oxygen the place should have at different temperatures (NCCF, 2000). The percentage saturation was calculated from (Equation 1):

$$\frac{\text{Measured dissolved oxygen} \times 100}{\text{Potential dissolved oxygen}} = \%\ \text{Saturation} \qquad \textbf{(Equation 1)}$$

Appendix D shows the scoring guide for the water quality investigation.

3.6.3.3 Habitat investigations

The banks of waterways were described and scored according to NCCF framework (NCCF, 2000). In addition, sediment buildup along water ways was visually assessed and scored as sediment could reduce channel of water flow and also smothering aquatic species and plants during heavy rainfall. The various kinds of habitats, the curvature of waterways, percentage of water on waterway in the ecosystems and blockages were visually assessed and scored at each sampling location (NCCF, 2000). Appendix E presents the scoring guide for the habitat quality investigation.

3.6.3.4 Physicochemical characteristics of water

Physicochemical parameters were also assessed to observe seasonal trends. Monitoring was performed for the two seasons (dry and wet). Sampling was done in May, June and July, 2016 for the wet season and in the dry season, it was conducted in the same locations in November, December, 2016 and January, 2017. Three replicates of water samples were taken at the thirteen different sites using random grab sampling method. At each site, waterproof handheld instrument, HORIBA Series was used onsite to measure the following parameters: pH, temperature, TDS and electric conductivity (EC), salinity, dissolved oxygen and turbidity. Additional water samples were collected at each of the sampling locations designated W1 to W13 and stored in clean 500 ml plastic bottles for analyses of nitrate and phosphates. These parameters were selected because they are directly linked to water attributes that are important for the health of aquatic ecosystems (Pesce & Wunderlin, 2000). The methods outlined in the Standard Methods for the Examination of Water and Wastewater (APHA, 1998) and HACH Company Ltd. (1996) DR/2010 Spectrophotometer Procedure Manual was followed for the analyses of nitrates and phosphates.

3.6.3.5 Aquatic Macroinvertebrate study

The procedure by Perkins and Ramberg (2004) was followed for the macroinvertebrate sampling. Sweep net samples were taken with 10 sweeps at fringe vegetation sites in the sampling locations. The collected samples were preserved with formaldehyde and Rose Bengal as a staining agent to help sort organisms. The samples were preserved in an ice chest at 4°C and taken to the Ecological Laboratory of University of Ghana for immediate analysis. Each invertebrate sample was washed and placed on white trays, sorted, identified and counted. A hand lens was used for the identification of smaller invertebrates that were difficult to identify by eye. The identification key by Macan (1979) was used. Analysis for macroinvertebrates was done using biological diversity indices.

3.6.3.6 Aquatic macrophyte study

For the aquatic macrophyte inventory, twelve out of thirteen sites were sampled within an area of $50m^2$. Site S13 had no macrophytes. Macrophytes found in the waterways or on the margins and inner banks of the sampling sites were collected and identified by means of random quadrat throws. Ten throws of $1m^2$ quadrat were conducted at each site and plants in each quadrat were inventoried. Counts were done and population density was estimated for each species as (number of plants of the species “x” / 10 throws). Samples were collected and identified at the Ecological laboratory of the University of Ghana. Figure 7 below shows the systematic procedure followed to undertake the macrophyte study.

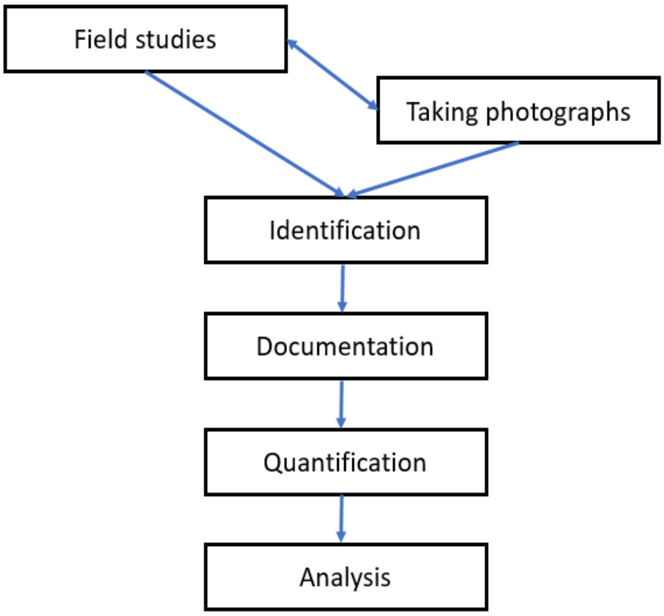

Figure 7: Field data collection approach for Aquatic macrophyte study

3.6.3.7 Data analysis

Both qualitative (observational) and quantitative data were scored according to NCCF framework (NCCF, 2000) similar to a Likert scale. The Likert scale allows the researcher to make personal responses to a series of statements which are related to the study objectives (Tweneboah, 2009). Descriptive statistics were used to describe results from monitoring physicochemical parameters of water, macroinvertebrate and aquatic macrophyte studies. Mean values of physicochemical parameters were compared with recommended WHO standards and natural background levels for healthy aquatic ecosystem, using the One-sample T-Test analysis. The paired-samples T-Test analysis was also used to determine the significant difference between the dry and wet season mean values. All measurements were done at 5% level of significance. The richness and evenness of species were computed to describe biodiversity in the study area (Leinster & Cobbold, 2012; Bibi & Ali, 2013). The Shannon-Weiner Index (Shannon and Weaver, 1949) and Simpson Index (Simpson, 1949) were also used to evaluate the macroinvertebrate and macrophyte diversity. Shannon diversity is a widely used index for comparing diversity among various habitats (Clarke & Warwick, 2001). It was calculated to compare species diversity in the different sampling locations based on the formula below:

$$H' = - [\sum Pi\ln Pi] \qquad (Eq2)$$

Where, H′ = Diversity Index; Pi = is the proportion of each species in the sample; lnPi = natural logarithm of this proportion. The value of Shannon Weiner Diversity Index usually falls between 1.5 and 3.5. Values outside these ranges are usually computed in rare cases. Higher values close to 4.6 give an indication that the numbers of individuals are evenly distributed between all the species (Bibi & Ali, 2013). Simpson index (D) was computed to determine the probability that any two individuals randomly selected from a sample will belong to the same species. It was measured by the formula:

$$D = 1-\{\sum n\ (n-1)/N\ (N-1)\} \qquad (Eq3)$$

Where n = the total number of macroinvertebrate /macrophyte of a particular species.

N = the total number of macroinvertebrates/macrophyte of all species.

Microsoft Excel was used to compute the correlation coefficient between physicochemical parameters and bio-indices to establish a relationship.

3.6.4 Review of Environmental Educational Strategies

In order to develop an application guideline and educational modules to enhance community stewardship, a desk study which focused on literature review of various environmental educational strategies was conducted. The approach acquired knowledge on various strategies which introduces an understanding of the indigenous ecological systems and addresses the human impacts on coastal environments. Sustainable practices for exploiting ecosystem resources and on concepts which integrates human and ecological systems were also acquired from literature. The final aspect of the review focused on adopting practical approaches which combine different tools and methods to engage community inhabitants in the non-formal approach of environmental education. Some activities in the modules were sourced from the NOAA - National Oceanic and Atmospheric Administration (2016) and the National Estuarine Research Reserve System (NERRS) websites. Relevant information on the local setting was acquired from the Social Welfare Department of the Ada East District Assembly and from internet sources.

3.6.5 Expert Consultations

In consultation with the local authorities and environmental professionals in the Ada East District Assembly, the concept of the application guideline for enhancing community stewardship of aquatic ecosystems was developed. The concept approach was shared with scientists and experts in the area of environmental management and community education from the University of Ghana. With their inputs and modifications, the first draft of the ESEM application guide was developed. Through several consultations with experts in environmental education from the Ada East District draft educational modules suitable for the Ada coastal environment were developed to enhance community stewardship of aquatic ecosystems. Ecological scientists from the University of Ghana also reviewed the prepared educational modules and their notes and comments guided the final versions.

Consultations were done with experts in the field of coastal environmental management and education to discuss the conceptual sequence and detail rationale for all the activities in the ESEM modules. In order to meet the national standards of education, consultations were done with experts from Academia, Environmental Protection Agency (EPA) and Wildlife division of the Forestry Commission in Ghana who are involved in community education. These experts also reviewed the ESEM adapting it to suit the local study environment. Figure 8 below shows the schematic approach in designing the ESEM application guideline and educational modules.

Figure 8: Approach for the development of ESEM

3.6.6 Pilot community programmes

Schools have an important role in knowledge development for building community resilience and it is also important to involve communities with assigned roles and responsibilities to enhance ecosystems quality. In order to assess the effectiveness of the stewardship educational model, community based programmes were organised in schools along the coast. Programmes were also conducted for community groups along the coastal area. These programmes applied the concept of stewardship to deal with major environmental issues identified in the coastal area. In total, fifty students and fifty community members participated in the programmes. The students constituted 5 girls and 5 boys in the Junior High school selected in each of the schools to ensure gender equality. The community groups were also made up of at least 10 participants involving both males and females during each programme. Four evaluators were engaged in each of the pilot programmes. They constituted members from the Wildlife Division of the Forestry Commission, Social Welfare Department of the Ada East District Assembly and teachers in the selected schools. These agencies undertake community educational programmes which usually take the non-formal approach. Members of these agencies were present in all the events of the stewardship programme. They acted as observers and evaluated the outcomes of the events.

3.6.7 Evaluation of the ESEM

An assessment questionnaire was developed to evaluate the effectiveness of the stewardship educational model. This was determined by measuring evaluators responses to survey questions adapted from NCCF (2000) Assessment guide for environmental educational programmes. The evaluators were given questionnaire to report on the extent to which they “agreed” or “disagreed” with the activities conducted to enhance ecosystem stewardship. Assessment was done under four premises. These are fairness and accuracy, development, instructional soundness and usability. The Fairness and Accuracy described how true the model reflects on the environmental problems and conditions within the local community. Development assessed whether the model follows the educational pathway to action. The Instructional Soundness assessed the instructional techniques to know if the models create an effective learning environment. The Usability also assessed how the activities are well designed and the easiness of use. Evaluators rated their views against questions under each premise. The evaluators were also given space to provide additional comments if desired. The final question asked them if they would like to adopt the concept in their community outreach programmes. The students and community members were also engaged in interviews to provide qualitative evidence to gain deeper understanding of the programmes and comprehend the quality of its effectiveness.

3.6.8 Data analysis

The data collected was analysed using descriptive statistics. Results were presented in frequency tables and charts showing numbers and in some cases in percentages. Table 4 presents the assessment guide for the model evaluation. The various scores for each evaluator were summed up under each premise and classified in the ranges of below average, average and above average. High scores indicate satisfaction with the use of model as educational approach to enhance community stewardship of ecosystems.

Table 4: Assessment guide for the Stewardship model

	ASSESSMENT			
	Fairness and Accuracy	Development	Instructional soundness	Usability
Below average	3-4	6-10	6-10	4-6
Average	5-7	11-14	11-14	7-9
Above average	8-9	15-18	15-18	10-12

CHAPTER FOUR

RESULTS

4.0 Introduction

The major findings from the study have been presented in this chapter. They have been categorized into the three objectives of the study. It begins with the descriptive results and analysis of the issues and local knowledge pertaining to the aquatic ecosystems. It proceeds to determine the health of aquatic ecosystems and the community structure and finally concludes with the evaluation of a designed ecological educational model to strengthen community stewardship. Further detailed results are also available in the Appendices.

4.1 Issues and local knowledge issues pertaining to the aquatic ecosystems

4.1.1 Issues of aquatic ecosystems

The discussants listed barriers of aquatic ecosystem health which were categorized into lack of knowledge of coastal ecosystem structure and functioning, population and economic pressures, unsustainable exploitation of biological resources, prevention and early detection of coastal hazards and pollution of coastal waters. A large proportion of the discussants (41%) also noted population and economic pressures to be the major issue within the Ada coastal communities. Figure 9 shows the results.

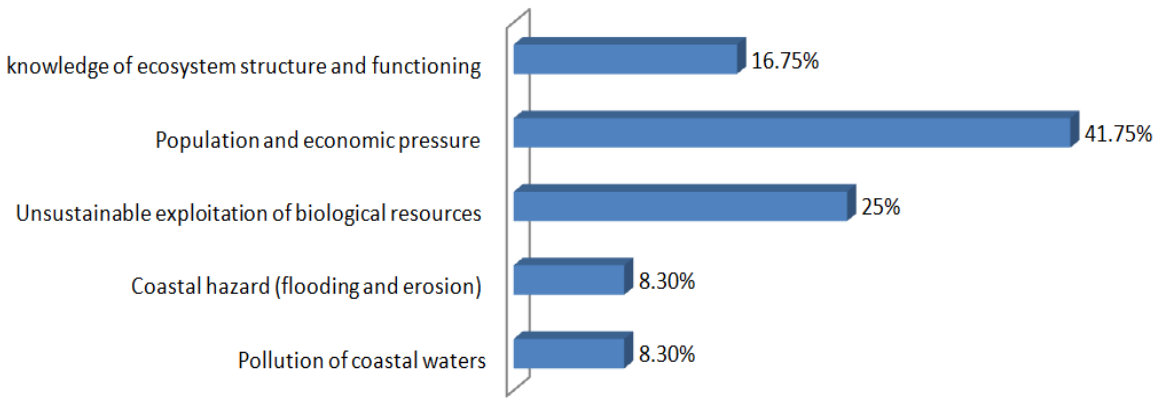

Figure 9: Aquatic Ecosystem issues and stakeholders rating as number one

4.1.2 Role in safe guarding aquatic ecosystems

All discussants indicated a "NO" response that the institutions in place by government can solely safeguard coastal aquatic ecosystems without community participation. Figure 10 shows the discussants' view on the extent to which local communities are involved in the conservation of aquatic ecosystems. More than half (67%) of the discussants rated "fairly involved" which gives the impression of some degree of apathy towards participation in the process of helping to conserve aquatic ecosystems. All discussants were positive that enhancing community stewardship can contribute to improve aquatic ecosystem health.

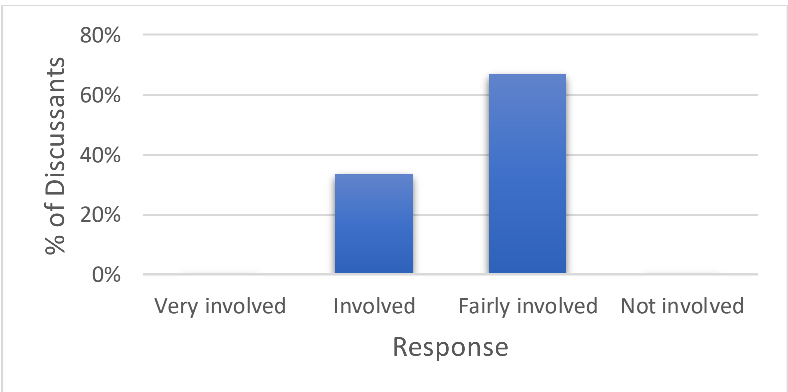

Figure 10: Discussants perception on community participation in conservation of aquatic ecosystems

4.1.3 Assistance of Key Community groups

Responses indicated that there are a number of community groups and partners who undertake environmental awareness programmes in the coastal area to enhance stewardship of aquatic ecosystems. Such groups included community based organisations (CBOs), non-governmental organisations (NGOs), faith based organisations (FBOs), and neighbourhood associations.

4.1.4 Methods in place to enhance stewardship of aquatic ecosystems

Discussants indicated there are talk shows, film shows and community-based activities to sensitise community members. When asked to appraise these measures, most discussants reported that they have not achieved the desired goals of community stewardship. Figure 11 shows the responses.

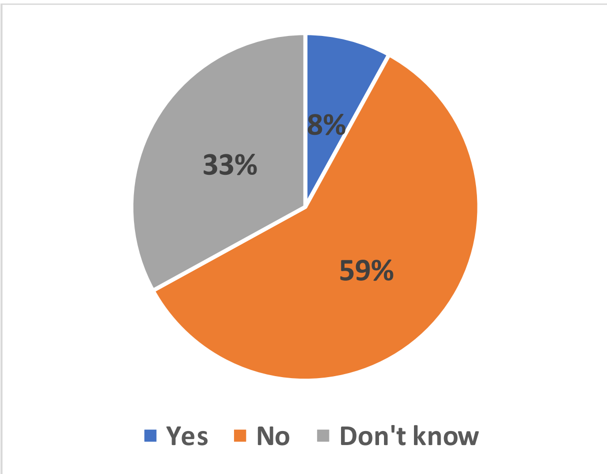

Figure 11: Discussants perception on the effectiveness of current approaches to enhance stewardship

4.1.5 Knowledge and Behaviour in relation to the prevention of aquatic ecosystem degradation

Discussants were of the opinion that public knowledge on ecosystem structure and functioning is satisfactory. The results are shown in figure 12. Discussants opinion on the behaviour in relation to the prevention of ecosystem degradation indicated a "Negative" response. The results are shown in Figure 13 below.

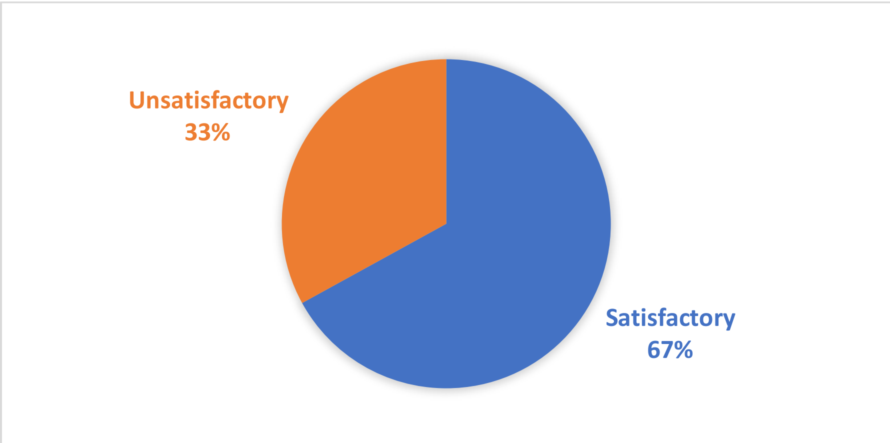

Figure 12: Knowledge of aquatic ecosystems among community inhabitants

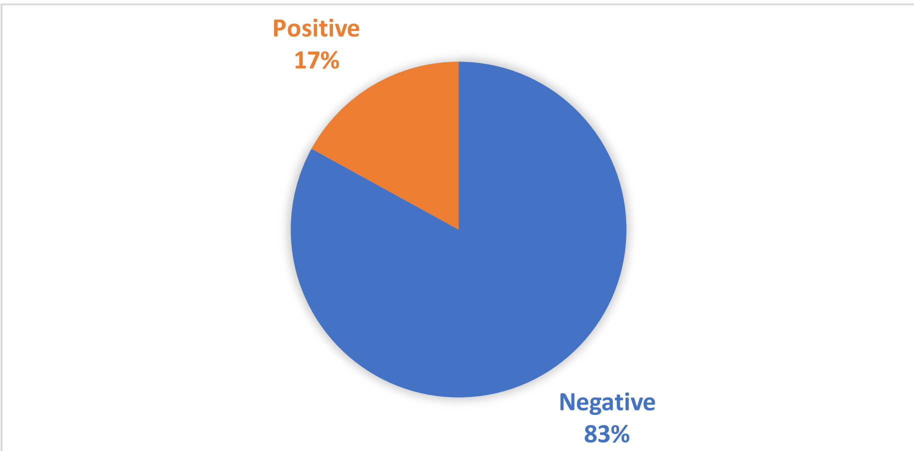

Figure 13: Behaviour in relation to prevention of aquatic ecosystem degradation

4.1.6 Highlights of the focus group discussion

From the focus group discussion, a consensus was reached about the need to enhance stewardship of the coastal ecosystems. Stakeholders acknowledged the need for an educational model which could be used to target the non-formal sector since there was no structured materials for sensitisation programmes. Also, members suggested that the wildlife and the social welfare department of the Ada East Assembly could use the educational material to undertake sensitization programmes in the coastal communities.

Members also requested to have an educational model which addresses issues sustainably and should reveal the benefits that would be derived from the peaceful co-existence between society and the ecosystems. Stakeholders agreed with the practical activities to engage community members to learn about their local environment. They indicated that this will empower inhabitants with skills to reduce the risk of hazards in the coastal zone which are considered threats to the aquatic ecosystems.

After several discussions, members reached a consensus that the educational model should be simplified for easy use and should focus on issues affecting the coastal ecosystems of Ada so the inhabitants could easily get related. They added that measures should also include ways that community members could adopt in order to be very good stewards. The case of medium for communicating stewardship came up and members also suggested that since most of the community members have television or radio, it could also be better to sometimes use these electronic platforms to enhance community stewardship of ecosystems. Stakeholders agreed that the youth groups are the best targets for the environmental education to enhance stewardship of aquatic ecosystems.

4.1.7 Stewardship Educational Model from the Perspective of Stakeholders

The model in figure 14 is a conceptual framework proposed by the stakeholders to enhance ecosystem stewardship particularly for the non-formal approach. It describes that environmental educators should design specific educational strategies to deal with specific challenges affecting ecosystems. Challenges should therefore not be put together in the educational process. In this proposed model, environmental educators integrate three key educational strategies (awareness raising, dialoguing and community engagement) to provide the needed knowledge, sustainability values and skills to community members. The attention is focused on enhancing stewardship where individuals are inspired to learn about the natural systems and human factors which influence the health of aquatic ecosystems particularly, those in their immediate environment or in connection to their livelihoods. Stakeholders also emphasize on the need to provide basic incentives to motivate local community members who participate in the stewardship programme.

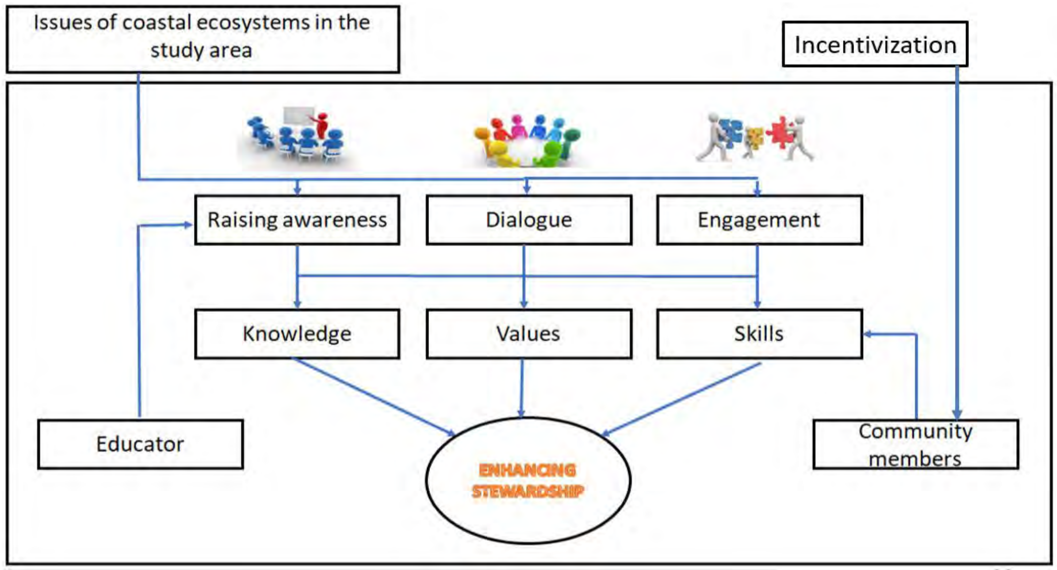

Figure 14: Stewardship Educational Model from the Perspective of Stakeholders

4.1.8 Demographics of Key Informants

More than two-thirds out of 203 individuals who responded to the key informant survey were males (70%) and majority of the respondents fell in the age group of 40 to 49 constituting (42%). More than half of the respondents are engaged in farming and fishing along the coastal area. Artisans, dressmakers, civil and public servants formed a small proportion of respondents (about 5%). Over 90% of the respondents are Christians. Few respondents (5%) had tertiary education which reflects poor educational levels in the coastal communities. Figures 15, 16, 17 and 18 show the distribution pattern of the demographic characteristics of the respondents.

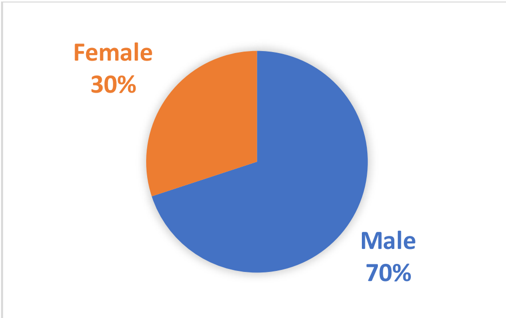

Figure 15: Distribution of Respondents by Sex

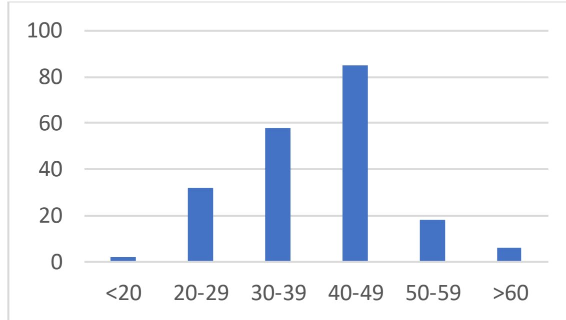

Figure 16: Distribution of Respondents by Age

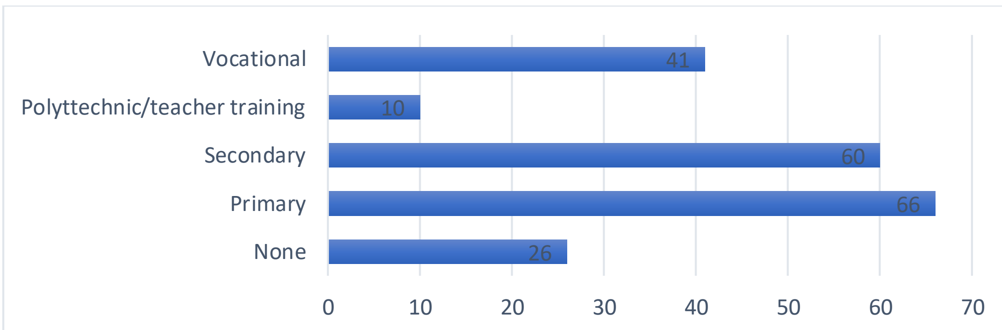

Figure 17: Level of Education of Respondents

Figure 18: Main Occupation of Respondents

4.1.9 Farming and land cover change

More than two-thirds (74%) of the respondents indicated that, farming even though provides livelihood and food for many inhabitants poses several negative impacts to the aquatic ecosystems in the coastal area. However, 26% stated they perceive no negative impacts on the aquatic ecosystems resulting from the farming activities.

a) Land preparation

From the responses of the respondents on the land preparation methods in the area. It was clear that the common approach for preparing land for farming is the slash and burn method which exposes land along the water ways to erosion.

b) Fertilizer

More than half (57%) of the Respondents stressed on the use of fertilizer by farmers as having negative impacts on the soil fertility and in water flowing in the ecosystems. They cited problems as inappropriate application of fertilizer on the crops in terms of the quantity, type, location, timing and not following recommended methods.

c) Pesticides/herbicides/fungicides

The respondents (56%) described that the use of agrochemicals by farmers is gradually having a negative impact on ecosystems particularly citing the water bodies. They emphasized that the chemicals find their way into the water, making it inhabitable for other useful organisms like the fishes and clams. However, a small number of respondents (10%) indicated that, use of such chemicals has no impacts on the coastal aquatic ecosystems and just 1% was indifferent about the impacts of the agrochemicals.

Table 5 below shows the Multiple logistic regression analysis of awareness on the impact of pesticide application associated with demographic characteristics. It reveals that respondents' level of education was significant with a positive coefficient. This indicates that individuals who are more educated are two times more likely to be aware of the impact of pesticide application on soil and water than those who have lower or no formal education at all.

Table 5: Multiple logistic regression analysis of Awareness of impact of pesticide application associated with demographic characteristics of respondents

Variable	Coefficient	Std. Error	P-value	Odds Ratio	95% C.I
Gender	-0.550	0.493	0.265	0.577	(0.219,1.517)
Age	-0.067	0.044	0.130	0.935	(0.857,1.020)
Level of Education	0.473	0.178	0.008***	1.605	(1.133,2.273)

***Significant at 5%

a) *Harvest quality change*

Less than half of the respondents (42%) indicated a reduction in yield from the natural soil unless supported with agrochemicals to boost soil fertility. They attributed this to poor management of the soil fertility by farmers and land degradation resulting from indiscriminate waste disposal. However, others attributed the low outputs to climate change and climate variability.

4.1.10 Fishing in the communities

The coastal area is a fishing community. All respondents indicated that fishing activities are currently affecting coastal aquatic ecosystems. They explained this with factors such as overfishing, destructive fishing techniques, alteration of the habitats by various human activities. From the survey, 63% of the respondents said there are regulations to control fishing activities in the communities. However, they emphasized that there is lack of enforcement. Approximately 25% of the respondents said they think there are no regulations on fisheries and the rest were indifferent about the regulations.

For an idea about the fish catch over the past 15 years, within the coastal communities, more than eighty percent (81%) reported significant changes over the years emphasizing on a decrease in the catch. Less than ten percent (8%) rather reported on an increase in the catch attributing to factors such as the use of effective fishing gears.

4.1.11 Livestock impacts

Livestock keeping is one activity that could have a negative impact on ecosystem unless well managed. Fifty-five percent of the respondents indicated a negative impact on the aquatic ecosystems while 45% also said the impact of livestock on the ecosystems is not significant. Reasons given to the negative effect included water contamination and destruction of vegetation. An appreciable 42% of the respondents indicated there is the free-range system of keeping these animals with no regulations to control them around water bodies. Hence, the animals walk into the water bodies and also contaminate the water with their faeces.

Table 6 below presents a Cross tabulation showing the level of education and the likelihood to use manure on farmlands. The analysis reveals that majority of the respondents who have no education and those who have up to primary education (constituting 66.7% and 63.6%

respectively) are less likely to use manure in place of chemical fertilizer on their farms. However, it was observed from the responses that individuals who had a higher level of education are more likely to use animal waste as manure to fertilize the soil. For instance, 66.7% of the respondents who had up to secondary education were more willing to use manure in place of chemical fertilizers on their farmlands.

Table 6: Cross tabulation - Level of education and use of manure

Level of Education		Is any manure recycled for fertilizer use?					
		Yes	No	Don't know	Chi-Square	D.f.	P-Value
None	Count	6	12	0	20.240	8	0.009
	%	33.3	66.7	0.0			
Primary	Count	12	28	4			
	%	27.3	63.6	9.1			
Secondary	Count	26	12	4			
	%	61.9	28.6	9.5			
Polytechnic/teacher training	Count	4	2	0			
	%	66.7	33.3	0.0			
Vocational	Count	5	16	2			
	%	21.7	69.6	8.7			

4.1.12 Hunting

There is a presumption that hunting of bush meat is not a serious threat to aquatic ecosystems in the coastal communities. However, the few respondents forming 5% who stressed hunting activities are having some negative impacts mentioned the use of bush meat as protein supplement. They described that hunting occasionally leads to bush burning along waterways and therefore exposes the aquatic ecosystems to erosion Respondents (10%) also indicated that bush meat is declining over the years but the majority (90%) had no idea about the trend of wildlife in the area.

4.1.13 Sources of fuel

On the choice of fuel, over 82% of respondents use firewood and charcoal as fuel for domestic or commercial activities. They were also aware of the impacts of firewood and charcoal production on aquatic ecosystems. More than half of the respondents (55%) said they have observed a rapid decline in the vegetation mass along various aquatic ecosystems over the years.

Table 7 below presents a cross tabulation of the level of education and effects of charcoal production on aquatic ecosystems. From the results, majority of the respondents who have no education and those who have up to primary education indicated that they do not know the effect of charcoal production on the aquatic ecosystems representing (constituting 72.7% and 60.7% respectively as compared to those who are aware of the impacts). However, it was observed from the responses that individuals who had a higher level of education were able to describe some impacts of charcoal production on the aquatic ecosystems.

Table 7: Cross tabulation - Level of education and effects of charcoal production

Level of Education		Effects of charcoal production on the ecosystems					
		Yes	No	Don't know	Chi-Square	D.f.	P-Value
None	Count	0	16	6	26.288	8	0.001
	%	0	72.7	27.3			
Primary	Count	10	34	12			
	%	17.9	60.7	21.4			
Secondary	Count	14	20	20			
	%	25.9	37	37			
Polytechnic/teacher training	Count	4	0	6			
	%	40	0	60			
Vocational	Count	6	13	16			
	%	17.1	37.1	45.7			

4.1.14 Flooding and erosion

a) Flooding

From the survey, 48% of the respondents stressed that there have been issues of flood disaster over the years citing the locations affected most and the damaged caused. For aquatic ecosystem, they described that the flood waters wash in waste materials especially plastics into the rivers, lakes and ponds. An equally 48% of the respondents indicated that although there have been floods occurring intermittently they think it is really not a major issue in the coastal area and for aquatic ecosystems.

b) Erosion

From the survey, 71% of the respondents are aware of the impacts of erosion on aquatic ecosystems. However, they indicated that although there has been erosion in some localities they think it is really not a major issue in the coastal area. Close to half of the respondents (44%) said they have been affected by erosion citing destruction of their buildings and farmlands. Less than one-third (26%) of the respondents have not experienced any negative impact of the hazard and the rest had nothing to say about the condition of erosion.

4.1.15 Use of water in the surrounding aquatic ecosystems

From the survey, 83 % of the respondents and their households directly depend on the water from the aquatic bodies in the coastal zone. Particularly for domestic activities such as bathing, cooking, drinking, washing and cleaning. Seventeen percent (17%) cited no dependence on the aquatic bodies in the area.

4.1.16 Change in the water quality

From the survey, close to half (49%) of the respondents felt that there has been a decline in water quality over the years. They attributed the condition to indiscriminate dumping of refuse into water and in the surroundings, which find their way into various aquatic ecosystems, removal of vegetation cover and increasing domestic and livelihood activities which release waste into the water. More than one-third (38%) of the respondents think that there has been no change with regards to water quality since they continue to use it and have not experience any disease outbreak or any major disaster as result of decline in water quality. About 9% of the respondents were indifferent of the situation. Table 8 below shows a Multiple logistic regression analysis of the awareness of impact of human activities on the quality of aquatic ecosystem associated with demographic characteristics. It revealed that respondents' level of education was significant (p-value = 0.005) with a positive coefficient. This gives an indication that individuals who are more educated are 2 times more likely to be aware of the impact of human activities on the quality of water in the various aquatic ecosystem than those who have less or no formal education at all.

Table 8: Multiple logistic regression analysis of Awareness of impact of human activities on the quality of the ecosystem associated with Gender, Age and Level of Education

Variable	Coefficient	Std. Error	P-value	Odds Ratio	95% C.I
Gender	0.180	0.489	0.713	1.197	(0.459, 0.3118)
Age	0.030	0.061	0.622	1.030	(0.915, 1.161)
Level of Education	0.483	0.172	0.005***	1.620	(1.157,2.268)

***Significant at 5%

Table 9 below presents a Multiple logistic regression analysis of Awareness of Water Borne diseases associated with demographic characteristics of respondents. From the results, Respondents' level of education was significant in the analysis with a positive coefficient. The indication is that individuals who are more educated are two times more likely to be aware of water borne diseases in an unhealthy aquatic ecosystem than those who have less or no formal education at all.

Table 9: Multiple logistic regression analysis of Awareness of Water Borne diseases associated with Gender, Age and Level of Education

Variable	*Coefficient*	*Std. Error*	*P-value*	*Odds Ratio*	*95% CI*
Gender	-0.061	0.482	0.899	0.941	(0.366, 2.419)
Age	0.051	0.169	0.762	1.053	(0.755, 1.467)
Level of Education	0.689	0.212	0.001***	1.992	(1.314, 3.020)

*** Significant at 5%

4.1.17 Waste disposal and impacts on water bodies

From the interview, it was realized that respondents are aware of some of the consequences of waste disposal and their negative impacts on water bodies. Respondents explained that there are no sites for waste disposal in their homes and member in the communities' dump refuse in the surroundings which may end up in the aquatic ecosystems when it rains. About one-third (28%) of respondents indicated that refuse is dumped into public dumping sites which are also not properly managed. Hence running waters usually carry waste into the aquatic ecosystems.

Table 10 below is a cross tabulation of respondents Level of education and Waste disposal. The results reveal that, majority of the respondents who have no education and those who have up to primary education are not properly disposing of their refuse. However, it was observed from the responses that individuals who had a higher level of education are likely to dispose of their refuse properly. For instance, 80% of the respondents who had up to tertiary education had indicated that they bury their refuse.

Table 10: Cross tabulation - Level of education and waste disposal

Level of Education		Where do you dump your refuse?						
		Env't	Public dump	Burn	Bury	Chi-Square	D.f.	P-Value
None	Count	2	8	10	4	34.821	12	0.001
	%	8.3	33.3	41.7	16.7			
Primary	Count	2	28	14	20			
	%	3.1	43.8	21.9	31.3			
Secondary	Count	4	6	26	24			
	%	6.7	10.0	43.3	40.0			
Polytechnic/teacher training	Count	0	2	0	8			
	%	0.0	20.0	0.0	80.0			
Vocational	Count	0	12	15	12			
	%	0.0	30.8	38.5	30.8			

Table 11 below is a correlation matrix of Wastewater disposal and Environmental challenges. The results show that the respondents interviewed who have a higher level of education view their wastewater disposal site as a problem more than those who have a lower level of education. In the same way, they were also aware that improper wastewater disposal causes environmental challenges more than respondents who have little or no formal education. Majority of the respondents who indicated that there is a problem with discharge of wastewater viewed the problem as an environmental challenge.

Table 11: Correlation matrix (Wastewater disposal)

	Sex	Age	level of Education	Do you think this is a problem?	Do you think there will be an environmental impact?
Do you think this is a problem?	0.052	0.135	0.142*	1	
Existence of Environmental impacts	0.006	0.118	0.154*	0.809*	1

*. Correlation is significant at the 0.05 level

4.1.18 Knowledge of coastal ecosystems

The communities have different social groups including recreational, religious, political and several interest groups. More than half of the respondents (54%) indicated that their groups usually discuss issues concerning aquatic ecosystems in the coastal environment and the need to protect these natural sites. However, they added that the impact to bring about the necessary change has not been effective.

Respondents described the ecosystems based on four attributes - as being naturally occurring, made up of both biotic and abiotic components, interaction among the components and being a dynamic unit. Figures 19 shows the percentage of respondents who were able to describe each attribute.

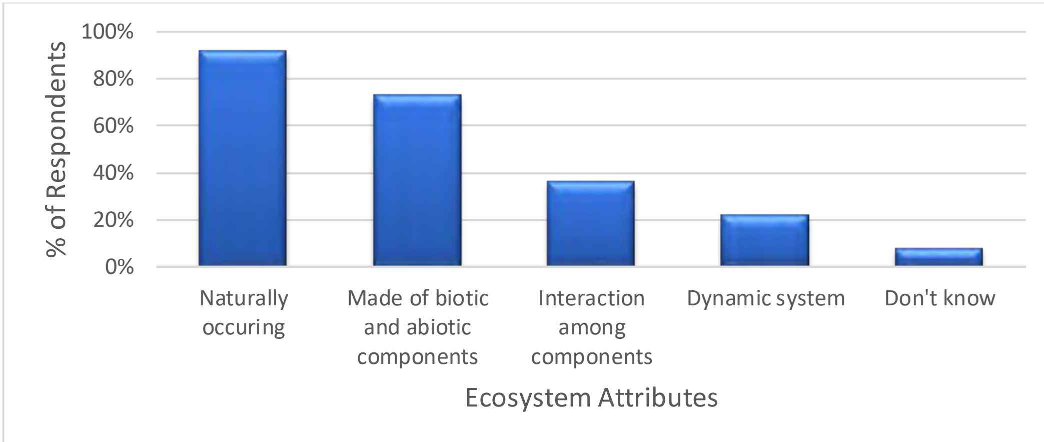

Figure 19: Understanding of ecosystem attributes

For over ninety percent of the respondents (93%) the concept of naturally occurring was perceived in their explanation of ecosystems. It means inhabitants understood that these natural sites have evolved without human interventions. Secondly, 62% of the respondents were able to explain the concept that ecosystems are comprised of biotic and abiotic factors. They indicated their awareness of both biotic factors and abiotic factors which exist to make up the ecosystems and also explained role to support the structure and functioning.

About the interaction among the components of the ecosystems, 30% were clear on the fact that the ecosystem involves complex interactions among the biological factors and among the abiotic factors and these interactions make the ecosystem a self-supporting unit.

The last key factor is the dynamism of ecosystems where components adapt to the prevailing environmental conditions it's able to support itself based on complex natural processes. For this aspect of the ecosystem, relatively few respondents were able to clarify the concept in their explanation (18%). In all, 7% of the respondents stated clearly that they have no idea about the ecosystem.

4.1.19 Economic and productive systems

From the responses of the interviews, the major livelihoods in the coastal communities are farming, fishing and tourism. From the perception of the respondents, the outputs of these economic activities are gradually declining. Fisheries have been the most severely affected resource (figure 20). They attributed this decline to four factors which are over exploitation, pollution of the ecosystem environments, poor knowledge of the ecosystem structure and functioning and climate change impacts.

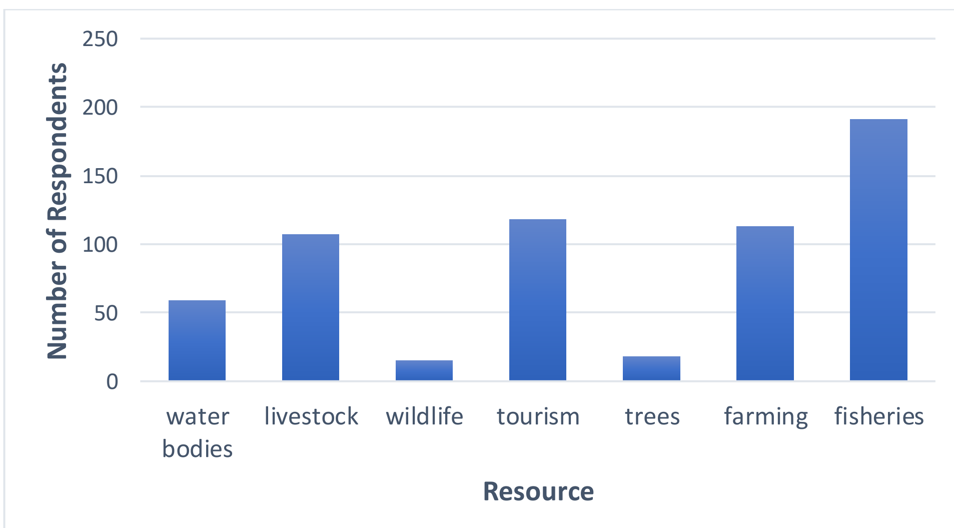

Figure 20: Affected economic activities in the coastal area

4.1.20 Sites, Plants and Animals of social importance

a) Sites of social importance

For the socio-cultural impacts on aquatic ecosystems, respondents cited specific areas in the aquatic ecosystems which have been reserved as sacred grooves, shrines and festival grounds. The people celebrate the Asafotufiam festival to commemorate ancient wars of the Ada people with neighbouring tribes. For tourism, the Ada coastal area is regarded as one of the tourist sites in Ghana. The Volta River, estuary and different types of animals and plant species attract people from all over the world for sightseeing. People visit the beach for several reasons including, fun, research work, holiday and relaxation etc. respondents indicated that, these activities have impacts on the aquatic ecosystems because of indiscriminate waste disposal and poor waste management.

b) Plants and animals of traditional importance

According to respondents, some ethnic groups within the communities revere some organisms in the aquatic ecosystems. In particular, crocodiles, turtles and whales are animals regarded traditionally important for several rituals or used as media for communication with their ancestors. For example, it is a taboo to hunt a crocodile in the communities. For the plant species, they cited a plant locally known as “Nyanyana”, typical revered for spiritual powers.

4.2 Aquatic Ecosystem health Assessment

4.2.1 Landuse Assessment

Figure 21 below presents the results of the landuse assessment along the waterways in the various aquatic ecosystems. More than two-thirds of the sampling areas were found to be in the poor condition. Generally, areas away from the settlement zones indicated a good landuse score. These are S1 (downstream of the Futue stream), S4 (western bank of the river), S6 (mangrove swamp) and S13 (estuary).

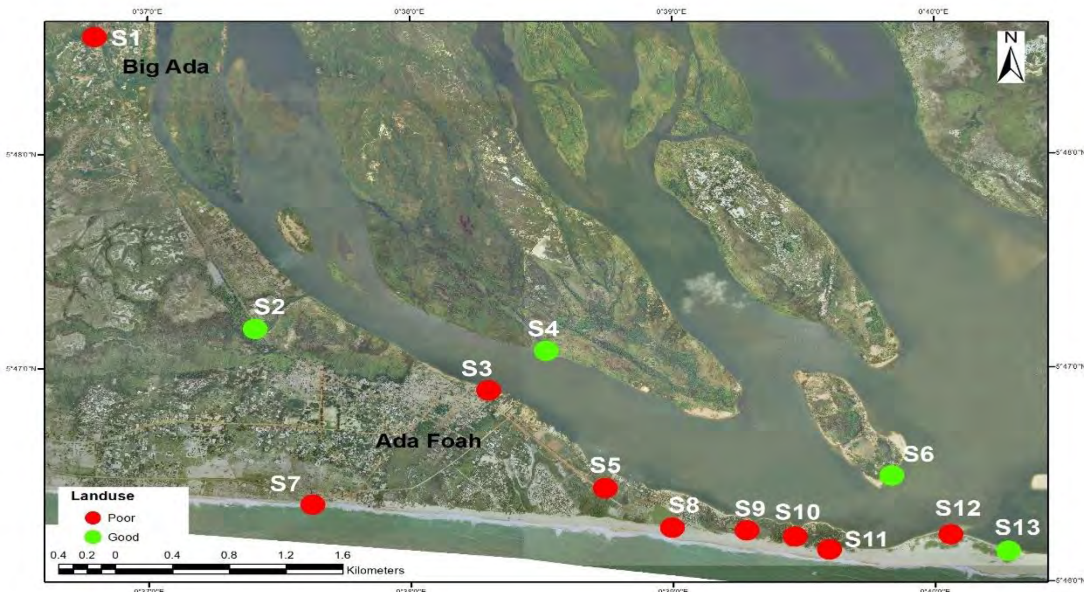

Figure 21: Landuse Assessment of the various sampling locations

4.2.2 Water Quality Assessment

Figure 22 below presents the results of the water quality assessment. The quality of water was good in more than two-thirds of the sampling areas. However, water in the stagnant aquatic ecosystems was found to be in poor condition. The poor sites are S5 (ditch), S8 (pond), S11 (lagoon) and S12 (lagoon).

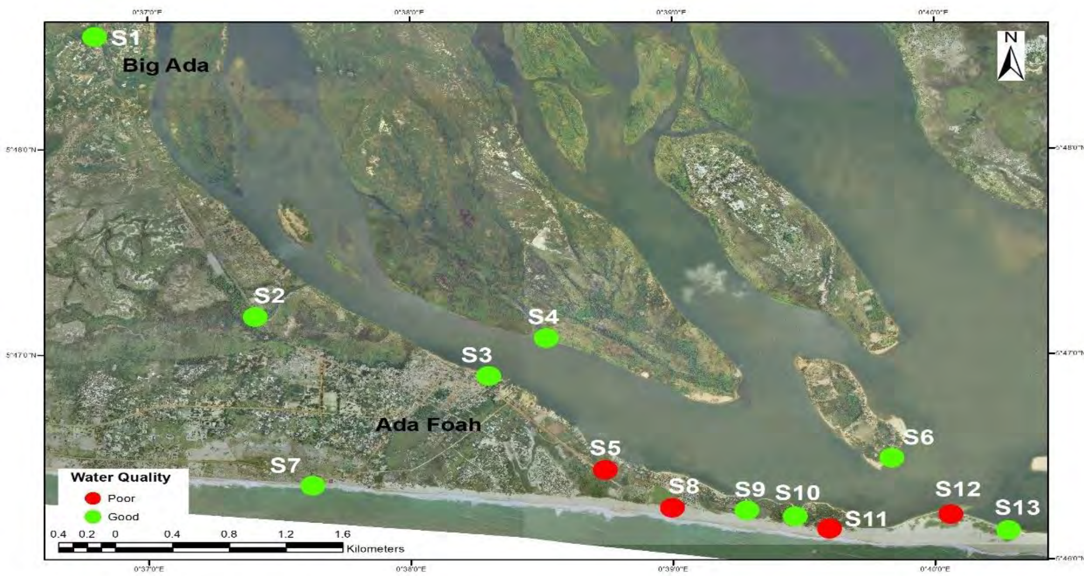

Figure 22: Water quality Assessment of the various sampling locations

4.2.3 Habitat Assessment

Figure 23 below shows the results of the habitat assessment. Close to 80% of the sampling areas were poor with respect to habitat quality. These ecosystems have eroded banks, blockages, lots of trash and poor habitable locations for biotic conditions. It was realized that only the aquatic ecosystems in the eastern side of the river had a good habitat quality. These sites are S4 (eastern bank of the river), S6 (mangrove swamp) and S13 (estuary).

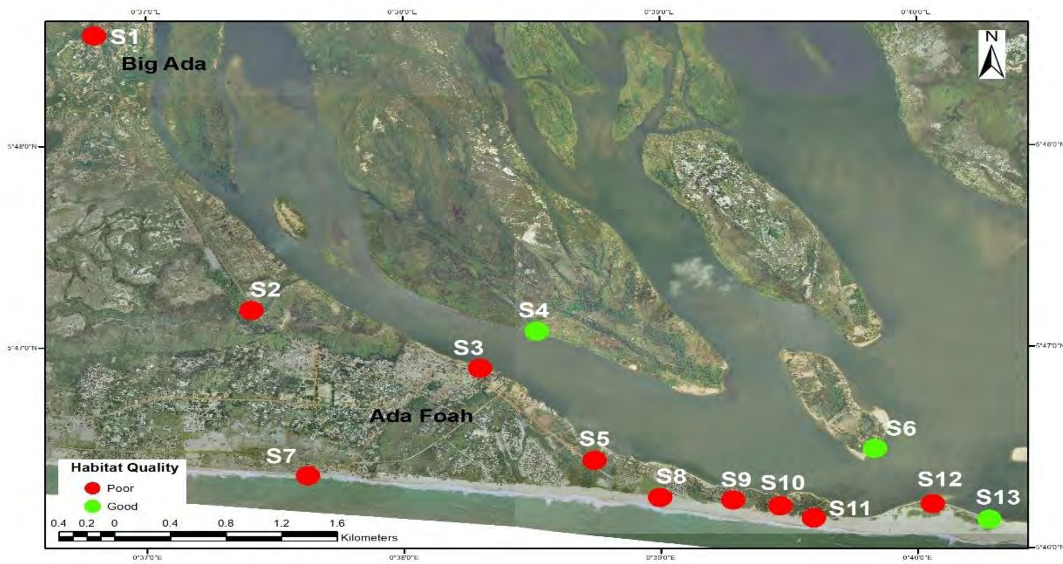

Figure 23: Habitat Assessment of the various sampling locations

4.2.4 Implications of Aquatic Ecosystem health index

Table 12 below presents the results from the ecological investigations categorized under landuse, water and habitat quality, conditions in sites S4 (eastern bank of the River Volta), S6 (mangrove swamp) and S13 (estuary) were found to be the locations which presented the ideal environment of a healthy aquatic ecosystem. These locations passed all the three ecological surveys conducted. This could be attributed to the fact that these zones were relatively far from human influence. Hence less landuse and land developments impacts. The mangrove swamp for instance help to sieve out pollutants from running waters before entering the main waterways in the aquatic ecosystems. Sites S5 (ditch), S8 (pond) S11 and S12 (lagoons) were poor in all three ecological assessments. The water from the ditch and lagoons were polluted as inhabitants living close by, continue to dispose of garbage into the water bodies. Sampling site S2 (downstream of the Futue stream), indicated a good water quality and landuse score but a low habitat quality score. The poor habitat condition could be attribute to landuse impact from the upstream by not caused by the nearby landuse. Site S3 (western bank of river) shows a high-water quality score but indicated a low landuse score which is an indication that landuse problem is not affecting ecosystems within the period of sampling. Such problem in the ecosystem might be seasonal or periodical. Site S2 (downstream of the Futue stream) presented a low habitat score and a high landuse score. This could be attributed to the fact that the problems in the habitats of the ecosystem were not caused by nearby landuse but could be the result of landuse up stream. Site S1 (upstream of the Futue stream) indicated a low score for both habitats and landuse assessment which reflects that landuse is negatively affecting the habitats in the stream.

Table 12: Landuse, Water quality and Habitat Assessment

	Sampling areas	Landuse score	Rating	Water quality score	Rating	Habitat score	Rating
S1	Stream	20	🔴	33	🟢	13	🔴
S2	Stream	28	🟢	31	🟢	21	🔴
S3	River	17	🔴	29	🟢	19	🔴
S4	River	29	🟢	35	🟢	25	🟢
S5	Ditch	18	🔴	23	🔴	11	🔴
S6	Mangrove Swamp	30	🟢	31	🟢	29	🟢
S7	Intertidal zone	15	🔴	25	🟢	18	🔴
S8	Pond	20	🔴	23	🔴	19	🔴
S9	Creek	20	🔴	29	🟢	15	🔴
S10	Creek	19	🔴	31	🟢	17	🔴
S11	Lagoon	19	🔴	23	🔴	19	🔴
S12	Lagoon	17	🔴	23	🔴	11	🔴
S13	Estuary	28	🟢	31	🟢	25	🟢

4.2.5 Seasonal variation of physicochemical parameters

Mean water temperature for the various sampling locations did not show significant variation for both dry and wet seasons. The highest temperature was recorded in site W8 (pond) during the dry season at 33°C. For both wet and dry season salinity values recorded indicated slight differences. The salinity levels recorded at sites W7 (intertidal zone) and W13 (estuary) were within range of natural background levels of 35mg/l and 0.5 to 35mg/l respectively. Site W7 is an intertidal zone containing marine water and W13 is estuarine which is influenced by both marine and fresh waters.

Figure 24 presents the mean DO for the sampling locations. There was no significant variation for both dry and wet seasons for mean DO concentrations (p-value = 0.693). However, for the inland areas within the coastal zone, the wet seasons recorded relatively higher values than the dry season. In all, DO concentrations for both the dry and wet seasons were above 4mg/l which is the minimum required for the survival of the biological components of the ecosystems (Begum, 2008). There was no significant difference compared with the natural background concentration for both dry and the wet seasons mean values. The highest mean DO was recorded at site W8 (pond) at 11mg/l.

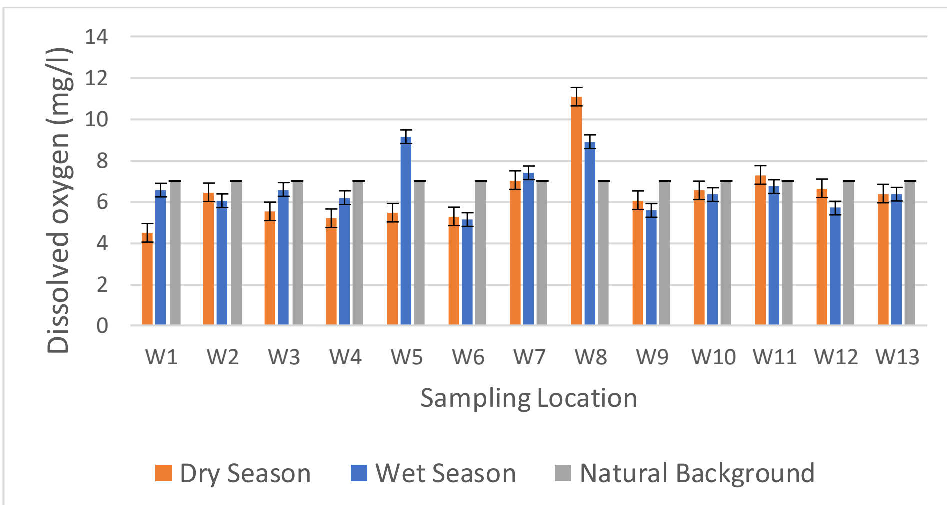

Figure 24: Mean dissolved oxygen concentrations at the sampling locations

Nitrate levels at the various sampling locations were relatively very high with a significant difference compared to the natural background of 0.23mg/l (APHA, 1998) with a p-value of 0.000. Similar trends were recorded for both dry and wet seasons. However, mean concentrations of both seasons did not show significant difference (p-value = 0.107). The highest nitrate concentration was recorded in site W7 (intertidal zone) at 2.75mg/l in the wet season (Figure 25).

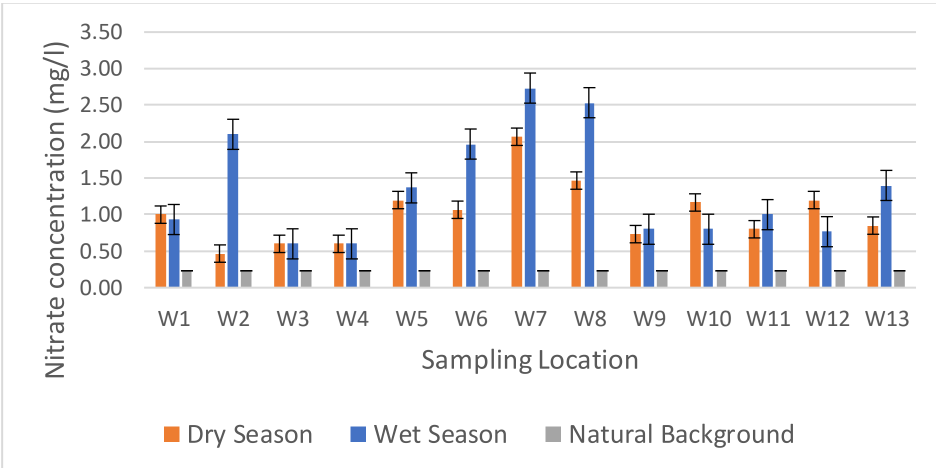

Figure 25: Mean Nitrate concentrations at the sampling locations

Mean phosphate concentrations at the various sampling locations were also relatively high with a significant difference compared to natural background of 0.02mg/l (APHA, 1998) with a p-value of 0.000. Higher levels were recorded at the sites close to marine environments compared to inland areas and site W5 (ditch) indicated the highest concentration of phosphate in the study area at 1.30mg/l (Figure 26). The was no significant difference between the wet and dry seasons mean values. (p-value = 0.645).

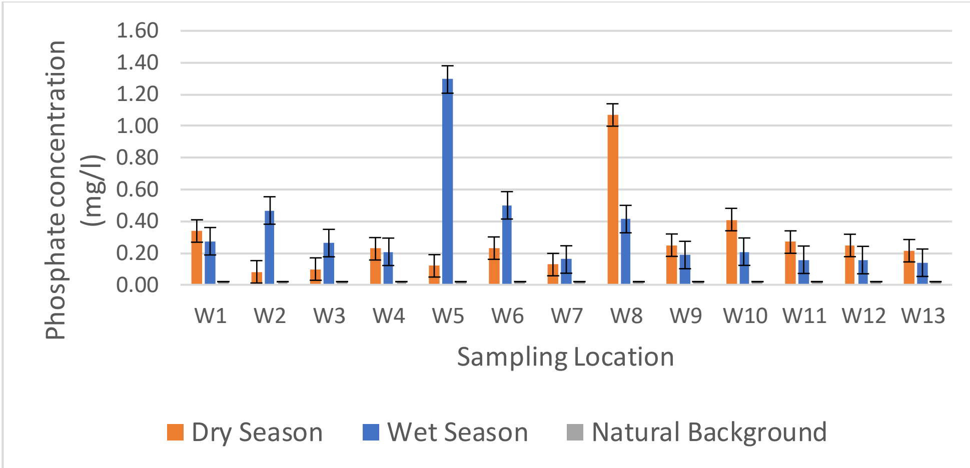

Figure 26: Mean Phosphate concentrations at the sampling locations

The mean total nitrogen concentrations in the wet season were significantly higher than in the dry season (p-value = 0.01). For total phosphorous concentration, the levels in the dry season were relatively higher but no significant variations (p-value = 0.12). However, site W5 (ditch) recorded the highest level at 3.5mg/l which was in the wet season.

The total dissolved solids (TDS) indicated higher level towards the near shore areas than the inland area of the study area. Mean conductivity increases from the inland areas towards the marine environments. There were no significant variations between the levels recorded in both seasons (p-value = 0.37).

Turbidity was relatively high in all the sampling locations. Figure 27 shows the highest turbidity which was recorded in the dry season in site W8 (pond) at 83NTU. The dry season recorded higher values with significant variations compared to the wet season (p-value = 0.014). Compared to natural background level of 5NTU, there were significant difference for both seasons (p-value = 0.000 for dry and 0.014 for wet seasons).

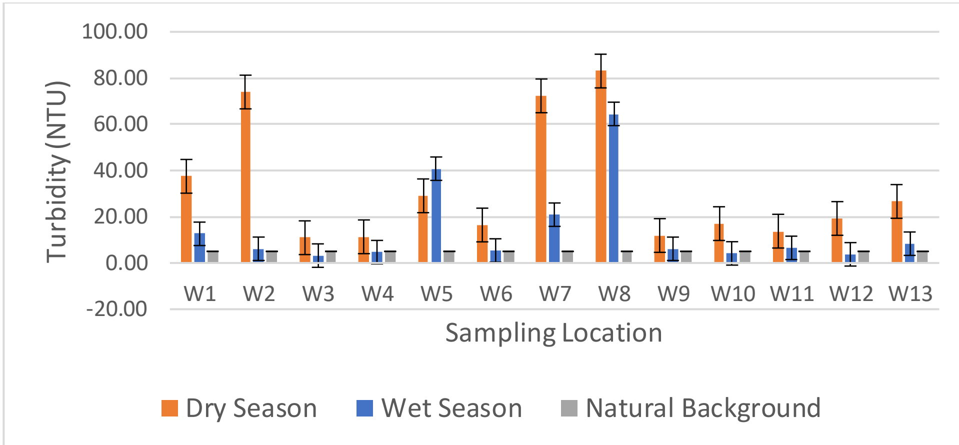

Figure 27: Mean Turbidity at the sampling locations

The pH levels in all the sampling locations were slightly above the natural background level of 7. However, the recordings were within the range of survival (6 – 8) for aquatic organisms in ecosystems.

Appendices F1 and F2 present the raw data values of physicochemical parameters recorded for the wet and dry seasons respectively.

4.2.6 Macroinvertebrates and ecosystem health

Table 13 below shows macroinvertebrate diversity in the sampling locations. Results indicated relatively low diversity in the study area. Shannon diversity index revealed very low species diversity in the study area. The highest recorded was 1.5 at site S8 (pond). Simpson's diversity index also confirmed site S8 as most biodiverse. Species evenness index was very low in the study area. The highest was recorded at site S8 (Pond). Species richness also indicated relatively low values in all sampling locations. In terms of species abundance, sampling site S9 (creek) recorded the highest number of 101 for six different species identified in the location. Species variety (total number of different species) of macroinvertebrate was highest in site S9 and S4 with six varieties each. Two most abundant macroinvertebrates in the study area were found to be *Penaeus* sp (total abundance of 140) and *Lymnaea* sp (total abundance of 102) which is an indication of unhealthy aquatic ecosystems.

Table 13: Number of Macroinvertebrate per ten sweeps and diversity indices in the sampling locations

Class/Order	**Family/Species**	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	TOT
Gastropoda	Ampullariidae/*Pomacea*											3			3
Decapoda	*Ocypode quadrata*	11						3	11	3					28
Diptera	Chironomidae/*Chironomus*		8						4					6	18
Diptera	Culicidae/*Anopheles*		9											4	13
Osteichthyes	Juvenile fish	3				14						6			23
Odonata	Calopterygidae/*Phaon iridipennis*				2										2
Bivalvia	Etheriidae/*Etheria*							1		1					2
Crustacea	Penaeidae/*Penaeus*		7		5	64	9		7	9	8	14	17		140
Gastropoda	Potamididae/*Tympanostonus fuscatus*	7							7	27	7	6	12	4	70
Gastropoda	Lymnaeidae/*Lymnaea*		2		18		10			56	16				102
Gastropoda	Pleuroceridae/*Pleurocera*			4				4							8
Polychaeta	Capitellidae/*Capitella*				5										5
Polychaeta	Nephtyidae/*Nephtys*				8					5	9				22
Ephemeroptera	Baetidae/*Centroptilum*				1										1
Odonata	Libellulidae/*Zygonyx*								4						4
Species abundance (n)		21	26	4	39	78	19	8	33	101	40	29	29	14	
Simpson Index of Diversity		0.38	0.27	1	0.27	0.70	0.47	0.32	0.21	0.39	0.26	0.31	0.50	0.30	
Evenness		0.64	0.83	0	0.95	0.31	0.45	0.64	1.00	0.78	0.87	0.81	0.44	0.70	
Species Richness		0.66	0.92	0	1.37	0.23	0.34	0.96	1.14	1.08	0.81	0.89	0.30	0.76	
Shannon Index of Diversity		0.98	1.28	0	1.45	0.47	0.69	0.98	1.54	1.19	1.33	1.24	0.68	1.08	
Species variety (S)		3	4	1	6	2	2	3	5	6	4	4	2	3	

4.2.7 Aquatic macrophytes and ecosystem health

Table 14 shows the aquatic macrophyte diversity description in the sampling locations. In total, 20 macrophyte species were recorded in the study area. Shannon Index of Diversity (H´) and Simpson's Index of Diversity (D) were relatively higher in the areas with less human influence. For example, site 4 located in the western bank of the River Volta is away from human impact and site 6 which is also in the mangrove swamp recorded the highest scores for diversity. From the random quadrat sampling technique, *Pycreus sp* was found to be highest in population density which was located in sampling site S5 (Vegetation along the ditch). According to the population size within the 50m^2, *Pycreus sp* was still found to be the most abundant estimated at 4200 species (Table 15). *Eichhornia crassipes* was the most frequent macrophyte in the study area. However, species like *Vossia, Nymphea, Ceratophyllum, Vallisneria* and *Typha* species were found to be common along the aquatic systems. It was observed that *Eichhornia crassipes* which has been described as an exotic plant is taking over the niche of the local plant species. There were no organisms recorded in site 13 which was along the estuary.

Table 14: Population density of Aquatic macrophyte species and diversity indices in the sampling locations

Family	**Species**	**Growth form**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**	**S10**	**S11**	**S12**
Pontederiaceae	*Eichhornia crassipes*	Free-floating	6.1	6.2	0.3	16.2		7.9			16.7			0.2
Cyperaceae	*Scirpus cubensis*	Emergent	2											
Nymphaeaceae	*Nymphaea lotus*	Floating-leaved	2.2					0.8						
Poaceae	*Vossia cuspidata*	Emergent	16.9		7.2	2.8		4		3		3		5.4
Alismataceae	*Sagittaria guayanensis*	Floating-leaved	1.7											
Cyperaceae	*Pycreus mundtii*	Emergent	1		0.3		84							
Acanthaceae	*Avicennia germinans*	Shrub	0.2				0.5			0.4		0.2	0.2	
Poaceae	*Panicum maximum*	Herb	1.5				9.8		20.9	23	2.8			3
Fabaceae	*Acacia*	Tree	0.3	1.4										
Fabaceae	*Mimosa pudica*	Emergent		4.9										
Lentibulariaceae	*Utricularia reflexa*	Submerged		7.9			0.3							
Meliaceae	*Azadirachta indica*	Tree			0.3									
Convolvulaceae	*Ipomoea aquatica*	Emergent				3.4								
Solanaceae	*Solanum lycopersicum*	Herb			0.3									
Polygonaceae	*Polygonum lanigarum*	Emergent				3		4.8						
Ceratophyllaceae	*Ceratophyllum demersum*	Submerged				5.4		0.5			0.9			
Hydrocharitaceae	*Vallisneria aethiopica*	Submerged				19		1			33.2			
Commelinaceae	*Commelina diffusa*	Emergent						0.3						
Typhaceae	*Typha domingensis*	Emergent								11		1.9	11.8	
Salviniaceae	*Salvinia molesta*	Free-floating						0.2	2.3					
Species abundance (n)			31.9	20.4	8.4	49.8	94.6	19.5	23.2	37.4	53.6	5.1	12	8.6
Simpson Diversity			0.67	0.70	0.26	0.73	0.2	0.73	0.18	0.53	0.52	0.51	0.03	0.48
Evenness			0.68	0.91	0.38	0.83	0.28	0.73	0.47	0.66	0.64	0.74	0.12	0.68
Species Richness			2.31	1	1.88	1.28	0.66	2.36	0.32	0.83	0.75	1.23	0.4	0.93
Shannon Diversity			1.5	1.26	0.61	1.49	0.39	1.53	0.32	0.91	0.88	0.81	0.09	0.75
Species variety (S)			9	4	5	6	4	8	2	4	4	3	2	3

Table 15: Macrophytes, Density, Population and Frequency in the sampling area

SITE	SPECIES	DENSITY (Plants/m^2)	POPULATION (50m^2)	FREQUENCY
S1	*Eichhornia crassipes*	6.1	305	0.6
	Scirpus cubensis	2	100	0.2
	Nymphaea lotus	2.2	110	0.4
	Vossia cuspidata	16.9	845	0.7
	Sagittaria guayanensis	1.7	85	0.1
	Pycreus mundtii	1	50	0.1
	Avicennia marina	0.2	10	0.1
	Panicum maximum	1.5	75	0.1
	Acacia	0.3	15	0.1
S2	*Eichhornia crassipes*	6.2	310	0.3
	Acacia	4.9	245	0.6
	Mimosa pigra	1.4	70	0.6
	Utricularia inflexa	7.9	395	0.3
S3	*Vossia cuspidata*	7.2	360	0.6
	Eichhornia crassipes	0.3	15	0.3
	Pycreus mundtii	0.3	15	0.3
	Azadirachta indica	0.3	15	0.3
	Solanum lycopersicum	0.3	15	0.3
S4	*Eichhornia crassipes*	16.2	810	1
	Impomoea aquatica	3.4	170	0.7
	Polygonum senegalense	3	150	0.4
	Vossia cuspidata	2.8	140	0.4
	Ceratophyllum submersum	5.4	270	0.7
	Vallisneria spiralis	19	950	0.4
S5	*Pycreus albo-Marginatus*	84	4200	0.8
	Panicum maximum	9.8	490	0.2
	Avicennia marina	0.5	25	0.1
	Utricularia inflexa	0.3	15	0.1
S6	*Eichhornia crassipes*	7.9	395	0.8
	Nymphaea lotus	0.8	40	0.1
	Ceratophyllum submersum	0.5	25	0.1
	Vossia cuspidata	4	200	0.5
	Vallisneria spiralis	1	50	0.1

	Polygonum senegalense	4.8	240	0.3
	Comelina diffusa	0.3	15	0.1
	Cyperus nudicaulis	0.2	10	0.1
S7	*Cyperus nudicaulis*	2.3	115	0.6
	Panicum maximum	20.9	1045	0.6
S8	*Typha domingensis*	11	550	0.8
	Panicum maximum	23	1150	0.6
	Avicennia marina	0.4	20	0.2
	Vossia cuspidata	3	150	0.2
S9	*Vallisneria spiralis*	33.2	1660	0.6
	Ceratophyllum submersum	0.9	45	0.2
	Eichhornia crassipes	16.7	835	1
	Panicum maximum	2.8	140	0.2
S10	*Typha domingensis*	1.9	95	0.1
	Vossia cuspidata	3	150	0.1
	Avicennia marina	0.2	10	0.1
S11	*Typha domingensis*	11.8	590	0.9
	Avicennia marina	0.2	10	0.2
S12	*Vossia cuspidata*	5.4	270	0.4
	Panicum maximum	3	150	0.2
	Eichhornia crassipes	0.2	10	0.1

4.2.8 Correlation matrix for physical, chemical and biological parameters

The relationship among the physical, chemical and biological parameters was examined using the Pearson's correlation analysis and the results are shown in the form of a correlation matrix in Appendices I1 and I2.

The pH of water exhibited a significant inverse correlation with salinity, nitrate, TDS and conductivity (r = -0.394, -0.153, -0.401, and -0.387 respectively). Temperature correlated significantly with Turbidity (r = 0.595). Salinity indicated a significant correlation with nitrate (r = 0.549), TDS (r = 0.996) and conductivity (r = 0.998). Nitrate revealed a significant correlation with TDS, Conductivity and turbidity (r = 0.576, 0.571 and 0.566 respectively). Phosphate correlated significantly with turbidity (r = 0.504). TDS significantly correlated with conductivity (r = 0.999).

For the macroinvertebrate diversity indices, Evenness correlated significantly with richness (r = 0.928). While richness also correlated significantly with Shannon index (r = 0.928). Appendix I2 shows the results of analysis for the macrophyte diversity indices. Simpson index significantly correlated with evenness, richness and Shannon index (r = 0.947, 0.675 and 0.973 respectively). Evenness correlated significantly with richness (r = 0.533) and Shannon index (r = 0.874). Richness significantly correlated with Shannon index (r = 0.775).

4.3 ESEM and Application

4.3.1 Application Guidelines

The guidelines developed in consultation with stakeholders for the implementation of the ESEM is briefly described below.

After the identification of an issue in the aquatic ecosystem, a lesson is structured as follows:

1. Objectives of lesson – Educators set lesson objectives to deal with the identified challenge in the ecosystem. These objectives also assist educators to prepare a strategy for presenting the lessons.
2. Background – This is to be developed and used as a guide for the audience presentation. It provides the background and recent information to the educator about the issues with respect to the human community and the aquatic ecosystems.
3. References – The references provide an in-depth knowledge about the issue in the lesson with respect to the local environment. Educators could read for more information.
4. Teaching and Learning Materials (TLM) – In order for participants to easily relate to the lesson, presenters are encouraged to use TLMs from the local environment.
5. Methods in presenting lesson –

   i. *Awareness Raising* – It is recommended to blend audio-visuals in presenting the concepts of human and natural systems. This could be done with simple materials innovatively to convey knowledge about the issue and the consequences in the ecosystems. Examples may include using flip charts, cartoons and recordings of events in connection with participants' everyday activities. Documentaries on the issue at stake could also be shown to participants to present the real facts and information. However, these approaches should be in accordance with the set objectives.

ii. *Engagement in Activity* – Participants work in small groups on various tasks in relation to improving ecosystem resilience. The purpose is to develop skills in dealing with challenges in their ecosystems. Reporters may be appointed in the various groups to present findings which are discussed in a plenary session. Facilitators may also aid and guide participants to contribute and share useful experiences.

iii. *Dialogue* – This session adopts a dialogue approach with facilitators allowing discussions among participants and providing information and resolutions in the end. The aim is to involve community members in promoting sustainable measures and values. This approach enables participants to come up with more examples and illustrations of sustainable solutions in respect to the issue of the aquatic ecosystems.

6. Evaluation - A summary of the whole process is done which is also followed by a review of objectives. Participants also make further contributions to evaluate the educational programme. Objectives which are not addressed are noted and re-strategized for improvement.

Figure 28 below shows the schematic diagram of the guidelines developed in consultation with stakeholders for the implementation of the ESEM.

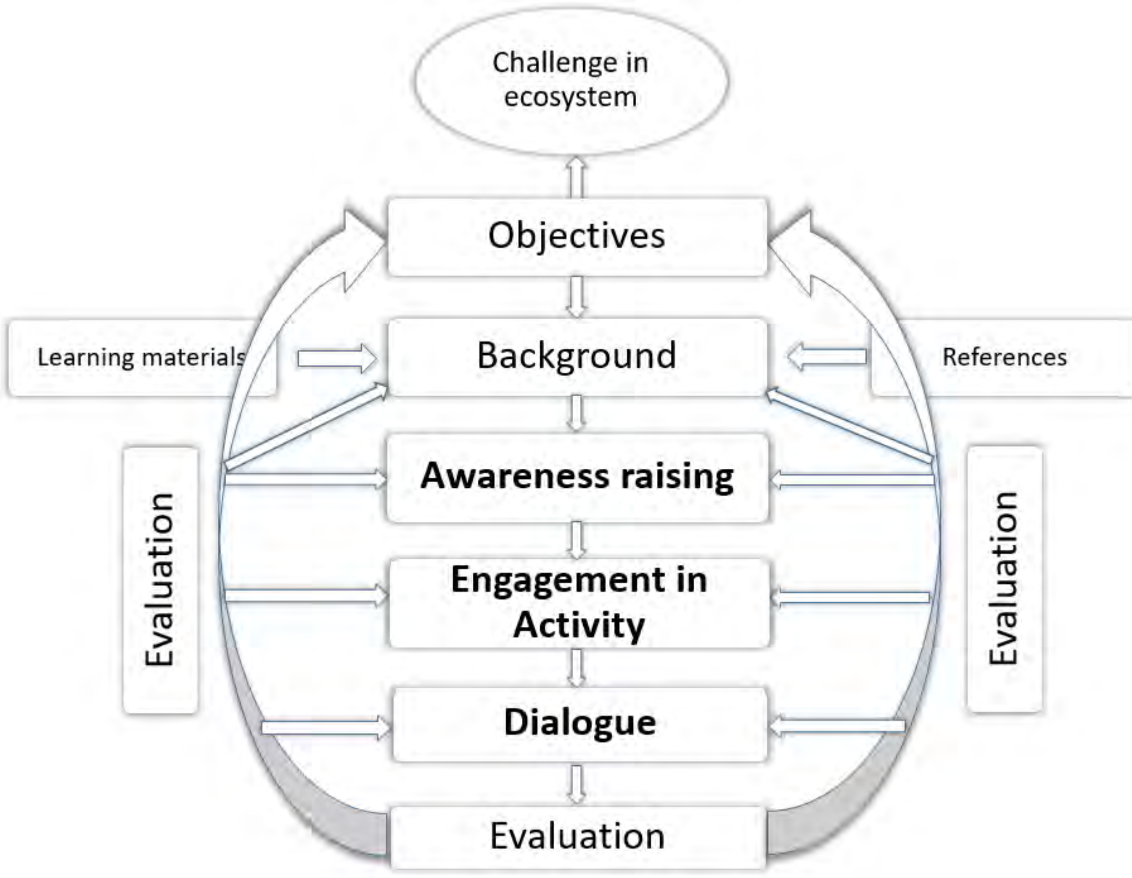

Figure 28: Application Guidelines for Stewardship Educational Model

4.3.2 Evaluation of ESEM

Participants were taken through the above guidelines which involved awareness raising, engagement in activities and dialoguing which lasted a maximum of two hours. The awareness raising and dialoguing sections took thirty minutes each and the activity section usually took a maximum of one hour. The presentations and discussions were done in the classrooms and the activities were either an indoor or outdoor event.

4.3.2.1 Awareness and knowledge of coastal aquatic ecosystems (Theme 1)

The first educational programme focused on promoting the concept of ecosystems in relation to the coastal environment. The awareness creation aspect of the programme exposed participants to the structure and functioning of the coastal aquatic ecosystems. For the Engagement section participants had a trip around the coastal area to observe the different kinds of aquatic ecosystems in the coastal zone and learned about their different compositions. In the dialogue section, participants were put into groups to discuss among themselves sustainable measures they could adopt to conserve the aquatic ecosystems. Appendix G1 shows the educational module prepared for theme 1. Figure 29 below presents the various sections of the ESEM approach which was undertaken at Totiemekope community.

Figure 29: Pilot programme at Totiemekope

Highlights of the resolutions made by participants are listed below:

"Re-planting new trees after cutting down trees"

"Avoid using poisonous chemicals like DDT in fishing"

"Avoid throwing rubbish into or near water bodies"

"Educate their families and friends to keep the environment clean"

Figure 30 below presents the evaluators scores for the four premises (fairness and accuracy, development, instructional soundness and usability) in which the ESEM was evaluated. The scores for all premises lied within the range of above-average. The orange bar indicates the average score for each premise.

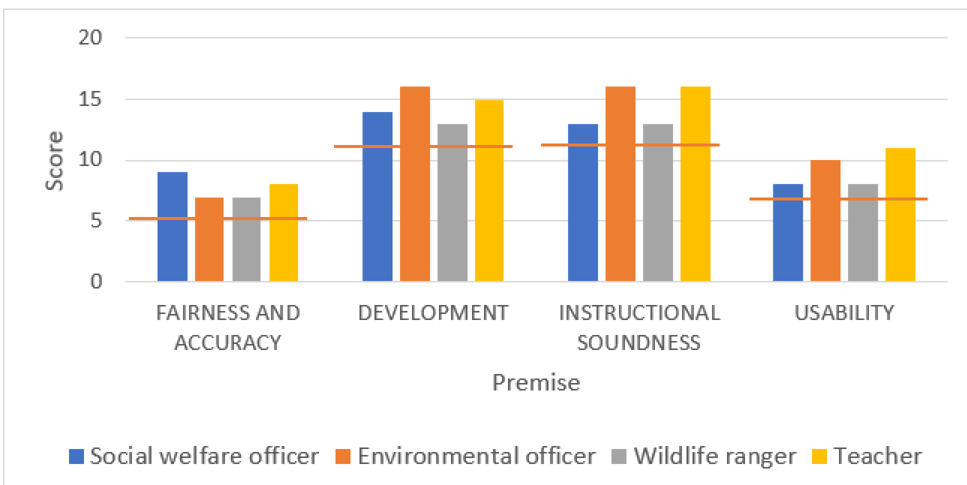

Figure 30: Evaluators score for theme 1: Knowledge of aquatic ecosystem structure and functioning

4.3.2.2 Population and economic pressures (Theme 2)

The second educational programme also focused on increasing human and economic pressures in the coastal zone. Awareness creation looked at the ways in which human activities are causing environmental and ecosystem degradation in the coastal zone. The participants were engaged to explore the coastal area taking notes of the various human and economic activities capable of causing ecosystem degradation. Participants then dialogued on ways in which these human activities could be done sustainably. Appendix G2 shows the educational module prepared for theme 2. Figure 31 below shows the ESEM activities undertaken at Ocanseykope community.

Figure 31: Pilot programme in Ocanseykope

Figure 32 shows the scores of the four scoring premises in which the stewardship programme was evaluated. Evaluators scored all four premises in the range of above-average and average.

Seventy-five percent (75%) of the scores lied in the above-average category and 25% was on the average.

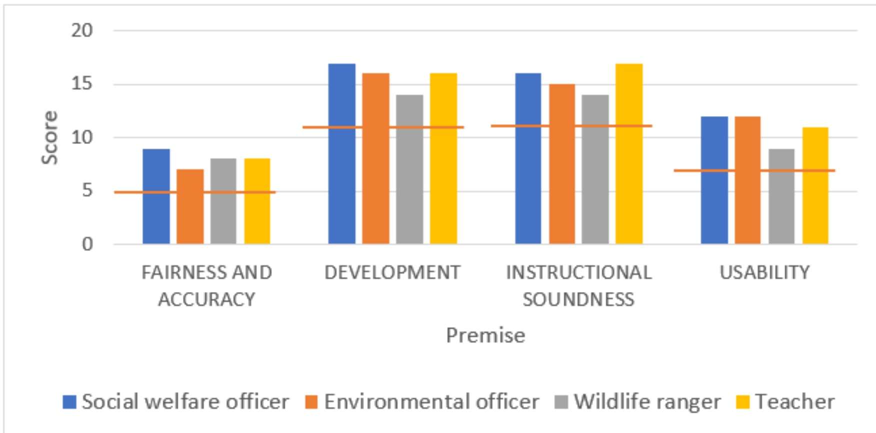

Figure 32: Evaluators score for theme 2: Population and Economic pressures

Highlights of the resolutions made by participants are listed below:

“Avoid deforestation”

“Avoid dumping rubbish anywhere”

“Avoid bush burning”

“Avoid sand winning”

“Avoid using chemicals in fishing”

4.3.2.3 Unsustainable exploitation of biological resources (Theme 3)

The third educational programme intended to deal with the unsustainable exploitation of the biological resources in the coastal ecosystems. The aspect of awareness creation exposed participants to the biological resources in the coastal environment and the ways in which humans are negatively exploiting these resources. It also highlighted on the reasons why biodiversity is worth preserving. During the engagement sections, participants were introduced to the concept of food chain and food web. They were engaged in games which helped to enable them construct their own food webs. The dialogue focused on why it is important to keep the biological components of the ecosystem in balance. Appendix G3 shows the educational module prepared for theme 3. Figure 33 below presents the various sections of the ESEM activities undertaken at Anyakpor community.

Figure 33: Pilot programme at Anyakpor

Figure 34 below presents the evaluators score for the four scoring premises. Evaluators scored all four premises within the range of above-average and average. Close to ninety percent of the scores (88%) lied in the above-average category and 12% on average.

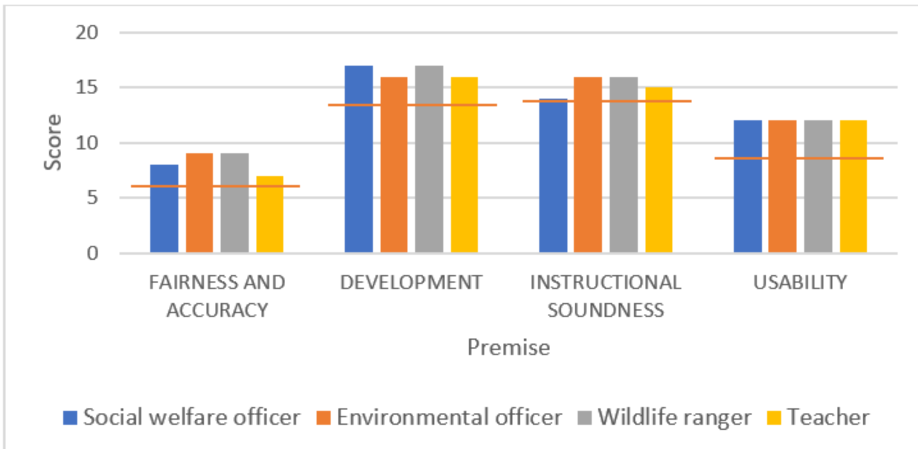

Figure 34: Evaluators score for theme 3: Unsustainable exploitation of biological resources

Highlights of the dialogue section are presented below:

Participants raised concern about some endangered species such as *"turtle, mangrove, crocodile, clams, some fishes"* and proposed strategies to protect them. These are presented below.

"Enforcement of laws on people who overexploit the resources"

"Public education on the effect of over exploitation"

"Reporting culprits"

"Plant more trees"

"Avoid using chemicals in fishing"

4.3.2.4 Prevention and early detection of coastal hazards (Theme 4)

The fourth programme focused on the early detection and prevention of coastal disasters. The awareness creation exposed the participant to the various natural hazards which have become prevalent in the coastal area and the possible negative effects. It also highlighted ways of early detection and possible adaptive measures to reduce the impact of such hazards in case of such events. A tree planting exercise was organised at some selected areas along the coastal area. All participants had their turn to plant a tree. Participants then had group dialogues on sustainable measures community member could adopt to reduce the risk of disasters in the coast. Appendix G4 presents the educational module prepared for theme 4. Figure 35 below shows the ESEM activities that took place in Elavanyo community.

Figure 35: Pilot programme at Elavanyo

Figure 36 shows the scores for the four scoring premises in which the stewardship programme was evaluated. All four premises are within the range of above-average and average. On the whole, the above-average category constituted (94%) and (6%) for the average.

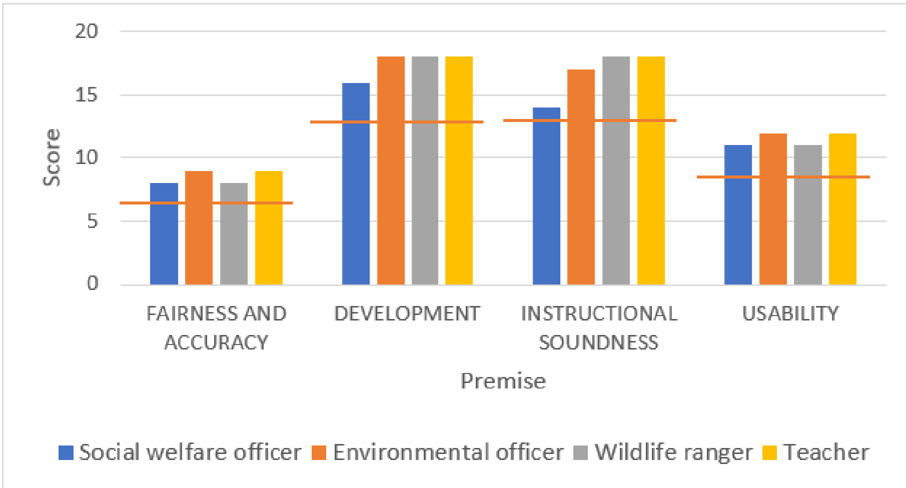

Figure 36: Evaluators score for theme 4: Coastal hazards (Flooding and Erosion)

Highlights of the results are featured below:

"Damage to homes and properties"

"Loss of human life"

"Destruction of the coastline"

"Destruction of spawning grounds and wildlife habitats"

Measures

"Plant more trees"

"Listen to advice from the wildlife people"

4.3.2.5 Pollution of coastal and estuarine waters (Theme 5)

The final educational programme highlighted on pollution of the coastal and estuarine waters. The awareness creation tackled the issue of pollutants in the aquatic ecosystems. Participants were also exposed to some physicochemical parameters which may stress aquatic organisms as a result of influx of pollutants from domestic and industrial sources. The engagement section was a clean-up exercise which was conducted along the beach at Pute. Participants had the dialogue focusing attention on sustainable solutions from the side of community members to protect and keep water sources from pollutants. Appendix G5 shows the prepared educational module for theme 5. Figure 37 below presents the ESEM activities undertaken at Pute community.

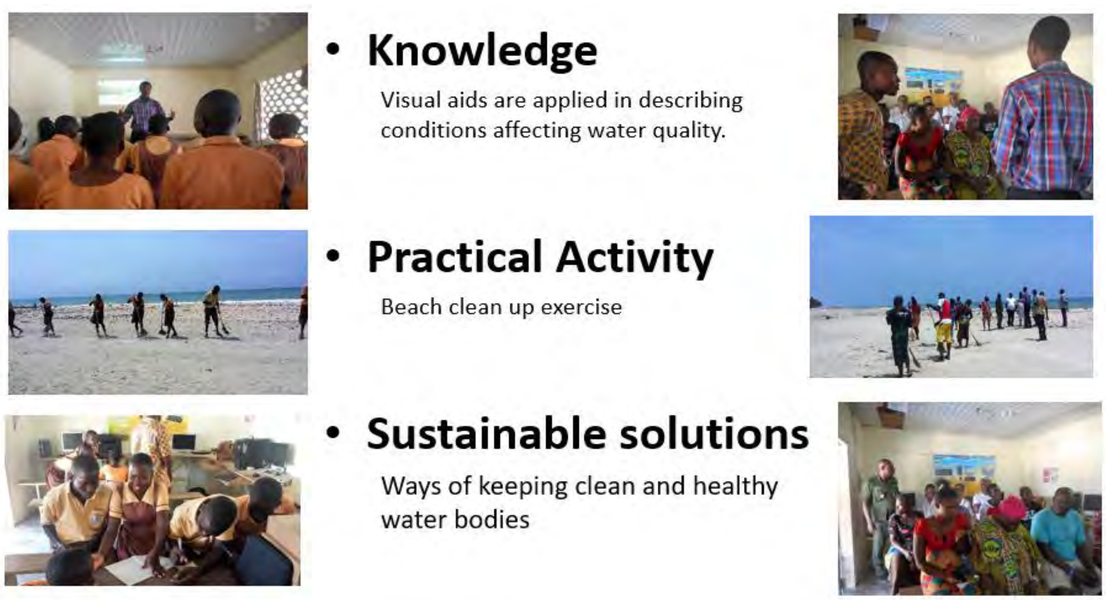

Figure 37: Pilot programme at Pute

Figure 38 shows the scores for the four scoring premises for evaluating the stewardship programme. All four premises were scored within the range of above-average and average. In general, (69%) of the scores lied in the above-average category and (31%) in the average category.

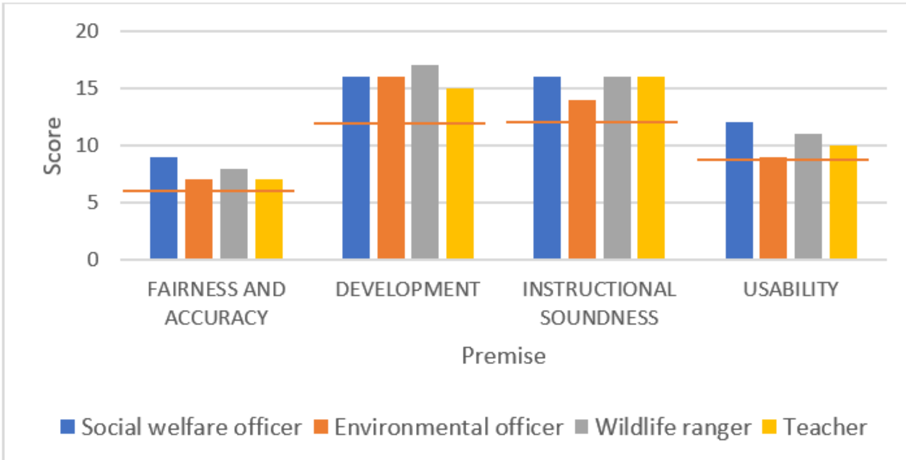

Figure 38: Evaluators score for theme 5: Pollution of coastal waters

Highlights of the dialogue section which focused on the impacts of waste on aquatic ecosystems have been listed below.

"Kills plants and animals in the water"

"Water is not good for daily activities such as drinking, cooking etc"

"Animals become weak in the water"

"Water is dirty"

"Fishes do not feel comfortable and come to the surface of the water"

Resolutions from participants:

"Avoid throwing rubbish into water bodies"

"Avoid deforestation"

"Avoid dumping refuse into water bodies"

"Avoid defecating around water bodies"

"Fishermen should practice good fishing methods"

4.3.2.6 Evaluators Score and Comments

In all, evaluators scored the programme at the above average category with a few scores in the average. The fairness and accuracy category was graded in the ranges of 8 to 9 for above average, 5 to 7 for average and 3 to 4 for below average. The evaluators' scores were within the range 7 to 9 for all the themes. For the development and instructional soundness category, evaluators graded in the above average which ranges from 14 to 18. In terms of usability, grading was also within the range of above average with a few score on the average level. The grading by evaluators proved that the new intervention for stewardship education is effective. Majority of the evaluators forming 40% indicated the activity section as the most effectual aspect of the whole programme (Figure 39). They were also asked if they would like to use the model in their sensitization programmes. Majority of them (65%) were positive to adopt the new strategy. However, 35% of the evaluators were indifferent (Figure 40). Appendix H shows the general assessment of the ESEM approach as graded by the evaluators.

All the four evaluators who took part in the educational programme were satisfied with the ESEM approach. The comments made by evaluators are as follows:

1. *"Programme is a good thing"*
2. *"It has helped to increase knowledge on ecosystem structure and functioning*
3. *"Increase the sense of involvement on conservation efforts"*

4. *"Arouse interest in helping governmental organisations to solve the challenge of ecosystem degradation in the coastal environment"*

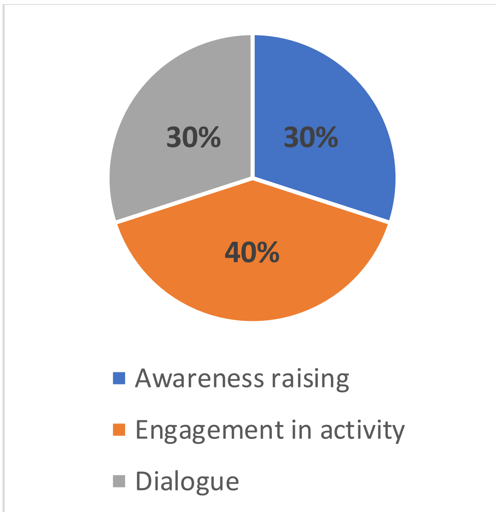

Figure 39: Most effectual aspect of the model described by evaluators

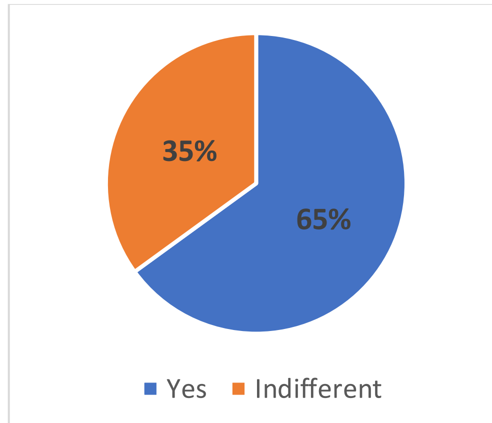

Figure 40: Evaluators willingness to adopt the educational approach

CHAPTER FIVE

DISCUSSION

5.0 Introduction

This chapter discusses the results from the study. It begins with the interlinkages of the issues of coastal aquatic ecosystems. It discusses the results of the various indicators used to determine aquatic ecosystem health and finally concludes on the outcomes of the Ecosystem Stewardship Educational Model application and evaluation.

5.1 Interlinkages of the issues of coastal aquatic ecosystems

The challenges of aquatic ecosystems revolve around human pressures in the coastal area of Ada. Coastal aquatic ecosystems, especially estuaries, creeks, mangrove swamps, lakes and river mouths are vulnerable to the negative impacts of human activities. As stated in previous studies by Amlalo (2006), the coastal environment and ecosystems in Ada continue to show obvious changes due to a combination of climate change and human activities. The impacts of climate change are global in scale and the effect has been sea level rise which increases the risk of coastal disasters in the coastal area. A major issue of human concern which affect aquatic ecosystems in the study area was identified to be poor knowledge of the ecosystem structure and functioning. This has also been confirmed by Boon and Ahenkan (2012). There are indigenous beliefs and knowledge misconceptions which need to be corrected and set a focus on the human and natural systems pertaining to the local environment as supported by (Mensah & Amoah, 2013).

Fishing, farming and tourism are growing economic ventures in the coastal area of Ada. This is confirmed in a study by Lawson (2013) that due to the rich natural resources, the coastal zone has become an area of active economic development with an increasing population trend over the years. The human footprint is increasing in the coastal area due to economic ventures. Lawson (2013) highlights Important economic sectors such as agriculture and tourism to be expanding in the zone. Increase in human population has a negative implication on landuse pattern. Without proper measures in place, people cut down trees indiscriminately affecting lots of habitats. Particularly, vegetations around aquatic ecosystems are removed for settlements and other ventures. A similar study by Ahadzie and Proverbs (2011) confirms this action exposes land to erosion which may carry pollutants and other nutrients into water, killing the biological components of the aquatic ecosystems.

Improper land planning and vegetation removal make the aquatic ecosystems vulnerable to coastal hazards such as tidal waves and flooding in the coastal environment. Flood waters may fill aquatic systems with sediments and filth which may destroy habitats and breeding ground of many species including fishes in the aquatic ecosystems. Human population increase may also increase waste generation. Without any effective waste management systems, the incident of indiscriminate waste disposal in the coastal area exacerbates all the time. The quantity of waste generated from domestic sources increases as more people migrate to the coastal area. When there is rainfall, running water carry pollutants and other waste materials which are mostly plastics and may end up in aquatic ecosystems as described by Patil et al. (2012). The issue of plastic menace is already a serious implication of the poor waste management in the coastal area of Ada. Miezah et al. (2015) confirmed that plastics form the greatest fraction of the waste materials along the beaches of Ghana. Pollutants in water sources render the water quality poor, unhealthy and unfavourable for the survival of most aquatic organisms.

Composting is a possible alternative for handling manure. Manure from livestock keeping could serve as a source of nutrients for soil fertility. Reponses from the study indicated that manure from livestock keeping is rarely used to enhance soil fertility. Livestock keepers sweep the farm animal droppings and may dispose them in the environment. This could however, be used to make compost to enrich soil fertility as described by Sandeen and Gamroth (2003). Vegetable crop farmers may directly benefit from livestock farmers which contribute to reduce the costs of production and also reduce the impact of nutrient load in water as these animal droppings may end up in water bodies when it rains.

Hunting techniques included the use of local guns, traps and bush burning. Negative hunting methods such as bush burning is not prevalent and therefore not considered as major threats to the aquatic ecosystems in the study area. They may occur occasionally over small areas of the vegetation. However, necessary measures should be put in place to control the incident to reduce the risk of major disasters in the coastal area. Animals hunted included monkeys, rats, birds and turtles. According to the IUCN list, turtle is one of the endangered species.

In spite of the regulations in the coastal environment, some poachers illegally cut down mangroves and trees for commercial purposes which are gradually depleting the mangrove vegetation along the estuary. The situation is affecting the resilience of coastal aquatic ecosystems as several buffer zones have been removed exposing biological components to the direct impacts of pollutants. (Hackman, 2014; Bamford et al., 2014) describe the intensification of agricultural activities extending into buffer zones as one of the major issues of aquatic ecosystems in Ghana.

More people in the coastal area certainly have a negative implication on resource exploitation. The fishing and farming activities continue to attract people to the coastal area of Ada. Improper farming methods and techniques may have detrimental effects on the aquatic ecosystems. Vegetation removal may cause destruction to habitats around the aquatic ecosystems. When more people are involved in fishing and farming, it creates competition and unsustainable measures begin to set in. Fishers tend to adopt illegal fishing methods such as light fishing, use destructive fishing gears and sometimes even use poisonous substances in the water. These activities are unsustainable because they tend to destroy juvenile fishes and other sensitive species in the aquatic ecosystems.

Flooding is a major hazard in the Ada coastal zone. Flood disaster occurs intermittently from both inland waters and sea tidal waves. This incident is further aggravated by haphazard settlements in the coastal area. Buildings are found in water ways and gutters choked with garbage in the communities. As confirmed by Ahadzie and Proverbs (2011), with increasing population growth alongside haphazard settlement conditions, the worst effects of flooding might be imminent.

Migrants moving into the coastal area for economic opportunities may have poor or no knowledge of the local aquatic ecosystems structure and functioning hence they may have very little concern for keeping healthy ecosystems. Usually, the main goal of such group of people is to make economic gains without care of the environment. Therefore, local authorities could allow development in the coastal zone but must ensure that it is done in a more environmentally sound manner so that the need of the growing population is met without causing harm to the aquatic ecosystems.

5.2 Aquatic Ecosystem Health

It is necessary to conduct periodic ecological investigations to monitor pollution of aquatic environment as recommended by (Adjei-Boateng et al., 2010). The study has revealed a couple of challenges concerning landuse, water and habitat quality in the aquatic ecosystems in the Ada coastal environment of Ghana. Threats to the aquatic ecosystems are primarily due to human activities in the settlement areas of the coastal zone. The area continues to develop over the years as a result of rapid urbanization as confirmed by (AEDA, 2016). The study indicates that poor landuse is having a negative impact on habitat quality which results in the loss of macroinvertebrates and macrophytes. The general observation that buffer zones were devoid of vegetation is key to understanding some of the factors contributing to the degradation of ecosystems in the study area. Buffer zones are characterized by natural sites typically vegetation which separate human activities from water bodies. They thus help to sieve out pollutants from running water before ending up in streams, lakes, rivers and the sea (Costa & Hughes, 2012). Improper landuse due to habitat destruction as reflected in the findings suggest activities such as illegal felling of trees within the buffer zones contribute to the degrading state of the aquatic ecosystems. Improper landuse activities, declining water quality and habitat destruction are gradually affecting the resilience of aquatic ecosystem in the coastal area of Ada. A recent study by Owusu et al., (2016) confirms that biodiversity has been affected in various water resources as a result of declining water quality in Ghana. The situation also poses danger to the human health and the overall sustainability of the environment. Studies by Addo et al., (2015) supports that water bodies running through industrial and settlement areas are heavily polluted and requires a high cost for treatment before public use.

The seasonal variations of physicochemical parameters during the monitoring period indicated slightly higher values in the wet season (May, June and July, 2016) compared to the dry season (November, December 2016 and January, 2017). However, most of the parameters indicated insignificant differences for the two seasons, A similar situation has been explained by Murwira et al. (2014) and Wilson and Tisdell (2001). High phosphate and nitrate levels in the water samples from the various sampling locations could be attributed to influx of domestic waste as inhabitants wash along the rivers and lagoons. The situation is also aided by other human actions like vegetation removal which may expose soil to erosion. Also, residue from fertilizers may be carried by the run-offs from farmlands into the aquatic environments. The influx of such waste into water bodies is intensified during the wet season. An earlier study by Karikari and Ansah-Asare (2006) and Aglanu and Appiah (2014) suggested human, animal and agricultural activities as the main sources of pollution in the aquatic ecosystems.

The bio-indices analysis indicated a relatively low macroinvertebrate diversity of the various aquatic ecosystems. This is an indication of unhealthy ecosystem for the survival of most biotic components. Highly sensitive macroinvertebrates such as mayfly nymph and stonefly nymph which are proxy indicators of good water quality were not recorded in any of the samples taken.

This gives is an indication of significant levels of pollution in the aquatic ecosystems. However, diverse macroinvertebrates recorded at the mangrove swamp zone indicates suitability of the ecosystem for the growth and development of other aquatic species like fish. Two most abundant macroinvertebrates within the sampling areas were the *Penaeus sp* and the *Lymnaea sp* which are crustacea and gastropods respectively. Gastropods are tolerant to sewage and are found to thrive well in polluted environment as described by Shimba et al. (2018). Low biodiversity in the study area could be attributed to human impacts such as release of pollutants and domestic wastes from the communities which degrade the habitat of species in the aquatic ecosystems.

5.3 Interconnection and outcomes of the ESEM

Usually, environmental programmes may have objectives targeting different outcomes (Stevenson et al., 2014). For example, some educational programmes may aim at enhancing pro environmental behavior. Others may also target science learning. The interconnections of an environmental model are important as it guides the development of the curriculum and evaluation for improvement in future.

The ESEM focused on integrating local knowledge, practical activities and sustainable values. These factors are usually integral parts of environmental education. Integrating these factors ensured the following outcomes of the stewardship educational programmes. The aspect of ESEM which focused on the knowledge of local environment projected two outcomes. These are sense of place and environmental identity.

The sense of place refers to enhancing community members' connectedness to nature and the positive perception of the aquatic ecosystems in their local environment. As an example awareness creation on the concept of ecosystems with regards to the local aquatic ecosystems enhanced the level of appreciation of community members and their willingness to create healthy aquatic ecosystems in their communities. According to Kudryavtsev et al. (2012) and Sellmann & Bogner (2013) the outcome of sense of place help people to appreciate their local environment and enrich their experiences.

Projecting environmental identity of community members enhances individuals' relationship with the environment. For instance, awareness creation on the benefits derived from the ecosystem services realised the appreciation of individual participants for such free nature's services to humankind. Weigert, (1997) propose that environmental identity can contribute to enhance stewardship.

The second aspect which focused on practical activities highlighted four outcomes. These are environmental quality, ecosystem services, biodiversity and community health. The programme engaged participants in a clean-up exercise around aquatic ecosystems and tree planting along buffer zones. These actions were found to trigger self and community responsibility of ensuring that aquatic ecosystems remain healthy to provide the various ecosystem services to humankind. The activity on food chain and energy flow projected the reasons why biodiversity is worth preserving. According to Levine and Strube (2012) and Krasny et al. (2014) engaging people in activities which improve environmental quality, ecosystem services, biodiversity and health provide tangible evidence to realize the need for healthy ecosystems.

The last aspect of the ESEM focused on promoting sustainability values which also projected three outcomes. These are social norm, social groups and governance. The outcome of social norms promoted common acceptable behaviours which may help to keep aquatic ecosystems health. As an example, dialoguing on sustainable measures of exploiting biological resource created a consensus among participants about the need of sustainable development in current times. According to Schultz (2011) social norms can guide human behaviour to conserve nature.

Social group outcome seeks to promote sustainable development approaches among the various social groups in the coastal environment. For example, focusing on the young people in the ESEM seeks to ensure that young people grow to become environmentally responsible citizens as supported by Schusler and Krasny (2010).

Improvement in environmental governance seeks to enhance processes in decision making to the management of the aquatic ecosystems. As an example, the ESEM aspect of dialoguing created a platform for the participants to take sustainable decisions concerning the livelihoods. Walker and Salt (2012) and Ostrom (2012) provide an example that community members and schools can establish partnerships to mitigate challenges in the aquatic ecosystems.

The future direction of this concept hopes to use emerging technologies to broaden the scope of ecosystem stewardship in an integrated management approach. This will involve incorporating best approaches and sustainable solutions in knowledge and action strategies which are driven by developing technologies. The concept could run at the strategic level of governance where it becomes imperative for community members and stakeholders to get involve in the process of helping to conserve the ecosystems. Incentives play a vital role in recognizing this objective. Some form of benefits is needed on the onset which may be in the form of monetary gains, waivers, awards and recognition of community participants. The long-term goal of the ESEM approach is for inhabitants to appreciate the benefits derived from ecosystem services and the importance of the stewardship role in conservation. Understanding the values of these active interventions hope to serve as the source of motivation to engage participants in the process of helping to maintain and enhance aquatic ecosystem health and resilience.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

6.0 Introduction

This chapter presents the conclusions in which the main findings of the study have been spelt out. Suggested recommendations have been given based on the conclusions of the study. It also proposes areas for further empirical studies.

6.1 Conclusion

The research revealed several issues concerned with the health of coastal aquatic ecosystems in Ada. These issues were categorized into five major themes which are pollution of coastal waters, population and economic pressures, lack of knowledge on aquatic ecosystem structure and functioning, unsustainable exploitation of biological resources and lack of preventive measures and early detection of coastal hazards.

Among these issues affecting the aquatic ecosystems, population and economic pressures was pointed out to be the most challenging with several negative impacts on the health of aquatic ecosystems. The study also revealed that knowledge of community inhabitants concerning aquatic ecosystems is satisfactory. However, the necessary practices in terms of attitude and behaviour to maintain healthy ecosystems are poor.

The aquatic ecosystem health assessments revealed that more than half of the aquatic ecosystems are unhealthy. The mangrove swamps on the island indicated a good health in all three assessments. However, the aquatic ecosystems in the inland areas of the coastal zone were found to be poor in terms of landuse and habitat quality. The aquatic ecosystems in the beaches were also poor.

Even though there are regulations to protect coastal aquatic ecosystems, lack of enforcement has enabled both community members and visitors to negatively exploit these natural sites. The poor ecosystem health in the coastal area was attributed to the effect of human activities such as indiscriminate waste disposal and habitat destruction.

The community structure of the various sampling locations was found to be generally poor in terms of the diversity of macroinvertebrates and macrophytes. The areas with limited human influence such as the mangrove swamps on the islands are relatively more biodiverse.

The macrophyte studies also expressed the relatively poor diversity. *Nymphaea sp,* which is an exotic plant species is taking over the areas of native hydrophytes in the waterways.

Water quality parameters are almost of the same level for both dry and wet periods in the sampled aquatic ecosystems. However, the levels of nitrates, phosphates, turbidity and conductivity were above WHO standards as well as natural background levels.

The ecosystem stewardship educational model (ESEM) proved to be feasible and dynamic as it provides a room for future developments through an evaluation and a feedback process. Integrating knowledge, action strategies and sustainable values in environmental educational programmes is more likely to enhance the pro-environmental behaviour of individuals since the approach stimulates interest, which motivates community members to be part of the process of protecting and maintaining healthy aquatic ecosystems.

Developing educational programmes, which deal with the driving forces of population and economic pressures, is effective to control behaviours and attitude toward good environmental management.

This study has revealed the importance and practicability of community participation in the effort to sustainably manage aquatic ecosystems in the coastal environment of Ada in Ghana.

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6.2 Recommendations

In view of the findings, the following recommendations are made to address the challenges confronting aquatic ecosystem health in the coastal environment of Ada and to also improve the effectiveness of sensitization and awareness programmes undertaken to prevent ecosystem degradation. These are discussed below.

6.2.1 Effective watershed management measures

The study has established that landuse patterns are relatively poor and human activities such as indiscriminate waste disposal is continuously having a negative impact on the coastal aquatic ecosystems. Water quality of the aquatic ecosystems in the settlement areas are poor. Effective watershed management measures are therefore recommended to ensure that Landuse and land developments are more environmentally sound.

6.2.2 Remediation measures

The study also revealed that Majority of the aquatic ecosystems in the coastal area have become vulnerable to eutrophication due to high levels of nitrate and phosphate concentration. Remediation measures have to be undertaken by the Volta River Authority to improve noxious aquatic ecosystems.

6.2.3 The ESEM approach

There is the need to enhance community stewardship of aquatic ecosystems which will expose inhabitants to the current situation and human disturbances which are degrading the natural sites. An integrated approach which is sustainable is therefore recommended to enhance the stewardship sensitization programmes. The ESEM approach that takes into consideration the indigenous natural and human systems, action strategies which involve local community members and promotes the values of sustainability is proposed. In using the ESEM approach, the following should also be noted.

6.2.3.1 Clear vision and objective

It is recommended that there should be a clear vision for every approach towards improving the health of aquatic ecosystem. Environmental Professionals should embark on preliminary studies in the local environments of the aquatic ecosystem in order to identify the various issues affecting the natural site. An applicable approach is then strategized with the major aim of improving conditions with respect to community participation. The approach is targeted at dealing with the driving factors of the issues investigated during preliminary survey. Where possible, objectives may be set in order to guide the development of the educational approach.

6.2.3.2 Focus on the youth

Stewardship education is for all categories of persons. However, the study has revealed that focusing on the youth especially on the young people between the ages of 12 to 15 years will have a greater impact on the community members as far as stewarding of aquatic ecosystem is concern. The young people are found to be enthusiastic, more involving and interested in issues concerning their local environment. They can set good example to their young siblings, engage in peer to peer education and can also influence the adults in the communities. Working with the youth groups is regarded as the best approach.

6.2.3.3 Exposure to the local environment

Effective stewardship begins with introducing participants to the immediate natural resources in local environments. There is always a cause to be concern if people have a connection with the subject of interest. It is very important to expose community members to the component of their ecosystems in which they have evolved with and bring them to the understanding of the structure, functioning, importance and the need to conserve the natural resources in the aquatic ecosystem. The level of appreciation to get community members involved in conservation matters is enhanced through local exposure. The study revealed it is a good strategy to capture the interest of local inhabitants.

6.2.3.4 Sustainable action strategies

Community members should be engaged in action strategies based on the drivers of ecological issues. Involving community members significantly influence their attitude and behaviour outcomes for improving ecosystems. Sustainable development strategies should be introduced and promoted more as conservation methods and the approach should be practical and innovative to develop skills for conservation. For example, projections may be done through social networking. It is recommended that the discussions should be organised in smaller groups for effective participation. Sustainability values should be promoted among local inhabitants. These strategies should focus on enhancing livelihood opportunities, ecosystem health and societal values in an integrated manner. Since most of the economic ventures within the Ada coastal environment are centered on the natural ecosystem and the services they provide, it is prudent to introduce inhabitants to more sustainable ways of exploiting the natural resource.

6.2.3.5 Training programmes

It is recommended that training programmes should be organised periodically for the people engaged in community sensitisation and awareness programmes to develop experience. Training programmes are very important to keep educators updated on current methods and approaches of sensitizing community members. In current times, technology is far advance and could be explored to facilitate the stewardship approach. Training programme will also serve as a platform for various stakeholders to share successful experiences to enhance ways of stewarding aquatic ecosystems.

6.2.3.6 Collaboration

Finally, it also recommended that some forms of collaboration among community social groups could help to enhance stewardship of aquatic ecosystems. Since the focus is more on the youth to influence society to be more responsible towards maintaining healthy aquatic ecosystems, community members could collaborate with youth institutions and school where there are more of such young people. This will foster more interventions to engage the youth in the process of becoming stewards of the aquatic ecosystems.

6.2.4 Future research

Future research can evaluate this educational model and adapt it to suit different ecosystems. There is the need for research into finding ways of evaluating the community change process within the short term. This will enable improvement on the concept model which will contribute to effectively monitor the behavioural change process.

REFERENCES

Abrahams, I., & Reiss, M. J. (2012). Practical work: Its effectiveness in primary and secondary schools in England. *Journal of Research in Science Teaching*, **49(8), 1035-1055**.

Ada East District Assembly (AEDA) Report. (2013). The composite budget of the Ada east district assembly for the 2013 fiscal year. This 2013 Composite Budget is also available on the internet at: www.mofep.gov.gh or www.ghanadistricts.com

Ada East District Assembly (AEDA) Report (2016). The composite budget of the Ada east district assembly for the 2016 fiscal year. This 2016 Composite Budget is available at http://www.mofep.gov.gh/sites/default/files/budget/2016/Composite/GR/Ada-East.pdf

Addo, M. A., Darko, E. O., Gordon, C., & Nyarko, B. J. B. (2015). Water quality analysis and human health risk assessment of groundwater from open-wells in the vicinity of a cement factory at Akporkloe, Southeastern Ghana.

Adjei-Boateng, D., Obirikorang, K. A., & Amisah, S. (2010). Bioaccumulation of heavy metals in the tissue of the clam Galatea paradoxa and sediments from the Volta Estuary, Ghana. *International Journal of Environmental Research*, **4(3), 533-540**.

Adkins, C., & Simmons, B. (2002). Outdoor, Experiential, and Environmental Education: Converging or Diverging Approaches? ERIC Digest.

Aftab, S. Y, Noorjahan, C. M., & Dawood, S, (2005), Physico-chemical and fungal analysis of a fertilizer factory effluent, *Nature Environment & Pollution Technology*, **4(4), 529-531.**

Aglanu, L. M., & Appiah, D. O. (2014). The Korle lagoon in distress: The stress of urban solid waste on water bodies in Accra, Ghana. *International Journal of Innovation and Applied Studies****, 7(2), 717.***

Ahadzie, D. K., & Proverbs, D. G. (2011). Emerging issues in the management of floods in Ghana. *International Journal of Safety and Security Engineering*, **1(2), 182-192.**

Amate, C. O. C. (1999). The making of Ada.Woeli Pub Serv.

Amlalo, D. (2006). The protection, management and development of the marine and coastal environment of Ghana.Administering Marine Spaces: International Issues, 36, 148–158. Retrieved: http://www.fig.net/pub/figpub/pub36/pub36.pdf#page=150

Ansari, A. A., Gill, S. S., & Khan, F. A. (2010). Eutrophication: threat to aquatic ecosystems. In Eutrophication: causes, consequences and control (pp. 143-170). Springer Netherlands.

Apha, A. (1998). Wpcf. Standard methods for the examination of water and wastewater, 20.

Appeaning Addo, K., Larbi, L., Amisigo, B., & Ofori-Danson, P. K. (2011). Impacts of coastal inundation due to climate change in a cluster of urban coastal communities in Ghana, West Africa. Remote Sensing, **3(9), 2029-2050**.

Appeaning Addo, K., Walkden, M., & Mills, J. P. (2008). Detection, measurement and prediction of shoreline recession in Accra, Ghana. *ISPRS Journal of Photogrammetry and Remote Sensing*, **63, 543–558**. doi: 10.1016/j.isprsjprs.2008.04.001

Armsworth, P. R., Chan, K. M. A., Daily, G. C., Ehrlich, P. R., Kremen, C., Ricketts, T. H., & Sanjayan, M. A. (2007). Ecosystem-service science and the way forward for conservation. *Conservation biology*, **21(6), 1383-1384.**

Arthington, Á. H., Naiman, R. J., Mcclain, M. E., & Nilsson, C. (2010). Preserving the biodiversity and ecological services of rivers: new challenges and research opportunities. *Freshwater Biology*, **55(1), 1-16.**

Athman, J. A., & Monroe, M. C. (2001). Elements of Effective Environmental Education Programmes.

Awuah-Nyamekye, S. (2013). Managing the environmental crisis in Ghana: The role of African traditional religion and culture—A case study of Berekum traditional area. University of Leeds.

Azizan, M. H, & Nabsiah Abdul W. (2012)."A proposed model on environmental stewardship." *Procedia-Social and Behavioral Sciences* **65: 587-592.**

Balica, S. F., Wright, N. G., & Van der Meulen, F. (2012). A flood vulnerability index for coastal cities and its use in assessing climate change impacts. *Natural Hazards,* **64(1), 73-105.**

Balmford, A., Bennun, L., Ten Brink, B., Cooper, D., Côté, I. M., Crane, P., ... & Gregory, R. D. (2005). The convention on biological diversity's 2010 target. *Science,* **307(5707), 212-213.**

Bamford, A. J., Ferrol-Schulte, D., & Wathan, J. (2014). Human and wildlife usage of a protected area buffer zone in an area of high immigration. Oryx, 48(4), 504-513.

Barbosa, F. A. R., Callisto, M., & Galdean, N. (2001). The diversity of benthic macroinvertebrates as an indicator of water quality and ecosystem health: a case study for Brazil. *Aquatic Ecosystem Health & Management*, **4(1), 51-59**.

Barlow, M., & Clarke, T. (2017). Blue gold: the battle against corporate theft of the world's water. Routledge.

Bell, J. D., Allain, V., Allison, E. H., Andréfouët, S., Andrew, N. L., Batty, M. J., ...& Harley, S. (2015). Diversifying the use of tuna to improve food security and public health in Pacific Island countries and territories. *Marine Policy*, **51, 584-591**.

Berkes, F. (2008). Commons in a multi-level world. International journal of the commons, 2(1), 1-6.

Berkes, F., & Ross, H. (2013). Community resilience: toward an integrated approach. *Society & Natural Resources,* **26(1), 5-20.**

Bhat, S. A., & Pandit, A. K. (2014). Surface water quality assessment of Wular Lake, a Ramsar site in Kashmir Himalaya, using discriminant analysis and WQI. *Journal of Ecosystems*, 2014.

Bibi, F., & Ali, Z. (2013). Measurement of diversity indices of avian communities at Taunsa Barrage Wildlife Sanctuary, Pakistan. *The Journal of Animal & Plant Sciences*, **23(2), 469-474.**

Boadi, K. O., & Kuitunen, M. (2002). Urban waste pollution in the Korle lagoon, Accra, Ghana. Environmentalist, 22(4), 301-309.

Bockstoce, J. R., & Burns, J. J. (1993). Commercial whaling in the North Pacific sector. The bowhead whale, 2, 563-577.

Bookwalter, J. T., Fuller, B. S., & Dalenberg, D. R. (2006). Do household heads speak for the household? A research note. Social indicators research, 79(3), 405-419.

Boon, E., & Ahenkan, A. (2012). Assessing climate change impacts on ecosystem services and livelihoods in Ghana: Case study of communities around Sui Forest Reserve.

Browne, M. A., Niven, S. J., Galloway, T. S., Rowland, S. J., & Thompson, R. C. (2013). Microplastic moves pollutants and additives to worms, reducing functions linked to health and biodiversity. *Current Biology*, **23(23), 2388-2392.**

Burnie, D. (2008). Shrimp. Microsoft Student 2009 [DVD]. Redmond, WA: Microsoft Corporation.

Chapin, F. S., Kofinas, G. P., & Folke, C. (Eds.). (2009). Principles of ecosystem stewardship: resilience-based natural resource management in a changing world. Springer Science & Business Media.

Chapin, F. S., Sommerkorn, M., Robards, M. D., & Hillmer-Pegram, K. (2015). Ecosystem stewardship: A resilience framework for arctic conservation. *Global Environmental Change*, **34, 207-217.**

Chapin, F. S., & Knapp, C. N. (2015). Sense of place: A process for identifying and negotiating potentially contested visions of sustainability. *Environmental Science & Policy*, **53, 38-46.**

Chapin, F. S., Carpenter, S. R., Kofinas, G. P., Folke, C., Abel, N., Clark, W. C., ... & Berkes, F. (2010). Ecosystem stewardship: sustainability strategies for a rapidly changing planet. **Trends in Ecology & Evolution**, **25(4), 241-249.**

Chapin, F. S., Power, M. E., Pickett, S. T., Freitag, A., Reynolds, J. A., Jackson, R. B., & Bartuska, A. (2011). Earth Stewardship: science for action to sustain the human-earth system. *Ecosphere*, **2(8), 1-20.**

Chapin, T. (2014). Ecosystem stewardship: planning for change. University of Alaska Fairbanks.

Chua, T. E., & Garces, L. R. (Eds.). (1992). Waste management in the coastal areas of the ASEAN region: roles of governments, banking institutions, donor agencies, private sector and communities (**Vol. 10**). WorldFish.

Chuenpagdee, R., Liguori, L., Palomares, M. L., & Pauly, D. (2012). Bottom-up, global estimates of small-scale marine fisheries catches.

Cicin-Sain, B., & Belfiore, S. (2005). Linking marine protected areas to integrated coastal and ocean management: a review of theory and practice. *Ocean & Coastal Management,* **48(11), 847-868.**

Cicin-Sain, B., Knecht, R. W., Vallega, A., & Harakunarak, A. (2000). Education and training in integrated coastal management: lessons from the international arena. *Ocean & Coastal Management*, **43(4), 291-330.**

Clarke, K. R., & Warwick, R. M. (2001). A further biodiversity index applicable to species lists: variation in taxonomic distinctness. *Marine ecology Progress series*, **216, 265-278.**

Coalition for Buzzards Bay. January 12, 2015.www.savebuzzardsbay.org

Conrad, D., & Hedin, D. (1991). School-based community service: What we know from research and theory. Phi Delta Kappan, **72(10), 743-49.**

Costa, A. & Hughes, P. (2012). How is Our Bay? Five Years of Environmental Monitoring of Cape Cod Bay A report from the Provincetown Center for Coastal Studies

Costanza, R., & Mageau, M. (1999). What is a healthy ecosystem? *Aquatic ecology*, **33(1), 105-115.**

Costanza, R., Norton, B. G., & Haskell, B. D. (Eds.). (1992). Ecosystem health: new goals for environmental management. Island Press.

CRC - Coastal Resources Center. (2014). The Integrated Coastal and Fisheries Governance (ICFG) Programme for the Western Region of Ghana, Final Report, 2014. September 4, 2009 to January 13, 2014. Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island. PW016. 78 pp.

Creel, L. (2003). Ripple effects: population and coastal regions (pp. 1-7). Washington, DC: Population Reference Bureau.

Curtin, R., & Prellezo, R. (2010). Understanding marine ecosystem-based management: a literature review. *Marine Policy,* **34(5), 821-830.**

Dadson, I. Y., Owusu, A. B., & Adams, O. (2016). Analysis of Shoreline Change along Cape Coast-Sekondi Coast, Ghana. *Geography Journal,* **2016.**

Dale, V. H., Joyce, L. A., McNulty, S., Neilson, R. P., Ayres, M. P., Flannigan, M. D., ...& Simberloff, D. (2001). Climate change and forest disturbances: climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides. *BioScience*, **51(9), 723-734.**

Danquah, L. Abass, K., & Nikoi, A.A (2011)."Anthropogenic Pollution of Inland Waters: The Case of the Aboabo River in Kumasi, Ghana", *Journal of Sustainable Development*. **Vol. 4, No. 6, pp 103 - 115**.

Danso, G., Drechsel, P., Obuobie, E., Forkuor, G., & Kranjac-Berisavljevic, G. (2014). Urban vegetable farming sites, crops and cropping practices.

Danso, G.; Drechsel, Pay; Obuobie, E.; Forkuor, G.; Kranjac-Berisavljevic, G. 2014. Urban vegetable farming sites, crops and cropping practices. In Drechsel, Pay; Keraita, B. (Eds.) Irrigated urban vegetable production in Ghana: characteristics, benefits and risk mitigation. Colombo, Sri Lanka: International Water Management Institute (IWMI). pp.7-27

Davenport, J., & Davenport, J. L. (2006). The impact of tourism and personal leisure transport on coastal environments: a review. Estuarine, *Coastal and Shelf Science*, **67(1), 280-292.**

Dawson, T. P., Jackson, S. T., House, J. I., Prentice, I. C., & Mace, G. M. (2011). Beyond predictions: biodiversity conservation in a changing climate. science, 332(6025), 53-58.

Decker, D. J., Riley, S. J., & Siemer, W. F. (Eds.). (2012). Human dimensions of wildlife management. JHU Press.

Dey, K, Mohapatra, S. C., & Misra, B. (2005), Assessment of water quality parameters of the river Brahmani at Rourkela, *Journal of Industrial Pollution Control*, **21(2), 265-270.**

Díaz, S., Fargione, J., Chapin III, F. S., & Tilman, D. (2006). Biodiversity loss threatens human well-being. PLoSBiol, 4(8), e277.

Dixon, D. O., Siemer, W. F. & Knuth. B.A. (1995). Stewardship of the Great Lakes environment: A review of literature. Department of Natural Resources, Cornell University, Human Dimensions Research Unit, Publication No.95-5, Ithaca, New York, USA.

Dwyer, W. O., Leeming, F. C., Cobern, M. K., Porter, B. E., & Jackson, J. M. (1993). Critical review of behavioral interventions to preserve the environment research since 1980. *Environment and behavior*, **25(5), 275-321.**

Edjere, O., Ibezute, A. C., & Ibezute, S. U. (2016). Impact of Brewery Factory Effluent on the Physicochemical Characteristics of Ikpoba River in Edo State, Nigeria. Resources and Environment, 6(3), 53-62.

Engelking, P. (2008). "Pollution."Microsoft® Student 2009 [DVD]. Redmond, WA: Microsoft Corporation,

Farley, J., & Costanza, R. (2010). Payments for ecosystem services: from local to global. *Ecological Economics*, 69 (11), **2060-2068.**

Flotemersch, J. E., Leibowitz, S. G., Hill, R. A., Stoddard, J. L., Thoms, M. C., & Tharme, R. E. (2016). A watershed integrity definition and assessment approach to support strategic management of watersheds. *River Research and Applications*, **32(7), 1654-1671.**

Flowers, A. B., (2007). Assessing the Effectiveness of a Place-based Conservation Education Programme by Applying Utilization-focused Evaluation. Theses, Dissertations, Professional Papers. Paper 67.

Folke, C. (2006). Resilience: The emergence of a perspective for social–ecological systems analyses. *Global environmental change*, **16(3), 253-267.**

Forget, G., & Lebel, J. (2001). An ecosystem approach to human health. *International Journal of Occupational and Environmental Health*, **7(2), 3-38.**

Freese, C. H., & Trauger, D. L. (2000). Wildlife markets and biodiversity conservation in North America. *Wildlife Society Bulletin*, **28(1), 42-51.**

Gagern, A., & Van den Bergh, J. (2013). A critical review of fishing agreements with tropical developing countries. *Marine Policy*, **38, 375-386.**

Galli, A., Wackernagel, M., Iha, K., & Lazarus, E. (2014). Ecological footprint: Implications for biodiversity. *Biological Conservation*, **173, 121-132**

Gambino, M., Accadia, P., Pinello, D., Russo, T., Malvarosa, L., Sabatella, E. C., ...& Sabatella, R. F. (2016). Towards an Integrated Coastal Zone Management in Campania Region (Italy): A Multidisciplinary Approach to the Analysis of Coastal Fishery Activities and their Socio-Economic Management. *Procedia-Social and Behavioral Sciences*, **223, 342-348.**

Garriga, M., & Losada, I. J. (2010). Education and training for integrated coastal zone management in Europe. *Ocean & Coastal Management*, **53(3), 89-98.**

Gedan, K. B., Silliman, B. R., & Bertness, M. D. (2009). Centuries of human-driven change in salt marsh ecosystems. Marine Science, 1.

Goldenberg, M. (2001). Outdoor and Risk Educational Practices.

Golo, B. W. K., & Yaro, J. A. (2013). Reclaiming stewardship in Ghana: religion and climate change. *Nature and Culture*, **8(3), 282-300.**

GSS - Ghana Statistical Service (2014) District Analytical Report - Ada East

Gupta, D. P., Sunita & J. P. Saharan, (2009), Physiochemical Analysis of Ground Water of Selected Area of Kaithal City (Haryana) India, Researcher, 1(2), pp 1-5.

HACH Company Ltd. (1996) DR/ 2000 Spectrophotometer Procedures Manual. USA.

Hackman, K. O. (2014). The state of biodiversity in Ghana: Knowledge gaps and prioritization. *International Journal of Biodiversity and Conservation*, **6(9), 681-701.**

Halkos, G., & Matsiori, S. (2012). Determinants of willingness to pay for coastal zone quality improvement. *The Journal of Socio-Economics*, **41(4), 391-399.**

Hammerman, D. R., Hammerman, W. M., & Hammerman, E. L. (2001). Teaching in the outdoors (5th ed.). Danville, IL: Interstate Publishers.

Hart, J. (2008). Water Pollution.Microsoft® Student 2009 [DVD]. Redmond, WA: Microsoft Corporation.

Hauerwas, S. (1981). A community of character. London: Norte Dame.

Hens, L. (2006). Indigenous knowledge and biodiversity conservation and management in Ghana. *Journal of Human Ecology*, **20(1), 21-30.**

Hewawasam, I. (1998). Integrated coastal zone management strategy for Ghana.

Hirschheim, R., Saunders, C. S., & Straub, D. W. (2012). Historical Interpretations of the IS Discipline: An Introduction to the Special Issue. J. AIS, 13(4), 4.

Huitric, M., Folke, C., & Kautsky, N. (2002). Development and government policies of the shrimp farming industry in Thailand in relation to mangrove ecosystems. *Ecological Economics*, **40(3), 441-455.**

Hungerford, H. R., & Volk, T. L. (1990). Changing learner behavior through environmental education. *The journal of environmental education*, **21(3), 8-21**.

Hungerford, H., Peyton, R. B., & Wilke, R. J. (1980). Goals for curriculum development in environmental education. *The Journal of Environmental Education*, **11(3), 42-47.**

Igben, J. L., & Ohiembor, O. M. (2015). Lumbering as a Factor of Deforestation in the Freshwater Swamp Forest in Delta State Nigeria. International Journal, 1.

Iliopoulou-Georgudaki, J., Kantzaris, V., Katharios, P., Kaspiris, P., Georgiadis, T., & Montesantou, B. (2003). An application of different bioindicators for assessing water quality: a case study in the rivers Alfeios and Pineios (Peloponnisos, Greece). *Ecological indicators,* **2(4), 345-360.**

IPCC (2014). Climate Change 2014: synthesis report: summary for policymakers. United Kingdom.

IPCC. (2001). Climate Change 2001: The Scientific Basis. Climate Change 2001: The Scientific Basis (p. 881). doi:10.1256/004316502320517344

Islam, M. S., & Tanaka, M. (2004). Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: a review and synthesis. *Marine pollution bulletin,* **48(7), 624-649.**

Jonah, F. E. (2014). Coastal Erosion in Ghana; the case of Elmina-Cape Coast-Moree area. Department of Fisheries and Watershed Management. Kwame Nkrumah University of Science and Technology, Kumasi http://hdl. handle. net/123456789/6882 Google Scholar.

Jones, R. T. (2014). Empire of Extinction: Russians and the North Pacific's Strange Beasts of the Sea, 1741-1867. Oxford University Press, USA.

Kannen, A. (2004). Holistic systems analysis for ICZM: The Coastal Futures approach. Geographie der Meere und Küsten. Coastline reports, 1, 171-181.

Karikari, A. Y., & Ansah-Asare, O. D. (2006). Physico-chemical and microbial water quality assessment of Densu River of Ghana. *West African Journal of Applied Ecology*, **10(1).**

Kates, R. W., Parris, T. M., & Leiserowitz, A. A. (2005). What is sustainable development? *Environment*, **47(3), 8.**

Kessey, K. D., & Arko, B. (2013). Small scale gold mining and environmental degradation, in Ghana: Issues of mining policy implementation and challenges. *Journal of Studies in Social Sciences*, **5(1).**

Key, J. P. (1997). Research design in occupational education. Oklahoma State University.

Krasny, M. E., Russ, A., Tidball, K. G., & Elmqvist, T. (2014). Civic ecology practices: participatory approaches to generating and measuring ecosystem services in cities. *Ecosystem services*, **7, 177-186.**

Kudryavtsev, A., Stedman, R. C., & Krasny, M. E. (2012). Sense of place in environmental education. *Environmental education research,* **18(2), 229-250.**

Larkin, P. A. (1996). Concepts and issues in marine ecosystem management. Reviews in fish biology and fisheries, 6(2), 139-164.

Lawrence, D. M., Slater, A. G., & Swenson, S. C. (2012). Simulation of present-day and future permafrost and seasonally frozen ground conditions in CCSM4. *Journal of Climate*, **25(7), 2207-2225.**

Lawson, E. T. (2013). Your leisure, my space: using residents' perceptions as indicators in sustainable coastal tourism development in Ghana.

Lawson, E. T., Gordon, C., Mensah, A., & Atipoe, E. (2015). Developing Tools for Community-Based Environmental Education for Migrant Children and Youth in Ghana. *Journal of Education and Learning*, **4(2), 6-18.**

Leach, M., Mearns, R., & Scoones, I. (1999). Environmental entitlements: dynamics and institutions in community-based natural resource management. World development, 27(2), 225-247.

Leenhardt, P., Teneva, L., Kininmonth, S., Darling, E., Cooley, S., & Claudet, J. (2015). Challenges, insights and perspectives associated with using social-ecological science for marine conservation. *Ocean & Coastal Management,* **115, 49-60.**

Leinster, T., & Cobbold, C. A. (2012). Measuring diversity: the importance of species similarity. *Ecology*, **93(3), 477-489.**

Levine, D. S., & Strube, M. J. (2012). Environmental attitudes, knowledge, intentions and behaviors among college students. *The Journal of social psychology*, **152(3), 308-326.**

Linden, O., & Lundin, C. G. (1996). Integrated coastal zone management in Tanzania: Proceedings of the national workshop. World bank.

Lorenzen, E. D., Nogués-Bravo, D., Orlando, L., Weinstock, J., Binladen, J., Marske, K. A., ...& Ho, S. Y. (2011). Species-specific responses of Late Quaternary megafauna to climate and humans. *Nature,* **479(7373), 359-364.**

Ly, C. K. (1980). The role of the Akosombo Dam on the Volta River in causing coastal erosion in central and eastern Ghana (West Africa). *Marine Geology*, **37(3-4), 323-332.**

Macan, T. T. (1979). A guide to freshwater invertebrate animals. Longman Group Ltd. London.

Macbeath, C., & Topiltzin, E. (2014). An analysis of the spatial distribution of freshwater fishes of Mexico, their conservation status, and the development of a conservation strategy for species with imminent risk of extinction based on contemporary theories and practices (Doctoral dissertation, Manchester Metropolitan University).

Malhi, Y., Roberts, J. T., Betts, R. A., Killeen, T. J., Li, W., & Nobre, C. A. (2008). Climate change, deforestation, and the fate of the Amazon. science,319(5860), 169-172.

Mallory, T. G. (2013). China's distant water fishing industry: Evolving policies and implications. *Marine Policy*, **38, 99-108.**

Marcinkowski, T. (1998). Predictors of responsible environmental behavior: A review of three dissertation studies. In.

Mathers, N., Fox, N., & Hunn, A. (2007). Surveys and questionnaires. Trent: RDSU.

Matthews, B. E., & Riley, C. K. (1995). Teaching and Evaluating Outdoor Ethics Education Programmes.

McDonnell, J. D. (2001). Best Practices in Marine and Coastal Science Education: Lessons Learned from a National Estuarine Research Reserve.

McLean, R. F., Tsyban, A., Burkett, V., Codignotto, J. O., Forbes, D. L., Mimura, N., ...& Ittekkot, V. (2001). Coastal zones and marine ecosystems. *Climate change*, **343-379.**

MEA (2005). Ecosystems and human well-being: synthesis. Island, Washington, DC.

Medlock, J. M., Hansford, K. M., Schaffner, F., Versteirt, V., Hendrickx, G., Zeller, H., & Bortel, W. V. (2012). A review of the invasive mosquitoes in Europe: ecology, public health risks, and control options. Vector-borne and zoonotic diseases, 12(6), 435-447.

Meliadou, A., Santoro, F., Nader, M. R., Dagher, M. A., Al Indary, S., & Salloum, B. A. (2012). Prioritising coastal zone management issues through fuzzy cognitive mapping approach. *Journal of environmental management*, **97, 56-68.**

Melkert, M., & Vos, K. (2010). A comparison of quantitative and qualitative approaches: Complementarities and trade-offs. Cultural tourism research methods, 33-40.

Meltofte, H. (2013). Synthesis: implications for conservation. Chapter 1. Arctic Biodiversity Assessment-Status and trends in Arctic Flora and Fauna, Akureyri, 21-65.

Meltofte, H., Barry, T., Berteaux, D., Bültmann, H., Christiansen, J. S., Cook, J. A., ...& Friðriksson, F. (2013). Arctic Biodiversity Assesment. Synthesis. Conservation of Arctic Flora and Fauna (CAFF).

Mensah, A. M. (2009). The influence of land use activities on nutrient inputs into small upland catchment streams, Ghana (Doctoral dissertation, Bonn, Univ., Diss., 2009).

Mensah, A. M., & Castro, L. C. (2004). Sustainable resource use & sustainable development: a contradiction. Center for Development Research, University of Bonn.

Mensah, S. O., & Amoah, S. T. (2013). Co-Managing Ecosystem Services in Forest Reserves in Ghana: The Case of the Bobiri Forest Reserve (Bfr) in Kubease in the Ashanti Region of Ghana. Developing country studies, 3, 50-61

Miezah, K., Obiri-Danso, K., Kádár, Z., Fei-Baffoe, B., & Mensah, M. Y. (2015). Municipal solid waste characterization and quantification as a measure towards effective waste management in Ghana. *Waste Management*, **46, 15-27.**

Mikkelsen, A., & Langhelle, O. (2008). Arctic oil and gas: sustainability at risk? Routledge. (Eds.).

Moffitt, C. M., & Cajas-Cano, L. (2014). Blue growth: the 2014 FAO state of world fisheries and aquaculture. *Fisheries,* **39(11), 552-553.**

Moldan, B., Janoušková, S., & Hák, T. (2012). How to understand and measure environmental sustainability: Indicators and targets. *Ecological Indicators*, **17, 4-13.**

Moller-Jensen, L., & Knudsen, M. H. (2008). Patterns of population change in Ghana (1984–2000): urbanization and frontier development. *GeoJournal,* **73(4), 307-320.**

Molnar, J. L., & Kubiszewski, I. (2012). Managing natural wealth: Research and implementation of ecosystem services in the United States and Canada. *Ecosystem Services*, **2, 45-55.**

Mooney, H., Larigauderie, A., Cesario, M., Elmquist, T., Hoegh-Guldberg, O., Lavorel, S., ... & Yahara, T. (2009). Biodiversity, climate change, and ecosystem services. Current Opinion in Environmental Sustainability, 1(1), 46-54.

Moser, S. C., Jeffress Williams, S., & Boesch, D. F. (2012). Wicked challenges at Land's End: Managing coastal vulnerability under climate change. *Annual Review of Environment and Resources*, **37, 51-78.**

Murwira, A., Masocha, M., Magadza, C. H., Owen, R., Nhiwatiwa, T., Barson, M., & Makurira, H. (2014). Zimbabwe-Strategy for Managing Water Quality and Protecting Water Sources.

Murwira, A., Masocha, M., Magadza, C. H., Owen, R., Nhiwatiwa, T., Barson, M., & Makurira, H. (2014). Zimbabwe-Strategy for Managing Water Quality and Protecting Water Sources. Ministry of Environment, Climate and Water

Myers, S. S., Gaffikin, L., Golden, C. D., Ostfeld, R. S., Redford, K. H., Ricketts, T. H., ... & Osofsky, S. A. (2013). Human health impacts of ecosystem alteration. Proceedings of the National Academy of Sciences, 110(47), 18753-18760.

National Oceanic and Atmospheric Administration and the National Estuarine Research Reserve System (NERRS) URL: http://www.estuaries.noaa.gov. retrieved on 01/07/2016

NCCF (2000). Coastal Connections, A Supplementary Classroom Curriculum. Newport.

Neuman, W. L. (2000). Social research method. University of Wisconsin at Whitewater.

Newton, A., Carruthers, T. J., & Icely, J. (2012). The coastal syndromes and hotspots on the coast. Estuarine, *Coastal and Shelf Science*, **96, 39-47.**

Nor, N. H. M., & Obbard, J. P. (2014). Microplastics in Singapore's coastal mangrove ecosystems. *Marine pollution bulletin*, **79(1), 278-283.**

Oktari, R. S., Shiwaku, K., Munadi, K., & Shaw, R. (2015). A conceptual model of a school–community collaborative network in enhancing coastal community resilience in Banda Aceh, Indonesia. International journal of disaster risk reduction, 12, 300-310.

Olympio, G. F. A., & Amos-Abanyie, S. (2013). Effects of shoreline erosion on infrastructure development along the coastal belt of Ghana: Case of Nkontompo community. *Journal of Science and Technology (Ghana)*, **33(3), 39-50.**

Opdam, P., Nassauer, J. I., Wang, Z., Albert, C., Bentrup, G., Castella, J. C., ... & Swaffield, S. (2013). Science for action at the local landscape scale. *Landscape Ecology*, **28(8), 1439-1445.**

Ostrom, E., Chang, C., Pennington, M., & Tarko, V. (2012). The Future of the Commons-Beyond Market Failure and Government Regulation.

Otoo, E. A., Whyatt, D. J., & Ite, U. E. (2006). Quantifying Urban Growth in Accra Metropolitan Area (AMA), Ghana and Exploring Causal Mechanisms Quantifying Urban Growth in Accra Metropolitan Area (AMA), Ghana and Exploring Causal Mechanisms, 1–9.

Owusu, P. A., Asumadu-Sarkodie, S., & Ameyo, P. (2016). A review of Ghana's water resource management and the future prospect. *Cogent Engineering*, **3(1), 1164275.**

Parry, M. L., Canziani, O. F., Palutikof, J. P., Van Der Linden, P. J., & Hanson, C. E. (2007). Climate change 2007: working group II–impacts, adaptation and vulnerability. Intergovernmental Panel on Climate Change (IPCC).

Patil, P. N., Sawant, D. V., & Deshmukh, R. N. (2012). Physico-chemical parameters for testing of water-A review. *International Journal of Environmental Sciences,* **3(3), 1194.**

Pauly, D., Christensen, V., Guénette, S., Pitcher, T. J., Sumaila, U. R., Walters, C. J., ...& Zeller, D. (2002). Towards sustainability in world fisheries. *Nature,* **418(6898), 689-695**.

Pawar, A. C., Nair, J., Kumar, J., Naresh, V., Devi, V., & Pawar, S, C., (2006), Physico-chemical study of ground work samples from Nacharam Industrial area, Hyderabad, Andhra Pradesh, *Journal of Aquatic Biology*, **21(1), pp 118-120.**

Pendleton, L., Donato, D. C., Murray, B. C., Crooks, S., Jenkins, W. A., Sifleet, S., ...& Megonigal, P. (2012). Estimating global "blue carbon" emissions from conversion and degradation of vegetated coastal ecosystems. PloS one, 7(9), e43542.

Pereira, H. M., & Cooper, H. D. (2006). Towards the global monitoring of biodiversity change. *Trends in Ecology & Evolution*, **21(3), 123-129.**

Pérez-López, M. E., González-Elizondo, M. D. S., López-González, C., Martínez-Prado, A., & Cuevas-Rodríguez, G. (2009). Aquatic macrophytes tolerance to domestic wastewater and their efficiency in artificial wetlands under greenhouse conditions. Hidrobiológica, 19(3), 233-244.

Perkins, J. S., & Ramberg, L. (2004). Environmental Monitoring of Tsetse Fly Spraying Impacts in the Okavango Delta-2002. Harry Oppenheimer Okavango Research Centre, University of Botswana.

Pesce, S. F., & Wunderlin, D. A. (2000). Use of water quality indices to verify the impact of Córdoba City (Argentina) on Suquía River. Water Research, 34(11), 2915-2926.

Pikitch, E., Santora, C., Babcock, E. A., Bakun, A., Bonfil, R., Conover, D. O., ... & Houde, E. D. (2004). Ecosystem-based fishery management. Science, 305(5682), 346-347.

Poff, N. L., Brinson, M. M., & Day, J. W. (2002). Aquatic ecosystems and global climate change. Pew Center on Global Climate Change, Arlington, VA, 44.

Pomerantz, G. A. (1991). Evaluation of natural resource education materials: Implications for resource management. *The Journal of Environmental Education*, **22(2), 16-23.**

Poonkothai, M., & Parvatham, R., (2005). Bio-physico and chemical assessment of automobile wastewater, *Journal of Industrial Pollution Control*, **21 (2), pp 377-380.**

Portman, M. E., Esteves, L. S., Le, X. Q., & Khan, A. Z. (2012). Improving integration for integrated coastal zone management: an eight-country study. *Science of the Total Environment*, **439, 194-201.**

Premlata, Vikal, (2009), Multivariant analysis of drinking water quality parameters of lakePichhola in Udaipur, India. Biological Forum, Biological Forum- *An International Journal*, **1(2), pp 97-102.**

Rahman, M. A., & Rahman, S. (2015). Natural and traditional defense mechanisms to reduce climate risks in coastal zones of Bangladesh. *Weather and Climate Extremes*, **7, 84-95.**

Rands, M. R., Adams, W. M., Bennun, L., Butchart, S. H., Clements, A., Coomes, D., ...& Sutherland, W. J. (2010). Biodiversity conservation: challenges beyond 2010. *Science*, **329(5997), 1298-1303.**

Rapport, D. J., Böhm, G., Buckingham, D., Cairns, J., Costanza, R., Karr, J. R., ... & Whitford, W. G. (1999). Ecosystem health: the concept, the ISEH, and the important tasks ahead. *Ecosystem health*, **5(2), 82-90.**

Rapport, D. J., Costanza, R., & McMichael, A. J. (1998). Assessing ecosystem health. Trends in ecology & evolution, 13(10), 397-402.

Rapport, D. J., Fyfe, W. S., Costanza, R., Spiegel, J., Yassie, A., Bohm, G. M., ... & Horwitz, P. (2001). Ecosystem health: definitions, assessment and case studies. Our Fragile World: Challenges and Opportunities for Sustainable Development. EOLSS, Oxford, 21-42.

Renaud, F. G., Syvitski, J. P., Sebesvari, Z., Werners, S. E., Kremer, H., Kuenzer, C., ... & Friedrich, J. (2013). Tipping from the Holocene to the Anthropocene: How threatened are major world deltas? Current Opinion in Environmental Sustainability, 5(6), 644-654.

Rochette, J. (2010). Coastal zone definition and geographic coverage of the ICZM Protocol issues, (December).

Rochman, C. M., Browne, M. A., Halpern, B. S., Hentschel, B. T., Hoh, E., Karapanagioti, H. K. & Thompson, R. C. (2013). Policy: Classify plastic waste as hazardous. *Nature*, **494(7436), 169-171.**

Rolston III, H. (2012). A new environmental ethics: the next millennium for life on earth. Routledge.

Romeo, T., Pietro, B., Pedà, C., Consoli, P., Andaloro, F., & Fossi, M. C. (2015). First evidence of presence of plastic debris in stomach of large pelagic fish in the Mediterranean Sea. *Marine pollution bulletin*, **95(1), 358-361.**

Ross, J. E. (2001). Water-Based Outdoor Recreation and Persons with Disabilities. http://www.rbff.org/educational/BPE10.pdf.

Sandeen, A. T., & Gamroth, M. J. (2003). Composting: An alternative for livestock manure management and disposal of dead animals. Corvallis, Or.: Extension Service, Oregon State University.

Schmidt S. (2008). Coastal Zone Education – How to!? (http://www.youtube.com/watch?v=uNhzWE381V8)

Schoch, R. R. (2009). Evolution of life cycles in early amphibians. Annual Review of Earth and Planetary Sciences, 37, 135-162.

Schultz, P. (2011). Conservation means behavior. *Conservation Biology*, **25(6), 1080-1083.**

Schusler, T. M., & Krasny, M. E. (2010). Environmental action as context for youth development. The Journal of Environmental Education, 41(4), 208-223.

Scrimgeour, G. J., & Wicklum, D. (1996). Aquatic ecosystem health and integrity: problems and potential solutions. *Journal of the North American Benthological Society*, **15(2), 254-261.**

Sellmann, D., & Bogner, F. X. (2013). Climate change education: Quantitatively assessing the impact of a botanical garden as an informal learning environment. Environmental Education Research, 19(4), 415-429.

Shannon, C. E., & Weaver, W. (1949). The mathematical theory of information.

Shimba, M. J., Mkude, I. T., & Jonah, F. E. (2018). Impacts of waste on macroinvertebrate assemblages of Msimbazi River, Tanzania. *International Journal of Biodiversity and Conservation,* **10(2), 106116.**

Sichel, B. A. (1988). Moral education. Temple University Press.

Siemer, W. F. (2001). Best Practices for Curriculum, Teaching, and Evaluation Components of Aquatic Stewardship Education.

Sih, A., Ferrari, M. C., & Harris, D. J. (2011). Evolution and behavioural responses to human-induced rapid environmental change. *Evolutionary Applications*, **4(2), 367-387.**

Simpson, E. H. (1949). Measurement of diversity. Nature.

Small, C., & Nicholls, R. J. (2003). A global analysis of human settlement in coastal zones. Journal of Coastal Research, **584-599.**

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., ... & Folke, C. (2015). Planetary boundaries: Guiding human development on a changing planet. *Science*, **347(6223), 1259855**.

Stendel, M., & Christensen, J. H. (2002). Impact of global warming on permafrost conditions in a coupled GCM. Geophysical Research Letters, 29(13).

Stern, P. C., Dietz, T., Abel, T. D., Guagnano, G. A., & Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case of environmentalism. *Human ecology review*, **6(2), 81-97.**

Stevenson, R. B., Brody, M., Dillon, J., & Wals, A. E. (Eds.). (2014). International handbook of research on environmental education. Routledge.

Su, M., Zhang, Y., Liu, G., Xu, L., Zhang, L., & Yang, Z. (2013). Urban ecosystem health assessment: Perspectives and Chinese practice. *International journal of environmental research and public health*, **10(11), 5874-5885.**

Tanticharoen, M., Flegel, T. W., Meerod, W., Grudloyma, U., & Pisamai, N. (2008). Aquacultural biotechnology in Thailand: the case of the shrimp industry. *International Journal of Biotechnology,* **10(6), 588-603.**

Teh, L. C., & Sumaila, U. R. (2013). Contribution of marine fisheries to worldwide employment. *Fish and Fisheries*, **14(1), 77-88.**

Thom, R. M., & O'Rourke, L. K. (2005). Ecosystem Health Indicator Metrics for the Lower Columbia River and Estuary Partnership. Prepared by Battelle Marine Sciences Laboratory, Sequim, Washington.

Tilman, D., & Lehman, C. (2001). Human-caused environmental change: impacts on plant diversity and evolution. Proceedings of the National Academy of Sciences, 98(10), 5433-5440.

Trucco, C., Schuur, E. A., Natali, S. M., Belshe, E. F., Bracho, R., & Vogel, J. (2012). Seven-year trends of CO2 exchange in a tundra ecosystem affected by long-term permafrost thaw. *Journal of Geophysical Research: Biogeosciences*, **117(G2)**

Tveterås, S., Asche, F., Bellemare, M. F., Smith, M. D., Guttormsen, A. G., Lem, A., ...& Vannuccini, S. (2012). Fish is food-the FAO's fish price index. PLoS One, 7(5), e36731.

Tweneboah, E. (2009). The role of environmental values and attitudes of Ghanaian coastal women in Natural Resource Management (Doctoral dissertation, Brandenburg University of Technology).

UNDP. (2007). Human Development Report 2007/2008 Fighting climate change: Human solidarity in a divided world. Human Development (pp. 229–232). doi: ISBN 978-0-230-54704-9

UNEP. (2006). Marine and coastal ecosystems and human well-being: A synthesis report based on the findings of the Millennium Ecosystem Assessment. Russell. The Journal of The Bertrand Russell Archives (p. 76).

Retrieved from http://www.vliz.be/imisdocs/publications/120064.pdf

Vanbergen, A. J. (2013). Threats to an ecosystem service: pressures on pollinators. *Frontiers in Ecology and the Environment*, **11(5), 251-259.**

Vikas, M., & Dwarakish, G. S. (2015). Coastal pollution: a review. *Aquatic Procedia***, 4, 381-388.**

Vitousek, P. M., Mooney, H. A., Lubchenco, J., & Melillo, J. M. (1997). Human domination of Earth's ecosystems. *Science*, **277(5325), 494-499.**

Wai, Y. S., & Bojei, J. (2015). Moderating effects of psychology factors for stewardship of sustainable behaviours: a conceptual framework.

Walker, B., & Salt, D. (2012). Resilience thinking: sustaining ecosystems and people in a changing world. Island Press.

Walter, R. C., Buffler, R. T., Bruggemann, J. H., Guillaume, M. M., Berhe, S. M., Negassi, B., & Néraudeau, D. (2000). Early human occupation of the Red Sea coast of Eritrea during the last interglacial. *Nature,* **405(6782), 65-69.**

WRC - Water Resources Commission (2003). Ghana Raw Water Criteria and Guidelines Series. Report Prepared for Ghana Water Resources Commission by CSIR-Water Research Institute. WRI/TR No. 556.114 COU WRI/CAR No. 133

Waycott, M., Duarte, C. M., Carruthers, T. J., Orth, R. J., Dennison, W. C., Olyarnik, S., & Kendrick, G. A. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems. Proceedings of the National Academy of Sciences, 106(30), 12377-12381.

Weigert, A. J. (1997). Self, interaction, and natural environment: Refocusing our eyesight. SUNY Press.

Wilson, C., & Tisdell, C. (2001). Why farmers continue to use pesticides despite environmental, health and sustainability costs. *Ecological economics*, **39(3), 449-462**

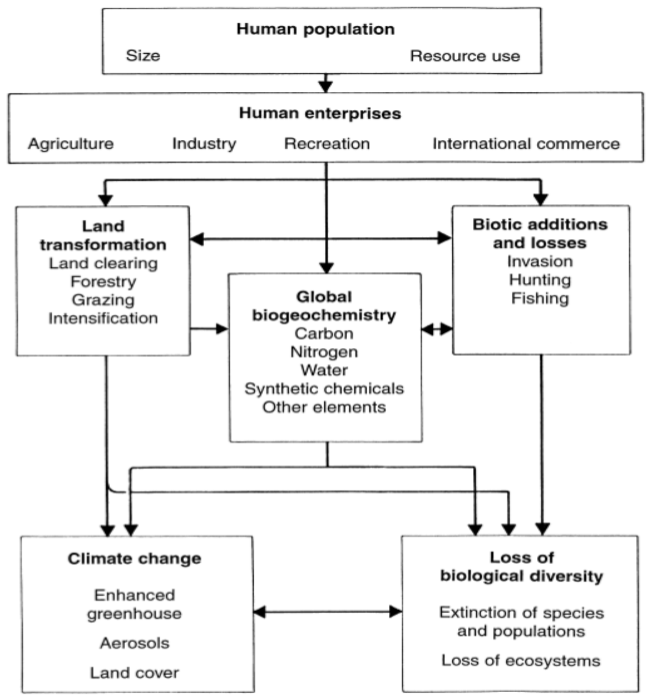
Wortman, D, Cooke, K, Hebert, K & Tilbury, D (2006) Assessing Provision and Effectiveness of Coastal Management Education. Canberra: Australian Government Department of the Environment and Water Resources and the Australian Research Institute in Education for Sustainability (ARIES).

Yazdian, H., Jaafarzadeh, N., & Zahraie, B. (2014). Relationship between benthic macroinvertebrate bio-indices and physicochemical parameters of water: a tool for water resources managers. Journal of Environmental Health Science and Engineering, 12(1), 30.

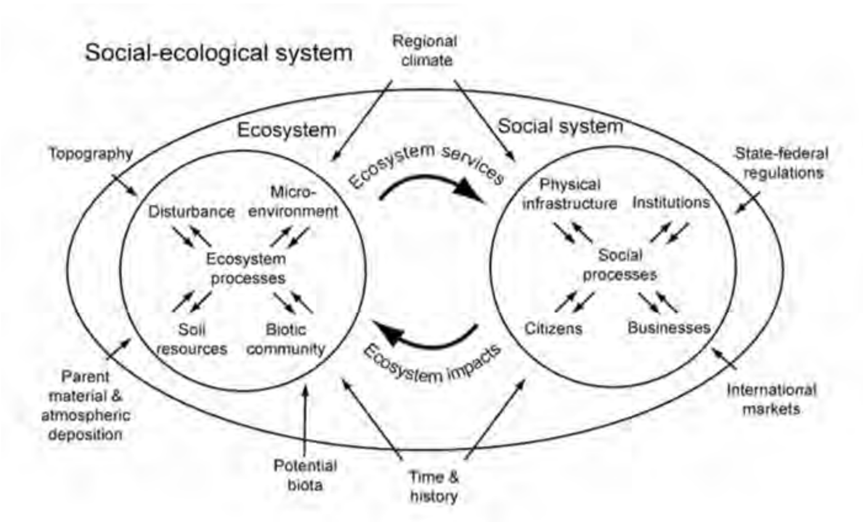
Zint, M. (2013). Advancing Environmental Education Programme Evaluation. International handbook of research on environmental education, 298-309.

APPENDICES

Appendix A1: A conceptual model illustrating humanity's direct and indirect effects on the Earth system (Source: Vitousek et al., 1997)



Appendix A2: Humans as part of the social-ecological systems (Source: Chapin, 2014)



Appendix B1: Guidelines for focus group discussion

Section A: Organisation background

1. Names (optional) and Institutions of discussants

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2. Position in the institution

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Section B: Coastal aquatic ecosystems and educational approach

3. What are the impacts of increasing human development on the coastal aquatic ecosystems?
4. What measures have been introduced to safeguard the coastal aquatic ecosystems (including livelihoods of the local communities)?
5. Are the measures put in place to safeguard the coastal aquatic ecosystems effective?
6. Do you think the institutions in place by government can solely safeguard aquatic ecosystems without community participation?
7. Are there any CBOs/NGOs/FBOs, Development Partners offering assistance in relation to aquatic ecosystem education?
8. How would you describe the community's level of knowledge about aquatic ecosystems?

9. How would you describe the attitude of the community in relation to the prevention of aquatic ecosystem degradation?
10. How would you describe the community's practice in relation to the prevention of aquatic ecosystem degradation?
11. To what extent do you think the local communities are involved in the conservation of aquatic ecosystems?
12. Do you think enhancing community stewardship can contribute to safeguard and improve the health of the coastal aquatic ecosystems?
13. Is there any structured educational model you follow to enhance community stewardship?
14. Do you think it would be relevant to have a structured educational model to enhance stewardship of aquatic ecosystems?
15. What would you recommend should be captured in the structured educational model to inspire community members towards safeguarding aquatic ecosystems?
16. Do you think learning about their indigenous local environment would trigger the interest of community members to safeguard aquatic ecosystems?
17. Do you think making community member have a feel of the natural coastal environment with hands-on activities would create the sense of being engaged in processes to conserve these ecosystems?
18. Which group of persons do you recommend to be the targeted for aquatic ecosystem education?

Appendix B2: QUESTIONNAIRE

BACKGROUND

The project seeks to evaluate the ecological state of the Coastal ecosystems of Ada, Ghana to develop innovative educational approaches for strengthening community stewardship. The current study is being undertaken to obtain socioeconomic and ecological information about the coastal communities of Ada.

I am grateful for your time to participate in this discussion. All personal information provided will be treated as confidential

Date	Date data entered
Locality	Data entered by
Interviewer	Data check by

Questionnaire # __________

1 **General information of respondents**

1.1 Name____

1.2 Sex ☐ Male ☐ Female

1.3 Age ☐ < 20 years ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐50-59 ☐ > 60 ☐ Don't know

1.4 Tribe (Ethnic group)

____

1.5 Language spoken ☐ Ashanti ☐ Ga ☐ Twi ☐Ewe ☐ English ☐ Others___________

1.6 Religion ☐ Christian ☐ Muslim ☐Traditionalist ☐Other________

1.7 Level of Education ☐ None ☐ Primary ☐ Secondary ☐ Polytechnic/Teacher Training ☐ Other

____

1.8 Type of main occupation ____

1.8.1 What is your secondary occupation ____________________________________

1.9 a) Marital Status ☐ Single ☐ Married ☐ Divorced ☐Widowed

b) Total Dependents ☐Adults (≥18 years) ________ ☐Children (< 18 years) _______

1.10 Children in school: ☐Male _______ #. in school_______ # not in School_______

☐Female _______ # in school_______ # not in School_______

2 Socio-Cultural Characteristics

2.1 Standard of Living

2.1.1 Estimated total **monthly** income (GHC) for the household (from all occupations) __________

2.1.2 Housing status ☐Own ☐Rent ☐Shared ☐ Family ☐Other

____

2.1.3 Main source of lighting ☐Electricity ☐Kerosene ☐ No light

☐Others____________

2.1.4 Accessibility to drinking water ☐Pipe borne water ☐Public tab/stand pipe

☐Borehole outside the house ☐Rain water/stream ☐Others ________________

2.1.5 Toilet facilities ☐KVIP ☐ Flush Toilet ☐ Pit Latrine ☐No facility

2.2 Residential Status

2.2.1 Were you born in this town or village? ☐Yes ☐ No ☐Don't know

2.2.2 If no, what was your purpose for moving to this community? ☐Livelihood opportunity ☐Family related / marriage ☐Education ☐Retirement ☐Others____

2.2.3 How long have you lived in this community?: ☐Less than one year ☐ 1year – 5years

☐5years -10years ☐ More than 10years

3 Environmental Characteristics

3.1 Health

3.1.1 Are you aware of any disease(s) transmitted through drinking water or bathing in surrounding aquatic systems? ☐ Yes ☐ No ☐Don't know

3.1.2 If yes, what type/s is it?

____

3.1.3 Are you registered under the National Health Insurance Scheme? ☐ Yes ☐ No

3.1.4 If no, why not? ____

3.1.5 Do you know of any medicinal plants? ☐ Yes ☐ No

3.1.6 If yes, name the most common____

3.1.7 Where are they found? ______________________________

3.1.8 What are the plants used for?______________________________

3.1.9 What are the types of treatment used when someone is sick? (Tick as many as is applicable)

☐Herbal treatment ☐Orthodox treatment (hospital, clinic etc) ☐Prayer healing

☐Others________

3.2 Farming and Land Cover Change

3.2.1 Is there farming in this community? ☐Yes ☐ No ☐Don't know

3.2.2 If yes, what types of crops are grown on the fields?

____

3.2.3 What methods are used in preparing the land for farming?

3.2.4 What happens to land after harvest and for how long?______________________________

3.2.5 Is there any fertilizer application? ☐Yes ☐ No ☐Don't know

3.2.6 Are there any impacts on the land or water?______________________________

3.2.7 Is there pesticides/herbicides/fungicides application? ☐Yes ☐ No ☐Don't know

3.2.8 Are there any impacts on the land or water?

3.2.9 What changes in the soil or land cover have you observed within your life time?

3.2.10 Have there been in any change in the quantity of your farm produce/harvest over the past 15 years? ☐Yes ☐ No ☐ Don't know

3.2.11 If yes, indicate the observed changes and why?

3.3 Fishing

3.3.1 Is there any fishing nearby? ☐Yes ☐ No ☐Don't know

3.3.2 Are there any fishing regulations? ☐Yes ☐ No ☐Don't know

3.3.3 If *yes*, what is it?

3.3.4 Have there been any changes in fish catch over the past 15 years?

☐Yes ☐ No ☐Don't know

3.3.5 If yes, indicate the observed change

☐ Increase in fish catch ☐ Decrease in fish catch ☐ Still the same

3.3.6 In your opinion, what might have caused this change______________________________

3.4 Livestock

3.4.1 Do you own any livestock? ☐Yes ☐ No

3.4.2 How/where are the livestock kept? ______________________________

3.4.3 Are there any regulations about watering/grazing livestock?

☐Yes ☐ No ☐ Don't know

3.4.4 If *yes*, is it adhered to? ☐Yes ☐ No ☐ Don't know

3.4.5 Is any of the manure recycled for fertilizer use? ☐Yes ☐ No ☐ Don't know

3.4.6 If *no*, what happens to the manure? ______________________________

3.5 Hunting

3.5.1 Is there hunting in the community? ☐Yes ☐ No ☐ Don't know

3.5.2 Do you use wild animals as protein supplement? ☐Yes ☐ No

3.5.3 If yes, which of these? ☐Monkey ☐ Rat ☐Birds ☐Turtles

☐Monitor lizards ☐Others

(specify)______________________________

3.5.4 Which method of hunting do you use? ☐Gun ☐Trap ☐Bushfire ☐Others

____

3.5.5 Have there been any changes in the quantity of game catch over the past 15 years?

☐Yes ☐ No ☐ Don't know

3.5.6 If yes, indicate the observed change?

☐ Increase in game ☐ Decrease ☐ The same

3.5.7 In your opinion what might caused this change

3.6 *Sources of Energy*

3.6.1 What energy sources are usually used in the preparation of food?

☐Firewood ☐ Charcoal ☐ Others____________

3.6.2 Is there any charcoal production in this community? ☐Yes ☐ No ☐Don't know

3.6.3 Do you think there are any effects of charcoal production on the community or in the forest?

☐Yes ☐ No ☐Don't know

3.6.4 If *yes*, please explain. ______________________________

3.6.5 Have there been any changes in your energy sources used in the preparation of food over the past 15 years? ☐Yes ☐ No

3.6.6 If yes, indicate change, ______________________________

3.6.7 Why do you think this change has happened?

____

3.7 *Bush fires*

3.7.1 Are (uncontrolled) bush fires common? ☐Yes ☐ No ☐Don't know

3.7.2 What are the causes of these bush fires? ______________________________

3.7.3 Is it forbidden to create bush fires? ☐Yes ☐ No ☐Don't know

3.7.4 Are there any methods to prevent bush fires? ☐Yes ☐ No ☐Don't know

3.7.5 If yes, explain ______________________________

3.7.6 Has the incidence of bush fires changed over the past 15 years?

☐Yes ☐ No ☐Don't know

3.7.7 If yes, how, and what could have caused this change________________________________
____

3.8 *Floods/Drought*

3.8.1 Have you observed more frequent flooding/droughts recently as compared to the past 15 years? ☐Yes ☐ No ☐Don't know

3.8.2 Explain these changes____

3.8.3 What do you think are the causes?____

3.8.4 Explain the way affects you?

3.9 *Erosion*

3.9.1 Have you observed erosion in your community? ☐Yes ☐ No ☐ Don't know

3.9.2 Where?____

3.9.3 When was this observed? ____

3.9.4 What do you think it's the cause?____

3.9.5 How serious does your community think the erosion its?

☐Very serious ☐ Quite serious ☐ Not serious

3.9.6 Has anyone been affected by erosion? ☐Yes ☐ No ☐ Don't know

3.9.7 Explain how severe it was?____

3.10 *Water Quality*

3.10.1 Do you use water from any surrounding aquatic systems? ☐ Yes ☐ No ☐Don't know

3.10.2 What is it used for?
____

3.10.3 Which aquatic system ____

3.10.4 Have you noticed any changes (past 15 years) in the aquatic systems within your life time (including water quality) ☐ Yes ☐ No ☐Don't know

3.10.5 If *yes*, please describe this____

3.10.6 Are any activities close to the aquatic systems? ☐ Yes ☐ No ☐Don't know

3.10.7 If *yes*, what are they?
____

3.10.8 Are the aquatic systems protected in anyway? ☐Yes ☐ No ☐ Don't know

3.10.9 Do you think there are any activities in this community that can affect the quality of the aquatic systems? ☐Yes ☐ No ☐ Don't know

3.10.10 If *yes*, what are they?
____

3.11 *Waste Disposal*

3.11.1 Where do you dump your refuse? ☐ Sewer ☐ Public dump ☐ -Burnt

☐ Others____________

3.11.2 Is there a community dumping site? ☐Yes ☐ No

3.11.3 If yes, do people use it? ☐Yes ☐ No ☐ Don't know

3.11.4 Is refuse being dumped into the environment/ecosystems?

☐Yes ☐ No ☐ Don't know

3.11.5 Where do you throw away water that has been used at home? __________________________

3.11.6 Do you think this is a problem? ☐Yes ☐ No ☐ Don't know

3.11.7 Do you think there will be an environmental impact? ☐Yes ☐ No Don't know

3.11.8 Why?

3.11.9 What should be done about it? ____

3.12 *Culture*

3.12.1 Name any sites that are traditionally important (E.g., sacred groves, festival grounds, cultural centres, etc).

Site **Importance**

____

____

____

____

3.12.2 Name any plants or animals that are traditionally important (e.g., as totems, taboos, etc.)

____

3.13 *Flora and fauna*

Have you observed any changes in the following over the past 15 years?

	Observed important type/species	Human activities (impact)	Changes over the years
Aquatic fauna			
Aquatic flora			
Terrestrial fauna			
Terrestrial flora			

3.14 *Weather and Climate*

3.14.1 Have you observed any changes in the weather conditions in your community over the past 15 years? ☐Yes ☐ No ☐ Don't know

3.14.2 If yes, what are the observed changes

3.14.3 What do you think has caused this change? ______________________________

3.14.4 How has the change affected you?_________________________________

3.15 *Galamsey*

3.15.1 Are there any '*galamsey'* activities in/around your community?

☐Yes ☐ No ☐ Don't know

3.15.2 How have these activities affected your environment?

____

3.15.3 How have these activities specifically affected the ecosystems?

____

3.15.4 How can this be dealt with?____

3.16 *Coastal Ecosystems Awareness*

3.16.1 Which of the following attributes of ecosystem are you aware of?

Naturally occurring ☐ made of biotic and abiotic components ☐ Interaction among components ☐ A stable system ☐ Don't know ☐

3.16.2 Do members of your household ever talk about conserving the coastal ecosystems?

☐ Yes ☐ No

3.16.3 Are there any organizations in the district? ☐ Yes ☐ No

3.16.4 What are they? ☐Recreational organization (sports/music/culture)

☐Religious organizations ☐Political organization/local government ☐Interest groups (Migrants/Women's group)

3.16.5 Are issues on conservation discussed at these meetings? ☐ Yes ☐ No

3.16.6 How would you describe the community's practice in relation to the prevention of coastal ecosystem degradation? ☐Adequate ☐ Inadequate

3.16.7 Do you think enhancing community stewardship can contribute to safeguard and improve the health of the coastal ecosystems? ☐ Yes ☐ No ☐Don't know

4 Economic and Productive Systems

4.1 *Economic Importance of Resources*

4.1.1 Rank the four (4) most important resources in your community in terms of economic importance

1

2.

3.

4.

4.1.2 Have there been any changes to the resources that have affected income?

☐Yes ☐ No ☐ Don't know

4.1.3 What are the causes of these changes? ☐ Poaching ☐ Pollution ☐ Over exploitation

☐ Changes in the weather ☐ Other_______________________________

4.1.4 What do you think can be done to increase the income level?

☐ Enforce regulations

☐ Reduce overexploitation of resources

☐ Provision of Credit to expand activities

☐ Introduction of alternative livelihoods ☐Improvement of Market avenues

☐ Others________________________________

Adapted from: Mensah, A. M. (2009). The influence of land use activities on nutrient inputs into upland catchment streams, Ghana. ZEF.

Appendix C: Landuse Investigations score guide and results for the various sampling locations

Appendix C1: Buffer zones

Score

a) At least 18m wide 5 points
b) Between 12-18m wide 3 points
c) Between 6-12m wide 2 points
d) Less than 6m wide 0 point

Buffer zone of the sampling locations

Sample station	Buffer zone (m)					
	Measurement 1	Measurement 2	Measurement 3	Mean	stdev	Score
S1	6	8	7	7	1	**2**
S2	12	17	15	14.67	2.52	**3**
S3	5	3	6	4.67	1.53	**0**
S4	20	20	23	21	1.73	**5**
S5	15	14	12	13.67	1.53	**3**
S6	25	21	22	22.67	2.08	**5**
S7	14	16	17	15.67	1.53	**3**
S8	7	10	7	8	1.73	**2**
S9	8	6	7	7	1	**2**
S10	10	8	11	9.67	1.53	**2**
S11	6	6	7	6.33	0.58	**2**
S12	8	10	7	8.33	1.53	**2**
S13	15	17	17	16.33	1.15	**3**

Appendix C2: Ground surface

Score

a) Mostly trees or wetlands 5 points
b) Mainly shrubs, bushy or pasture land 3 points
c) Mainly short grass or crops 2 points
d) Mainly road or pathways 0 point

Ground surface of the 18-meter buffer zone of the various locations

Sample station	Surfaces make-up of the 18 meters surrounding of ecosystem				
	Mostly trees or wetlands	Mainly shrubs, bushy or pasture land	Mainly short grass or crops	Mainly road or pathways	Score
S1	✓				5
S2	✓				5
S3	✓				5
S4	✓				5
S5		✓			3
S6	✓				5
S7				✓	0
S8		✓			3
S9		✓			3
S10		✓			3
S11		✓			3
S12		✓			3
S13	✓				5

Appendix C3: Wooden peg depth from the bank of waterways

<u>Score</u>

a) The wooden peg went in an average of five inches or more 5 points
b) The wooden peg went in an average of three to five inches 3 points
c) The wooden peg went in an average of one to three inches 2 points
d) The wooden peg went in an average of less than one inch 0 point

Wooden peg Depth from the bank of the various locations

Sample station	Compaction of the soil. Wooden peg depth from waterway (inches)						
	10 feet	20 feet	30 feet	40 feet	50 feet	Mean	Score
S1	3.2	2.4	1.8	0.8	0.3	1.7	2
S2	3.8	3.2	2.5	1.3	0.7	2.3	2
S3	3.4	2.8	2.1	1.4	0.7	2.08	2
S4	4.6	3.5	2.7	2.2	1.6	2.92	2
S5	2.6	1.4	0.7	0.4	0.3	1.08	2
S6	4.2	3.7	2.5	1.4	1.2	2.6	2
S7	5.4	4.2	3.4	2.7	1.5	3.44	3
S8	2.6	1.4	0.6	0.4	0.3	1.06	2
S9	4.6	5.2	4.3	3.5	1.6	3.84	3
S10	4.2	2.5	2.1	1.4	0.6	2.16	2
S11	4.5	3.7	2.6	2.1	0.8	2.74	2
S12	4.7	3.8	3.3	2.6	0.9	3.06	3

S13	5.6	4.3	3.8	3.2	2.1	3.8	3

Appendix C4: Erosion on the banks of waterways

Score
a) No erosion: have boulders, shrubs, trees, and vegetation present — 5 points
b) Small erosion: 10-30% of the bank shows signs of erosion — 3 points
c) Steep streambanks: 30-60% show bare, eroded soil — 2 points
d) 61-100% of the banks have bare, eroded soil and no vegetation — 0 point

Erosion on the banks of the various locations

Sample station	**Erosion on the banks of the waterway**				
	No erosion: have boulders, shrubs, trees, and vegetation present	Small erosion: 10-30% of the bank shows signs of erosion	Steep streambanks: 30-60% show bare, eroded soil	61-100% of the banks have bare, eroded soil	**Score**
S1			✓		**2**
S2	✓				**5**
S3		✓			**3**
S4	✓				**5**
S5		✓			**3**
S6	✓				**5**
S7	✓				**5**
S8			✓		**2**
S9		✓			**3**
S10		✓			**3**
S11		✓			**3**
S12			✓		**2**
S13	✓				**5**

Appendix C5: Origin of pipe lines or ditches
Score
a) Man-made wetlands or a natural area — 5 points
b) Stormwater retention pond; bushy area — 3 points
c) Farmland and short grass — 2 points
d) Pathways, buildings, bare ground — 0 point

Origin of pipe lines or ditches at the sampling locations

Sample station	Origin of pipe lines or ditches at the sampling locations				
	Man-made wetlands or a natural area	Stormwater retention pond; bushy area	Farmland and short grass	Pathways, buildings, bare ground	Score
S1		✓			**3**
S2	✓				**5**
S3	✓				**5**
S4	✓				**5**
S5		✓			**3**
S6	✓				**5**
S7				✓	**0**
S8	✓				**5**
S9		✓			**3**
S10		✓			**3**
S11		✓			**3**
S12		✓			**3**
S13	✓				**5**

Appendix C6: Percentage of shade on the waterway

Score

a) More than 80% 5 points

b) Between 50 and 80% 3 points

c) Between 30 and 49% 2 points

d) Less than 30%; greater part in direct sunlight 0 point

% of shade on the waterway at the various locations

Sample station	How much of the waterway is shaded?				
	More than 80%	Between 50 and 80%	Between 30 and 49%	Less than 30%	Score
S1			✓		**2**
S2		✓			**3**
S3				✓	**0**
S4		✓			**3**
S5				✓	**0**
S6		✓			**3**
S7				✓	**0**
S8			✓		**2**
S9			✓		**2**
S10			✓		**2**

S11	✓		**2**
S12		✓	**0**
S13	✓		**2**

Appendix C7: Land type of the watershed

Score

a) Naturally intact and rural, few houses 5 points

b) Rural, but with some suburban development 4 points

c) Mainly agricultural lands 3 points

d) Mostly developed, with a few rural areas 2 points

e) Fully developed; almost no rural areas 0 point

Land type of the watershed at the various locations

Sample station	**What land type makes up the watershed?**					
	Naturally intact and rural, few houses	Rural, but with some suburban development	Mainly agricultural lands	Mostly developed, with a few rural areas	Fully developed; almost no rural areas	**Score**
S1		✓				**4**
S2	✓					**5**
S3				✓		**2**
S4		✓				**4**
S5		✓				**4**
S6	✓					**5**
S7		✓				**4**
S8		✓				**4**
S9		✓				**4**
S10		✓				**4**
S11		✓				**4**
S12		✓				**4**
S13	✓					**5**

Appendix D: Water quality investigation scoring guide and results for the various sampling locations

Appendix D1: Water temperature

Score

a) Suitable temperature – under 32 degrees C 0 points

b) Not suitable for most organisms – at or over 32 degrees C -5 points

Temperature of water at the sampling locations

Sample station	Temperature of the water (degrees C)					
	Measurement 1 (May)	Measurement 2 (June)	Measurement 3 (July)	Mean	stdev	Score
S1	30.04	27.87	27.20	28.37	1.48	**0**
S2	29.75	27.77	27.00	28.17	1.42	**0**
S3	30.55	27.86	29.60	29.34	1.36	**0**
S4	31.04	27.97	27.40	28.80	1.96	**0**
S5	30.66	27.30	32.70	30.22	2.73	**0**
S6	30.80	27.70	26.60	28.37	2.18	**0**
S7	29.75	27.74	25.50	27.66	2.13	**0**
S8	31.86	29.48	30.80	30.71	1.19	**0**
S9	28.77	26.67	28.00	27.81	1.06	**0**
S10	30.28	28.10	29.10	29.16	1.09	**0**
S11	32.39	28.10	29.50	30.00	2.19	**0**
S12	31.78	28.06	27.70	29.18	2.26	**0**
S13	30.02	27.57	27.20	28.26	1.53	**0**

Appendix D2: Dissolved Oxygen

Score

a) Good for most aquatic organisms: more than 5 ppm 5 points
b) Uncomfortable for most aquatic organisms: 3-5 ppm 3 points
c) Uncomfortable for some aquatic organisms: 2-2.99 ppm 1 point
d) Below 2 ppm: will not support growth and activity 0 point

: Dissolved Oxygen (DO) concentration at the various locations

Sample station	The amount of dissolved oxygen in the waters (ppm - parts per million)					
	Measurement 1 (May)	Measurement 2 (June)	Measurement 3 (July)	Mean	stdev	Score
S1	10.25	3.80	5.62	6.56	3.33	**5**
S2	10.25	3.76	4.11	6.04	3.65	**5**
S3	9.41	5.38	4.97	6.59	2.45	**5**
S4	9.12	4.43	5.02	6.19	2.55	**5**
S5	7.61	15.02	4.79	9.14	5.28	**5**
S6	7.55	3.93	3.91	5.13	2.10	**5**
S7	10.02	5.71	6.45	7.39	2.30	**5**
S8	10.51	11.23	4.96	8.90	3.43	**5**
S9	7.67	5.52	3.52	5.57	2.08	**5**
S10	6.73	5.89	6.40	6.34	0.42	**5**
S11	8.80	5.93	5.45	6.73	1.81	**5**
S12	7.54	4.98	4.54	5.69	1.62	**5**

S13	7.41	5.92	5.75	6.36	0.91	**5**

Appendix D3: Percentage saturation of Dissolved Oxygen

Score

a) 80% to 100% of the potential D O — 5 points
b) 60% to 79% of the potential D O — 3 points
c) 40% to 59% of the potential D O — 1 point
d) Less than 40% of the potential D O — 0 point

Percentage saturation of DO at the various locations

Sample station	The Percent saturation of dissolved oxygen in the waters (%)	
	% Saturation	Score
S1	87.42	**5**
S2	80.53	**5**
S3	87.82	**5**
S4	82.53	**5**
S5	121.87	**5**
S6	68.40	**3**
S7	98.58	**5**
S8	118.67	**5**
S9	74.27	**3**
S10	84.53	**5**
S11	89.69	**5**
S12	75.82	**3**
S13	84.80	**5**

Appendix D4: pH of water

Score

a) 6.5 - 8.2: Suitable for most organisms — 5 points
b) 5.0-6.5 or 8.2-9.0: Harmful to sensitive species — 3 points
c) 4.5-5.0 or 9.0-10.5: May harm some fish — 1 point
d) Less than 4.5 or above 10.5: Harmful to most aquatic species — 0 point

pH of the water at the various locations

Sample station	pH of the water					
	Measurement 1 (May)	Measurement 2 (June)	Measurement 3 (July)	Mean	stdev	**Score**
S1	9.53	6.93	6.23	7.56	1.74	**5**
S2	9.66	6.71	6.04	7.47	1.93	**5**
S3	10.69	7.23	6.51	8.14	2.23	**5**
S4	10.80	7.23	6.19	8.07	2.42	**5**
S5	10.46	6.99	6.08	7.84	2.31	**5**
S6	10.80	5.96	6.03	7.60	2.77	**5**
S7	7.61	7.07	6.60	7.09	0.51	**5**
S8	9.44	7.85	6.47	7.92	1.49	**5**
S9	6.49	7.36	6.35	6.73	0.55	**5**
S10	10.29	7.27	6.84	8.13	1.88	**5**
S11	6.33	7.49	6.63	6.82	0.60	**5**
S12	10.78	5.66	6.24	7.56	2.80	**5**
S13	6.23	7.23	6.55	6.67	0.51	**5**

Appendix D5: Sewer lines

Score

a) No sign of sewer pipes. If present, they are well-covered 5 points
b) Presence of exposed pipe, but covers are secured 3 points
c) Evidence of past seepage (algae, toilet paper) cover is not tightly sealed. 1 point
d) Broken pipe or uncovered: sewage flowing out 0 point

Sewer lines at the various locations

Sample station	Sewer lines				
	No sign of sewer pipes. If present, they are well-covered	Presence of exposed pipe, but covers are secured	Evidence of past seepage (algae, toilet paper, etc.), cover is not tightly sealed	Broken pipe or uncovered: sewage flowing out	**Score**
S1	✓				**5**
S2	✓				**5**
S3		✓			**3**
S4	✓				**5**
S5			✓		**1**
S6	✓				**5**
S7		✓			**3**
S8		✓			**3**
S9	✓				**5**

S10	✓				**5**
S11		✓			**3**
S12		✓			**3**
S13	✓				**5**

Appendix D6: Pipes in waterways

Score

a) Absence of pipe lines — 5 points

b) Exposed pipes but no evidence of dangerous substances in the water. — 3 points

c) No leakage on pipes, but there is unusual substances in water. — 1 point

d) Unsual substance is coming out of the pipe — 0 point

Pipes in waterways at the various locations

Sample station	**Sewer lines**				
	Absence of pipe lines	Presence of exposed pipes but no evidence of dangerous substances.	No leakage on pipes, but there is unusual substances in water	Unsual substance is coming out of the pipe	**Score**
S1	✓				**5**
S2	✓				**5**
S3		✓			**3**
S4	✓				**5**
S5		✓			**3**
S6	✓				**5**
S7		✓			**3**
S8			✓		**1**
S9	✓				**5**
S10	✓				**5**
S11			✓		**1**
S12			✓		**1**
S13	✓				**5**

Appendix D7: Nitrates and Phosphates

Score

a) Concentrations of both are below 1 ppm — 5 points

b) Concentrations of both are between 5 and 1 ppm — 3 points

c) At least one of the levels is between 9 and 5.1 ppm — 1 point

d) Either of the levels is greater than 9 ppm — 0 point

Nitrates and Phosphates concentration at the sampling locations

Sample station	**nitrates and phosphates**				
	Nitrate Mean	stdev	Phosphate Mean	stdev	**Score**
S1	0.93	0.40	0.27	0.22	**5**
S2	2.10	2.10	0.47	0.32	**3**
S3	0.60	0.10	0.26	0.23	**5**
S4	0.60	0.10	0.21	0.10	**5**
S5	1.37	0.99	1.29	2.09	**3**
S6	1.97	1.59	0.50	0.63	**3**
S7	2.73	0.93	0.16	0.15	**3**
S8	2.53	1.76	0.41	0.34	**3**
S9	0.80	0.36	0.19	0.16	**5**
S10	0.80	0.26	0.21	0.13	**5**
S11	1.00	0.26	0.16	0.08	**3**
S12	0.77	0.12	0.16	0.18	**5**
S13	1.40	0.99	0.14	0.05	**3**

Appendix D8: Trash

Score

a) No trash present.	5 points
b) Trash is present, but it is all biodegradable	3 points
c) Trash present including non-biodegradables (plastics and metals)	1 point
d) Presence of industrial waste or sewage waste	0 point

Trash at the various locations

Sample station	**Trash**				
	No trash present	Trash is present, but it is all biodegradable	Trash present including non-biodegradables (plastics and metals)	Presence of industrial waste or sewage waste	**Score**
S1		✓			**3**
S2		✓			**3**
S3		✓			**3**
S4	✓				**5**
S5			✓		**1**
S6	✓				**5**
S7			✓		**1**
S8			✓		**1**
S9			✓		**1**

S10		✓	**1**
S11		✓	**1**
S12		✓	**1**
S13	✓		**3**

Appendix E: Habitat investigation scoring guide and results for the various sampling locations

Appendix E1: Erosion at the banks

<u>Score</u>

a) No erosion; presence of boulders, shrubs, trees and vegetation. 5 points
b) Little erosion: (10-30% signs of erosion). 3 points
c) Steep streambanks; (31-60% eroded soil). 1 point
d) Eroded banks with noe vegetation (61-100%) 0 points

Eroded banks at the various locations

Sample station	**Eroded banks**				
	No erosion; presence of boulders, shrubs, trees and vegetation.	Little erosion: (10-30% signs of erosion).	Steep streambanks; (31-60% eroded soil).	Eroded banks with noe vegetation (61-100%)	**Score**
S1			✓		**1**
S2	✓				**5**
S3			✓		**1**
S4		✓			**3**
S5		✓			**3**
S6		✓			**3**
S7		✓			**3**
S8		✓			**3**
S9		✓			**3**
S10		✓			**3**
S11		✓			**3**
S12			✓		**1**

Appendix E2: Sediment build-up

<u>Score</u>

a) Below 20% of the bottom is covered with sediment 5 points
b) Loose sediment forms about 20-50% of the bottom 3 points
c) Loose sediment forms about 51-80% of the bottom 1 point
d) Flow of water is impeded by mud, silt and/or sand fills 0 point

Sediment build-up at the various locations

Sample station	**sediment build-up**				
	Below 20% of the bottom is covered with sediment	Loose sediment forms about 20-50% of the bottom	Loose sediment forms about 51-80% of the bottom	Flow of water is impeded by mud, silt and/or sand fills	**Score**
S1		✓			**3**
S2		✓			**3**
S3		✓			**3**
S4		✓			**3**
S5			✓		**1**
S6	✓				**5**
S7		✓			**3**
S8			✓	✓	**1**
S9			✓	✓	**1**
S10			✓		**1**
S11			✓		**1**
S12			✓		**1**
S13		✓			**3**

Appendix E3: Variety of habitats in aquatic system

<u>Score</u>

a) Greater than 40% 5 points
b) Between (21-40%) 3 points
c) 10-20% 1 point
d) Less than 10% 0 point

Variety of habitats in aquatic systems at the various locations

Sample station	Variety of habitats in aquatic system				
	Greater than 40%	Between (21-40%)	10-20%	Less than 10%	**Score**
S1		✓			**3**
S2	✓				**5**
S3		✓			**3**
S4	✓				**5**
S5			✓		**1**
S6	✓				**5**
S7			✓		**1**
S8		✓			**3**
S9			✓		**1**
S10			✓		**1**
S11		✓			**3**
S12			✓		**1**
S13		✓			**3**

Appendix E4: Curves and Meanders

<u>Score</u>

a) Naturally curved with no evidence of human straightened modifications 5 points
b) 10-40% human straightened modifications from the natural state 3 points
c) Over 80% straightened or (41-60%) banks cemented 1 point
d) Over 60% of the banks are cemented or over 80% straightened 0 point

Curves and Meanders at the various locations

Sample station	curve and meander				
	Naturally curved with no evidence of human straightened modifications	10-40% human straightened modifications from the natural state	Over 80% straightened or (41-60%) banks cemented	Over 60% of the banks are cemented or over 80% straightened	**Score**
S1			✓		**1**
S2		✓			**3**
S3		✓			**3**
S4	✓				**5**
S5		✓			**3**
S6	✓				**5**

S7		✓			**3**
S8	✓				**5**
S9		✓			**3**
S10		✓			**3**
S11		✓			**3**
S12		✓			**3**
S13		✓			**3**

Appendix E5: Water in streambed

<u>Score</u>

c) Water touches both sides of the waterway 5 points
d) 75% of the waterwat is filled with water 3 points
e) 25-74% of the waterway is filled with water 1 point
f) Below 25% of the waterway is filled with water 0 point

Water content in streambed at the various locations

Sample station	**Water in stream bed**				
	Water touches both sides of the waterway	75% of the waterway is filled with water	25-74% of the waterway is filled with water	Below 25% of the waterway is filled with water	**Score**
S1			✓		**1**
S2			✓		**1**
S3		✓			**3**
S4		✓			**3**
S5			✓		**1**
S6	✓				**5**
S7		✓			**2**
S8		✓			**3**
S9		✓			**3**
S10		✓			**3**
S11		✓			**3**
S12			✓		**1**
S13	✓				**5**

Appendix E6: Depth and Speed

Score
a) Presence of slow, fast, deep and shallow waters 5 points
b) Three of the four present 3 points
c) Typically, shallow and slow waters 1 point
d) Only made of slow and shallow waters 0 point

Depth and speed of water at the various locations

Sample station	depths and speeds of the water.				
	Presence of slow, fast, deep and shallow waters	Three of the four present	Typically shallow and slow waters	Only made of slow and shallow waters	**Score**
S1			✓	✓	**1**
S2			✓	✓	**1**
S3		✓			**3**
S4			✓		**1**
S5			✓	✓	**1**
S6		✓			**3**
S7		✓			**3**
S8			✓		**1**
S9			✓		**1**
S10			✓		**1**
S11			✓		**1**
S12			✓		**1**
S13	✓				**5**

Appendix E7: Blockages

Score
a) Absence of bloackages 5 points
b) One small and easily removable blockage 3 points
c) One large and lasting blockage 1 points
d) More than two lasting blockages 0 point

Blockages at the various locations

Sample station	**blockages**				
	Absence of bloackages	One small and easily removable blockage	One large and lasting blockage	More than two lasting blockages	**Score**
S1		✓			**3**
S2		✓			**3**
S3		✓			**3**
S4	✓				**5**
S5			✓		**1**
S6	✓				**3**
S7		✓			**3**
S8		✓			**3**
S9		✓			**3**
S10	✓				**5**
S11	✓				**5**
S12		✓			**3**
S13	✓				**5**

Appendix F1: Mean Physico-chemical parameter recorded for the wet season (May, June and July, 2016) at the various sampling locations

Code	Aquatic system	Temperature (^{0}c)	Salinity (PPT)	Dissolved Oxygen (mg/L)	Nitrate Nitrogen (NO3-N) (mg/L)	Total Phosphorous (mg/L)	Total Nitrogen (mg/L)	Phosphate (PO4-3) (mg/L)	Total Dissolved Solids (TDS)	Conductivity	Turbidity (NTU)	pH
W1	Stream	28.37	0.53	6.56	0.93	2.4	2.87	0.27	0.6	1.07	12.62	7.56
W2	Stream	28.17	0.97	6.04	2.1	1.63	4.4	0.47	0.87	1.43	6.15	7.47
W3	River	29.34	1.47	6.59	0.6	1.87	3.13	0.26	1.43	2.7	3.2	8.14
W4	River	28.8	2.43	6.19	0.6	1.24	6.37	0.21	1.61	2.97	4.7	8.07
W5	Ditch	30.22	3.03	9.14	1.37	3.77	3.9	1.29	3.36	6	40.8	7.84
W6	Mangrove swamp	28.37	2.23	5.13	1.97	2.33	5.5	0.5	1.88	3.29	5.4	7.6
W7	Intertidal zone	27.66	36.33	7.39	2.73	0.93	3.97	0.16	30.91	59.39	20.9	7.09
W8	Pond	30.71	5.07	8.9	2.53	1.9	4.17	0.41	5.97	10.25	64.5	7.92
W9	Creek	27.81	5.2	5.57	0.8	2.1	4.17	0.19	3.95	7.2	6.15	6.73
W10	Creek	29.16	5.5	6.34	0.8	1.43	2.93	0.21	4.89	8.59	4.15	8.13
W11	Creek	30	5.33	6.73	1	1.73	1.57	0.16	5.54	9.68	6.55	6.82
W12	Creek	29.18	2.2	5.69	0.77	1.83	1.93	0.16	1.36	3.21	3.75	7.56
W13	Estuary	28.26	11.9	6.36	1.4	1.63	2.2	0.14	11.43	19.72	8.35	6.67

Appendix F2: Mean Physico-chemical parameters recorded for the dry season (November, December, 2016 and January, 2017) at the various sampling locations

Code	Aquatic system	Temperature (^{0}c)	Salinity (PPT)	Dissolved Oxygen (mg/L)	Nitrate Nitrogen (NO3-N) (mg/L)	Total Phosphorous (mg/L)	Total Nitrogen (mg/L)	Phosphate (PO4-3) (mg/L)	Total Dissolved Solids (TDS)	Conductivity	Turbidity (NTU)	pH
W1	Stream	29.06	0.23	4.49	1.00	3.13	2.63	0.34	0.27	0.43	37.50	8.70
W2	Stream	29.09	0.43	6.45	0.47	1.27	1.90	0.08	0.55	0.86	73.97	8.40
W3	River	29.64	0.70	5.53	0.60	1.90	3.37	0.10	1.10	1.72	10.93	9.60
W4	River	29.43	0.80	5.19	0.60	1.87	1.87	0.23	1.00	1.56	11.33	9.30
W5	Ditch	28.29	2.53	5.46	1.20	2.80	1.87	0.12	2.97	4.71	29.07	8.80
W6	Mangrove swamp	29.30	1.07	5.28	1.07	2.07	2.87	0.23	1.30	2.03	16.43	9.00
W7	Intertidal zone	29.64	34.20	7.04	2.07	1.97	2.63	0.13	31.43	52.17	72.30	7.50
W8	Pond	33.34	5.43	11.08	1.47	3.00	3.07	1.07	6.06	9.49	83.03	9.80
W9	Creek	29.97	1.67	6.07	0.73	2.30	2.77	0.25	1.97	3.11	11.89	7.90
W10	Creek	31.03	3.30	6.54	1.17	3.20	2.40	0.41	3.87	6.22	17.03	9.20
W11	Creek	31.01	5.90	7.29	0.80	2.73	3.03	0.27	6.49	10.44	13.77	8.70
W12	Creek	31.27	6.33	6.64	1.20	2.43	1.87	0.25	6.91	11.10	19.27	8.60
W13	Estuary	29.94	16.87	6.39	0.85	1.80	1.23	0.21	16.29	26.83	26.63	8.40

Appendix G1: Educational model on awareness and knowledge of coastal ecosystems

Topic	Awareness and Knowledge of Coastal Ecosystems
Goal:	• A community which is well informed about the structure and functioning of the indigenous ecosystems
Objectives:	• That the participants will: • Visually identify and describe various types of ecosystems in the coastal environments (Intertidal zones, mangrove swamps, dune areas, sandy beach, streams, creeks, lakes, ponds and others).
Materials:	• PowerPoint Presentation using Laptop and Projector, Pictures of a healthy coastal ecosystem and the kinds of ecosystems in the coastal area of Ada, activity guide, and review sheets.
Introduction:	• Begin by asking participants what they know about Ecosystems. Emphasize the variety of coastal ecosystems. • During the discussion, ask the following questions to get participants to think more deeply about ecosystems: • Is the ecosystem natural or man-made? • What are the components of the ecosystems? • Who supplies the needs of the ecosystem? • What keeps the ecosystem in sustenance?
Knowledge:	• Explain to participants that they will now take a trip down the Coastal area to investigate the kinds of ecosystems that are present. • Ask participants to describe the environment around the coastal zone, pointing out the specific ecosystems they see. (Ponds, rivers, streams, lakes, creeks, intertidal zones, and mangrove swamps) • Explain to participants the structure and functioning of the kinds of ecosystems they see (Ponds, rivers, streams, lakes, creeks, intertidal zones, mangrove swamps, farmland, forests etc.
Practice:	• Divide participants into teams and hand out the Activity guide — Scavenger Hunt. • Show the Coastal Ecosystem Landforms and Features PowerPoint presentation so participants have a basis for selecting features in the scavenger hunt. • Have the teams go through the pre-selected ecosystem images and challenge them to identify, locate and describe them in 10 minutes. • Have teams exchange lists and verify each other's lists. • Have participants place question marks on features that they either cannot find or those they feel are misidentified.
Sustainable solutions:	• Ask the participants to discuss and demonstrate ways for keeping healthy coastal ecosystems.
Checking for understandin g	• Discuss the following: • Which of the ecosystems on your scavenger hunt list were fairly common in your area? • Which ecosystems were not present at all?

Evaluation:	• Use review sheet to evaluate participants' attainment of all lesson objectives.
Instructor Reflections:	• The instructor will reflect on the effectiveness (strength and weaknesses) of the strategies used in the delivery of the lesson.

Appendix G2: Educational model on population and economic pressures

Topic:	• **Population and Economic Pressures**
Goal:	• Sensitized communities which appreciate developments with integrate ecosystem enhancement and resilience strategies
Objectives:	• That the participants will be able to:. • Identify the processes in the coastal communities that affect conditions in the ecosystems and explain some specific examples. • Apply basic strategies to enhance ecosystem resilience
Materials:	• PowerPoint Presentation using Laptop and Projector and review sheets.
Introduction:	• Ask participants to describe where does the water that passes through ditches, gutters in their communities go?
Knowledge:	• Explain how agricultural areas, industrial sites, tourist sites, landfills and sewage affect water quality of the ecosystem? • Explain the phenomena of algae blooms and eutrophication • Describe the effects of eutrophication on the ecosystems • Describe the importance of proper sanitation and how it can contribute to improve ecosystem health.
Practice:	• Walk outside with participants and choose one aquatic ecosystem downstream. • Identify areas and man-made features that may be potential sources of pollutants and contaminants in a heavy rain/flooding event. • Ask participants what might happen to the salinity and turbidity in the Ecosystem after a rainstorm.
Sustainable solutions:	• Ask the participants to discuss and demonstrate ways in which farmers in the communities can grow food in ways that the soil remains usable by future generations.
Checking for Understanding:	• Ask participants to suggest ways of improving conditions within the watershed areas which will enhance ecosystem health.
Evaluation:	• Use review sheet to evaluate participants' attainment of all lesson objectives.
Instructor Reflections:	• The instructor will reflect on the effectiveness (strength and weaknesses) of the strategies used in the delivery of the lesson.

Appendix G3: Educational model on unsustainable exploitation of biological resources

Topic:	• **Unsustainable exploitation of biological resources**
Goal:	• Inhabitants who accept sustainable strategies for resource exploitation and are mindful to adopt them.
Objectives:	• That the participants will be able to: • Describe biological components of habitats that exist as part of the ecosystem. • Explain the connection between living things in the ecosystem • Explain why biodiversity is important and worth preserving in the ecosystems.
Materials:	• PowerPoint Presentation using Laptop and Projector, large sheets of poster paper, large pieces of poster board, activity guide and review sheets.
Introduction:	• Ask participants to name some animals and plants found where they live
Knowledge:	• Describes the concept of food chain/web to participants. Consider drawing a simple chain in a coastal ecosystem. • Identify unsustainable practices in the community which affect the biological components of the coastal ecosystems • Lead a discussion on the importance of biodiversity, using examples where low biodiversity was problematic.
Practice:	• Divide participants into teams, distribute the large paper, and explain that they will produce a food web of biodiversity and the interrelationships of organisms in a dynamic ecosystem. • Have the participant teams create their ecosystem food web. • When participants are done with their food webs, attach the sheets to a board or wall and have a discussion on the similarities and differences between the various food webs. • Explain how human impacts affect this interaction.
Sustainable solutions:	• Ask participants to discuss: • Which animals or plants in the ecosystems are endangered? • What conditions in the ecosystems have caused populations of each of the endangered species to decline? • Which actions should be taken to protect the remaining population and support its recovery?
Checking for Understanding:	• Ask participants to describe the importance of biodiversity to man and other living things
Evaluation:	• Use review sheet to evaluate participants' attainment of all lesson objectives.
Instructor Reflections:	• The instructor will reflect on the effectiveness (strength and weaknesses) of the strategies used in the delivery of the lesson.

Appendix G4: Educational model on prevention and early detection of coastal hazards

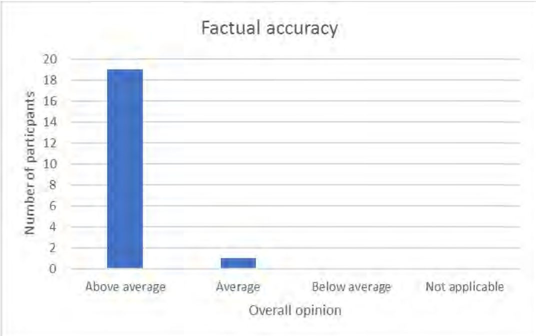
Topic:	• **Prevention and Early Detection of Coastal Hazards**
Goal:	• Well-informed and adequately prepared communities to reduce the risk of coastal disasters.
Objectives:	• That the participants will be able to: • Know how hazard events affect ecosystems in the coast. • Detect and monitor major hazard events in the coastal zone. • Reduce the disaster risk of an extreme hazard event in the coastal zone.
Materials:	• PowerPoint Presentation using Laptop and Projector, activity guide, and review sheets.
Introduction:	• Ask participants if they have lived through a tidal wave event. Ask what kind of damage the tidal waves did their homes, community, or to their environment in general.
Knowledge:	• Show the animation/video of coastal inundation and erosion resulting from tidal waves, sea level rise and heavy rains. • Describe the causes, effects and ways of reducing risk of disasters in the coastal environment. • Indicate ecosystems and possible areas in the coastal zone which are prone to inundation and erosion.
Practice:	• Organize a tree-planting exercise for participants at a local ecosystem.
Sustainable solutions:	• Ask the participants to discuss and demonstrate ways for keeping coastal ecosystems resilient in the event of natural hazards.
Checking for Understanding:	• Discuss the following with participants: • What were the effects of a major storm event in the Ada coastal area? • What effects do you think the storm might have had on different plants and animals in the ecosystems?
Evaluation:	• Use review sheet to evaluate participants' attainment of all lesson objectives.
Instructor Reflections:	• The instructor will reflect on the effectiveness (strength and weaknesses) of the strategies used in the delivery of the lesson.

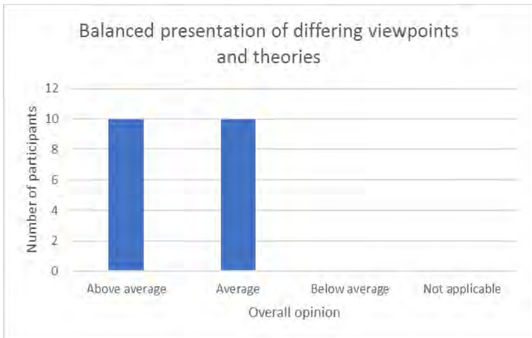
Appendix G5: Educational model on pollution of coastal and estuarine waters

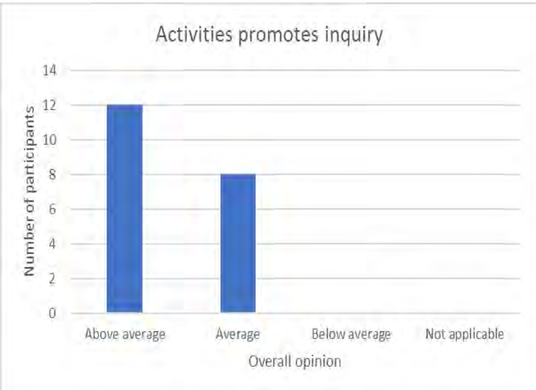
Topic:	• Pollution of Coastal and Estuarine Waters
Goals:	• Inhabitants who understand the conditions necessary for healthy ecosystems in the coastal environment. • Sensitized community inhabitants who are conscious of keeping clean and healthy water bodies
Objectives:	• That the participants will be able to: • Describe the particular environmental conditions necessary for organisms to survive in the coastal ecosystems. • List and explain four principal abiotic factors that influence the survival of aquatic life in the coastal ecosystems.
Materials:	• PowerPoint Presentation using Laptop and Projector (Prepare the PowerPoint presentation showing Coastal Ecosystems in the study area), activity guide, and review sheets.
Introduction:	• Ask the participants what resources and conditions they need to survive in their environment. They will probably mention food, water, warm clothes, etc. They may forget things like oxygen to breathe, and other chemical compounds needed to maintain good health.
Knowledge:	• Choose an animal or plant in an ecosystem and ask participants to suggest factors that affect conditions in its habitat. • List them on the board. Bring up the following water quality factors if participants do not include them and explain: • temperature • pH • salinity • dissolved oxygen. • Show the PowerPoint slides of the local conditions which are likely to affect the water qualities described above and ask participants to describe the environment they see. Ask some probing questions as they view the slides.
Practice:	• Locate a local water source (pond, river, stream, or lake) close to the Centre. • Have participants record water temperature, pH, salinity, and DO. • Direct participants to compare their data to the WHO standards required for Ecosystems. • Discuss with participants the differences in water quality between the local site and that of the recommended standards. • Is the local water source habitable for all animal species featured in this activity?
Sustainable solutions:	• Ask the participants to discuss and demonstrate ways for preserving clean and healthy water in coastal ecosystems.
Checking for Understanding:	• Ask participants to think of other effects that water pollution is having in their communities

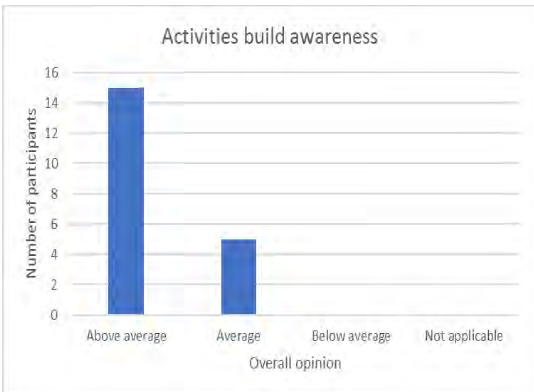
Evaluation:	• Use review sheet to evaluate participants' attainment of all lesson objectives.

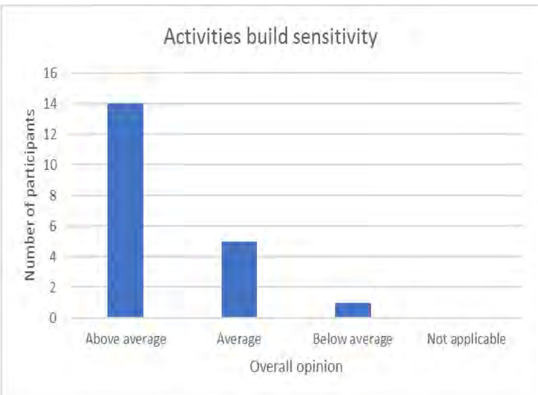
Appendix H: General assessment of the ESEM

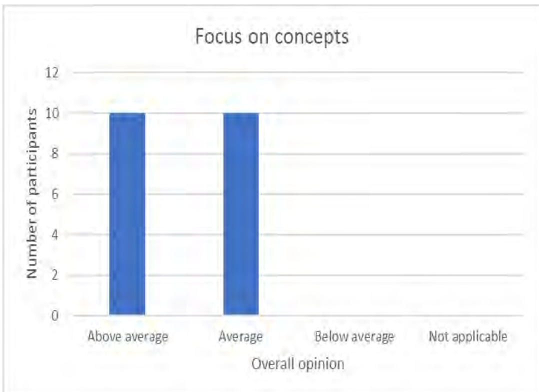


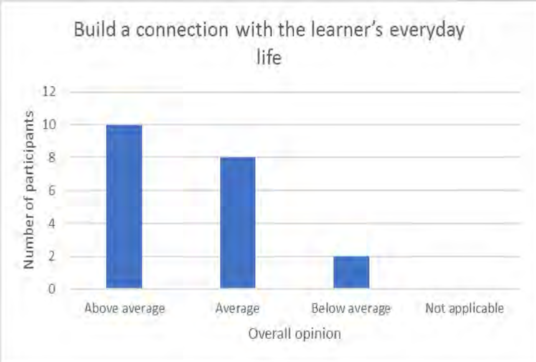


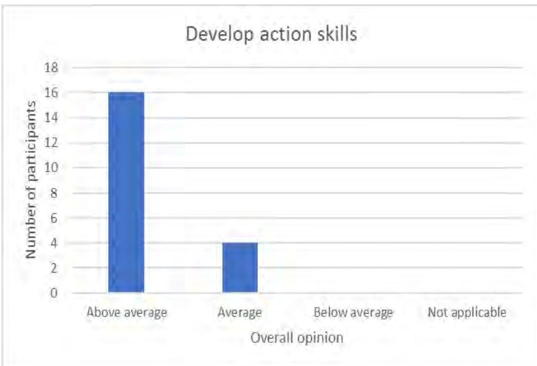


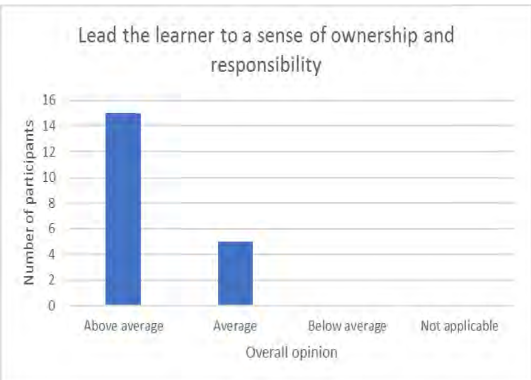


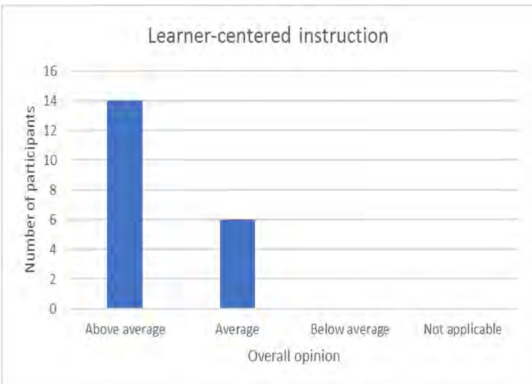


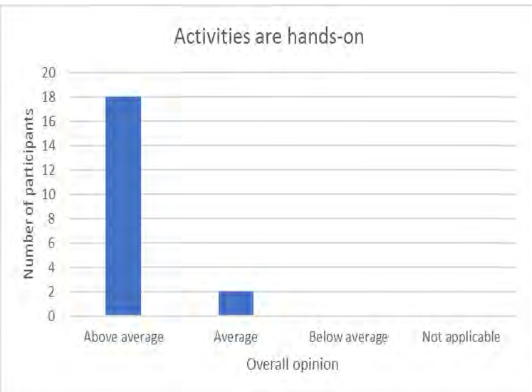


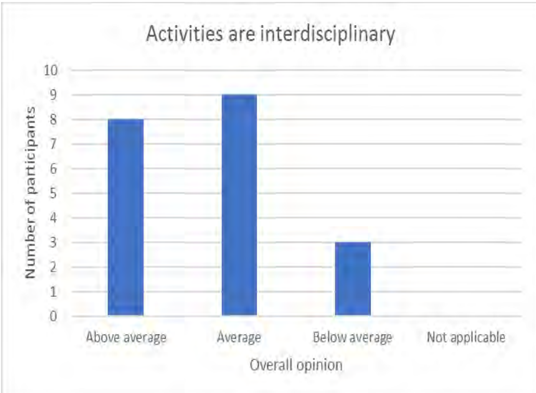

Build a connection with the learner's everyday life
Number of participants
0 2 4 6 8 10 12
Above average
Average
Below average
Not applicable
Overall opinion

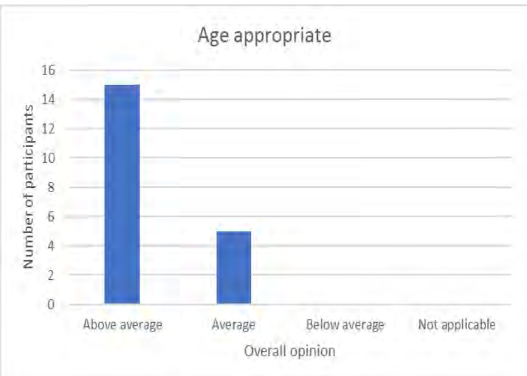

Develop action skills
Number of participants
0 2 4 6 8 10 12 14 16 18
Above average
Average
Below average
Not applicable
Overall opinion

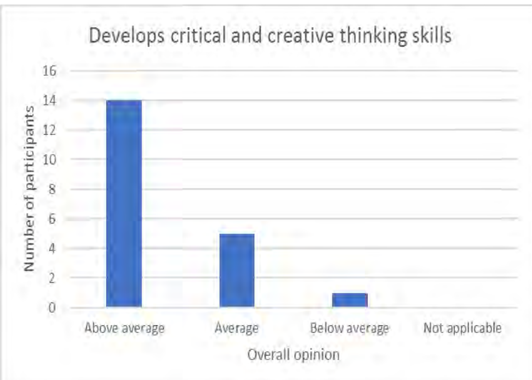

Lead the learner to a sense of ownership and responsibility
Number of participants
0 2 4 6 8 10 12 14 16
Above average
Average
Below average
Not applicable
Overall opinion

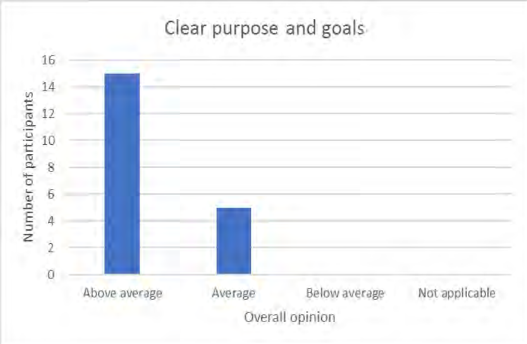

Learner-centered instruction
Number of participants
0 2 4 6 8 10 12 14 16
Above average
Average
Below average
Not applicable
Overall opinion

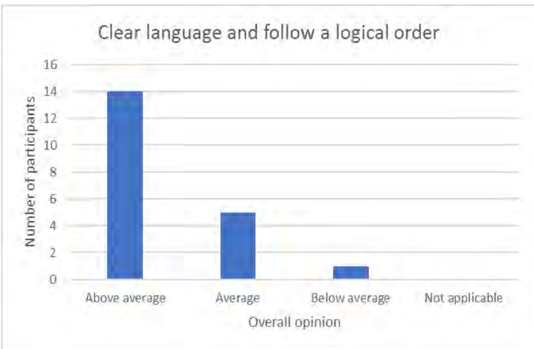

Activities are hands-on
Number of participants
0 2 4 6 8 10 12 14 16 18 20
Above average
Average
Below average
Not applicable
Overall opinion

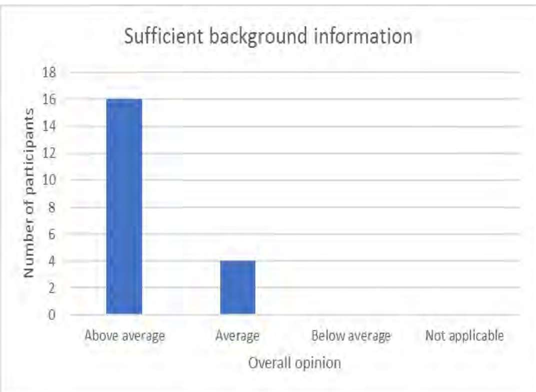

Activities are interdisciplinary
Number of participants
0 1 2 3 4 5 6 7 8 9 10
Above average
Average
Below average
Not applicable
Overall opinion

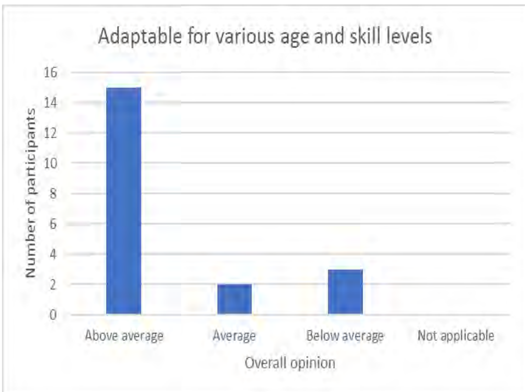

Age appropriate
Number of participants
0 2 4 6 8 10 12 14 16
Above average
Average
Below average
Not applicable
Overall opinion

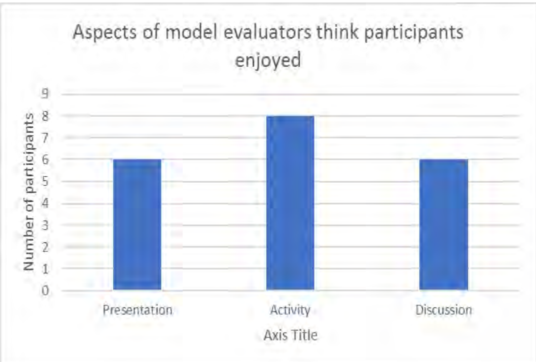

Develops critical and creative thinking skills
Number of participants
0 2 4 6 8 10 12 14 16
Above average
Average
Below average
Not applicable
Overall opinion

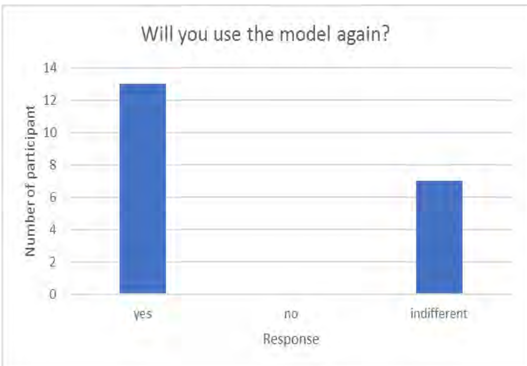

Clear purpose and goals
Number of participants
16
14
12
10
8
6
4
2
0
Above average
Average
Below average
Not applicable
Overall opinion

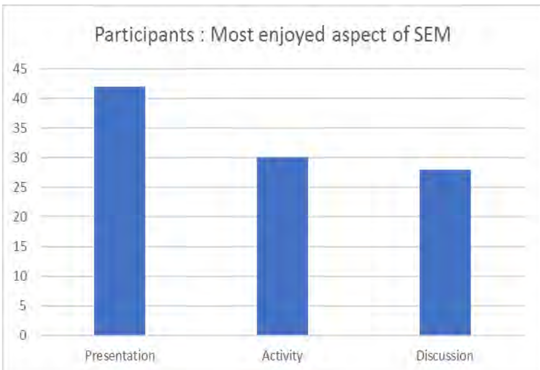

Clear language and follow a logical order
Number of participants
16
14
12
10
8
6
4
2
0
Above average
Average
Below average
Not applicable
Overall opinion


Sufficient background information
Number of participants
18
16
14
12
10
8
6
4
2
0
Above average
Average
Below average
Not applicable
Overall opinion


Adaptable for various age and skill levels
Number of participants
16
14
12
10
8
6
4
2
0
Above average
Average
Below average
Not applicable
Overall opinion


Aspects of model evaluators think participants enjoyed
Number of participants
9
8
7
6
5
4
3
2
1
0
Presentation
Activity
Discussion
Axis Title


Will you use the model again?
Number of participant
14
12
10
8
6
4
2
0
yes
no
indifferent
Response


Participants : Most enjoyed aspect of SEM
45
40
35
30
25
20
15
10
5
0
Presentation
Activity
Discussion

Appendix I1: Correlation matrix of physicochemical parameters and Macroinvertebrate bio-indices in the sampled aquatic ecosystems
(* Significant at 0.05 level)

	Temp	*Salinity*	*D O*	*Nitrate*	*Phosphate*	*TDS*	*Conductivity*	*Turbidity*	*PH*	*Simpson*	*Evenness*	*Richness*	*Shannon*
Temp	1.000												
Salinity	-0.381	1.000											
D O	0.654*	0.199	1.000										
Nitrate	-0.069	0.549*	0.380	1.000									
Phosphate	0.410	-0.243	0.577*	0.198	1.000								
TDS	-0.328	0.996*	0.253	0.576*	-0.222	1.000							
Conductivity	-0.339	0.998*	0.244	0.571*	-0.221	0.999*	1.000						
Turbidity	0.595*	0.127	0.884*	0.566*	0.504*	0.180	0.170	1.000					
PH	0.445	-0.394	0.240	-0.153	0.315	-0.401	-0.387	0.203	1.000				
Simpson	0.181	-0.228	0.073	-0.346	0.355	-0.240	-0.225	-0.113	0.322	1.000			
Evenness	-0.044	0.087	0.002	0.218	-0.325	0.101	0.085	0.169	-0.201	-0.949	1.000		
Richness	-0.175	0.250	0.019	0.211	-0.376	0.252	0.241	0.142	-0.244	-0.842	0.928*	1.000	
Shannon	-0.044	0.087	0.002	0.218	-0.325	0.101	0.085	0.169	-0.201	-0.949	1.000	0.928*	1.000

Appendix I2: Correlation matrix of physicochemical parameters and Macrophyte bio-indices in the sampled aquatic ecosystems (* Significant at 0.05 level)

	Temp	*Salinity*	*D O*	*Nitrate*	*Phosphate*	*TDS*	*Conductivity*	*Turbidity*	*PH*	*Simpson*	*Evenness*	*Richness*	*Shannon*
Temp	1.000												
Salinity	-0.381	1.000											
D O	0.654*	0.199	1.000										
Nitrate	-0.069	0.549*	0.380	1.000									
Phosphate	0.410	-0.243	0.577*	0.198	1.000								
TDS	-0.328	0.996*	0.253	0.576*	-0.222	1.000							
Conductivity	-0.339	0.998*	0.244	0.571*	-0.221	0.999*	1.000						
Turbidity	0.595*	0.127	0.884*	0.566*	0.504*	0.180	0.170	1.000					
PH	0.445	-0.394	0.240	-0.153	0.315	-0.401	-0.387	0.203	1.000				
Simpson	-0.206	-0.459	-0.368	-0.022	-0.001	-0.500	-0.481	-0.094	0.471	1.000			
Evenness	-0.228	-0.281	-0.322	0.059	-0.063	-0.329	-0.305	-0.087	0.488	0.947*	1.000		
Richness	-0.084	-0.506	-0.345	-0.234	0.048	-0.535	-0.517	-0.236	0.557*	0.675*	0.533*	1.000	
Shannon	-0.231	-0.467	-0.368	-0.047	0.019	-0.506	-0.488	-0.124	0.468	0.973*	0.874*	0.775*	1.000