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SUSTAINABLE FISHERIES MANAGEMENT PROJECT (SFMP)

A PLANNERS' GUIDE TO INTEGRATED COASTAL MANAGEMENT IN THE CENTRAL REGION OF GHANA

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CRC COASTAL RESOURCES CENTER

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Cover photo: Aerial photo showing shoreline modifications in Coconut Beach area, Elmina (Credit: Chris Damon, University of Rhode Island)

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ACRONYMS

CCM	Centre for Coastal Management
CEWEFIA	Central and Western Region Fishmongers Improvement Association
CRC	Coastal Resource Center
CSLP	Coastal Sustainable Landscape Project
DAA	Development Action Association
DFAS	Department of Fisheries and Aquatic Science
DMFS	Department of Marine Fisheries Sciences
DQF	Daasgift Quality Foundation
FtF	Feed the Future
GIFA	Ghana Inshore Fishermen's Association
GIS	Geographic Information System
GNCFC	Ghana National Canoe Fishermen's Council
HM	Hen Mpoano
ICFG	Integrated Coastal and Fisheries Governance
MESTI	Ministry of Environment Science and Technology
MOFAD	Ministry of Fisheries and Aquaculture Development
NDPC	National Development Planning Commission
NGOs	Non-Governmental Organizations
SFMP	Sustainable Fisheries Management Project
SMEs	Small and Medium Enterprises
SNV	Netherlands Development Organization
SSG	SSG Advisors
STWG	Scientific and Technical Working Group
UCC	University of Cape Coast
URI	University of Rhode Island
USAID	United States Agency for International Development
WARFP	West Africa Regional Fisheries Development Program

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INTRODUCTION

The coastal zone of Ghana's Central Region is undergoing fast transformation due to infrastructural development and challenges associated with climate change and exacerbated sea level rise. The changes along the coast are increasing competition for shorefront space among multiple coastal users. As competition for shorefront space increases, fishing-dependent communities and households become exposed to high disaster risk and vulnerable environments that put their livelihoods, property and lives at risk. Invariably, fishing communities are dependent on shoreline access for landing their canoes, processing and marketing fish and as places to live. These areas are also highly vulnerable to flooding and storm damage that is increasing in frequency and severity with sea level rise. An integrated approach to coastal planning is therefore required to support development of resilient communities that can cope and adapt to living in dynamic coastal zones and ensure that fishing communities have access to safe and secure areas to conduct their food production activities. Physical planners in the coastal districts of the Central region were involved in participatory processes and training events that resulted in the production of this toolkit. Generally, the toolkit is intended to guide planners and other professionals in the land use sector to engage more meaningfully in the task of searching for sustainable solutions to issues faced by coastal people and ecosystems.

Purposes of the Toolkit:

- It is a source of coastal hazards, vulnerability and risks information for coastal land use planners and managers.
- It provides coastal land use and spatial planning guidance to physical planners.
- It demonstrates in a stepwise manner, the utilization of basic geospatial mapping and coastal hazards modeling tools.
- It can be adapted as a training manual for physical planners and other professionals in the land use and spatial planning sector.

CHAPTER ONE: IDENTIFICATION, MAPPING AND CHARACTERIZATION OF KEY COASTAL FEATURES IN THE REGION

Geographical coverage of coastal zone

Coastal zones are areas which are close to the sea. Several persons and agencies have defined coastal areas for based on functionality or the issue being addressed by a coastal program. Definitions ranges from using watershed within coastal areas, areas within specific probability of flood event, distance from the sea and elevation above the sea level. In Ghana two major definitions has been used in most research based on watershed of major rivers which drains into the sea and areas with elevation below 30 meters close to the sea. In this guide, the outer boundary of the coastal districts is the landward limit of the coastal zone and the seaward limit extends from the shore to the 30meters depth contour or 6 nautical miles, whichever is further.

Nine districts are within the coastal zone demarcated comprising Awutu Senya East, Awutu Senya, Effutu Municipal, Gomoa West, Ekumfi, Mfantsiman Municipal, Abura Asebu Kwamankese, Cape Coast Metropolis and Komenda Edina Eguafo Abirem (Figure 1). The zone covers an area of about 2856.90 km^2 stretches about 40.45km inland. The biggest coastal district is Awutu Senya with and area of 628.941 while the smallest is Awutu Senya East with an area of 88.72km^2.
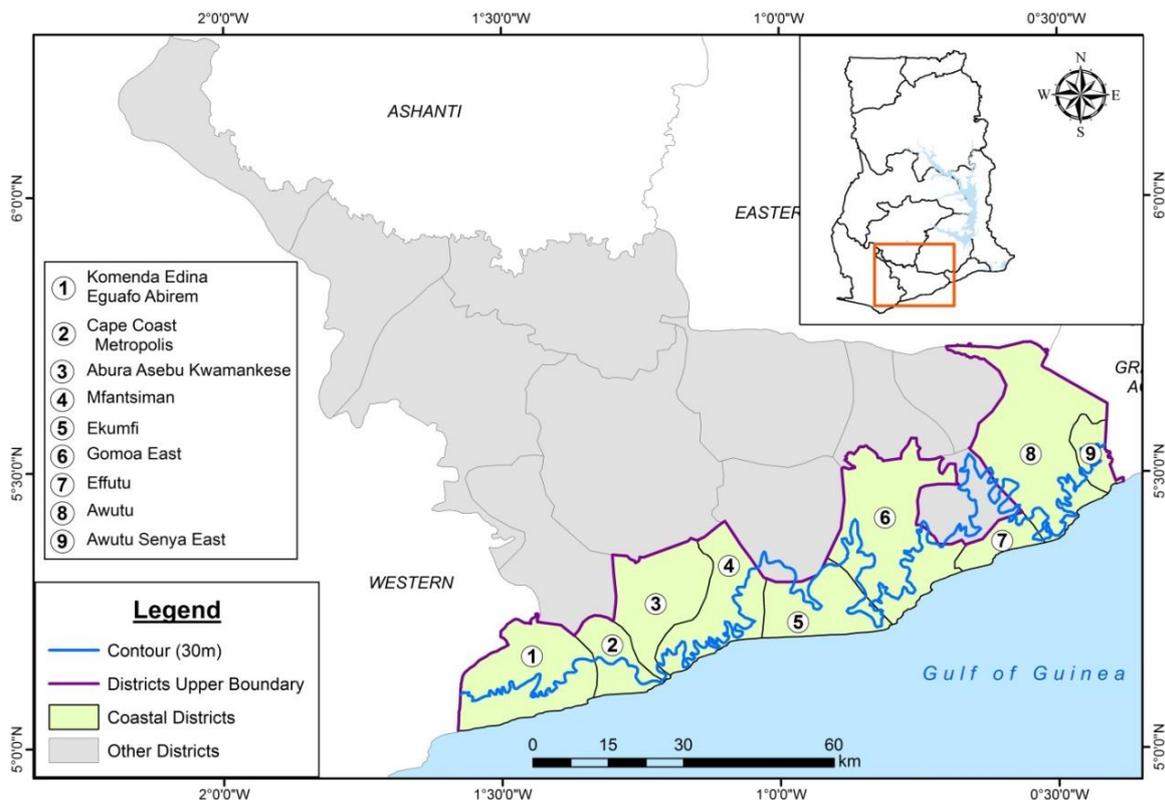
Figure 1 Coastal districts in Central Region

Relief, geology, soil and shoreline types

The relief of the coastal districts is mainly flat with series of highlands. Elevation ranges from sea level to about 379m (Figure 2). Elevation rises with distance away from the sea with approximately 70% of the land area below 30m. The terrain in some of the districts like Cape Coast and KEEA is undulating.
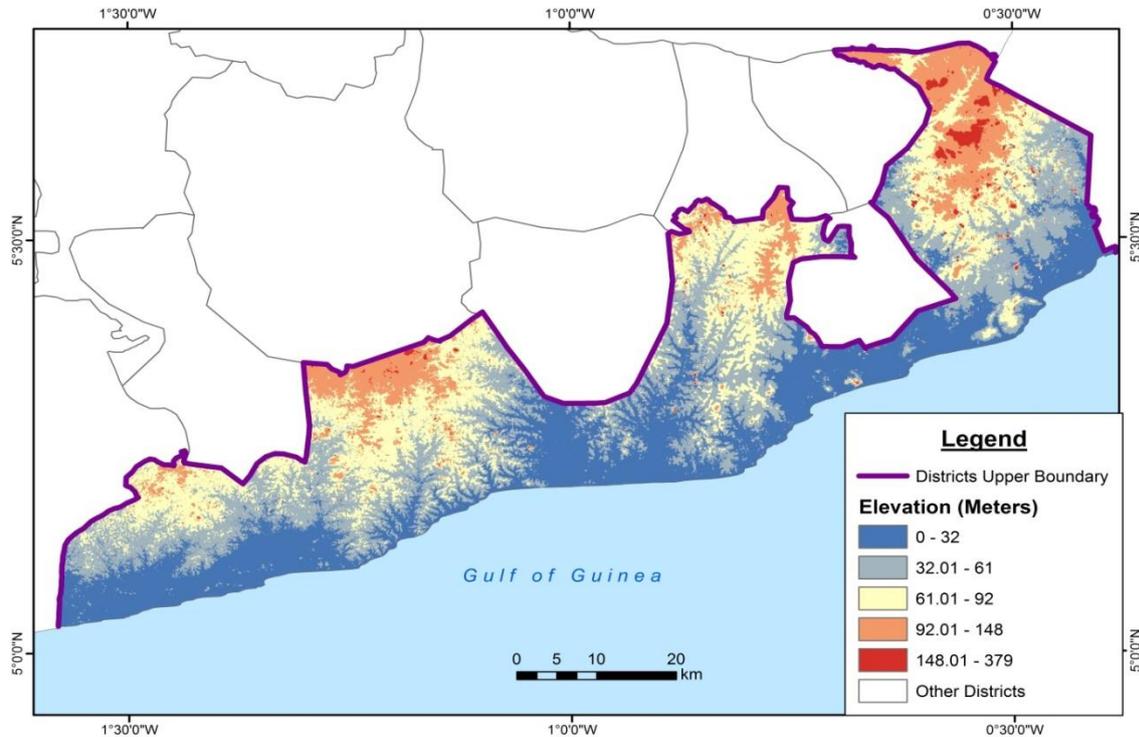
Figure 2 Elevation of coastal districts in Central Region

The highest point close to the sea is about 61m in areas around Awutu Senya, Moree, Biriwa and Yamoransa. Geology underneath the districts is a mixture of sedimentary and metamorphosed rocks. Specific geology types are limited to certain districts. Komenda Edina Eguafo Abirem and Cape Coast is underlaid by Sekodian and Dahomeyan. Birimian sediment is a common geology in Mfanstisam and Ekumfi districts while Gomoa East has Birimian rock and Dahomeyan geology which engulf most of the districts. The major groups of geology are felsic intrusions, clastic units (sandstones, mudstones, siltstone), marine clastic faces in sedimentary units (wackes, pelites and argillite) and mafic volcanic. Soils within the zone are a result of disintegration of underlying geology and deposition of sand. The dominant soil types are acrisols, fluvisols and vertisols (top portion of Figure 3).
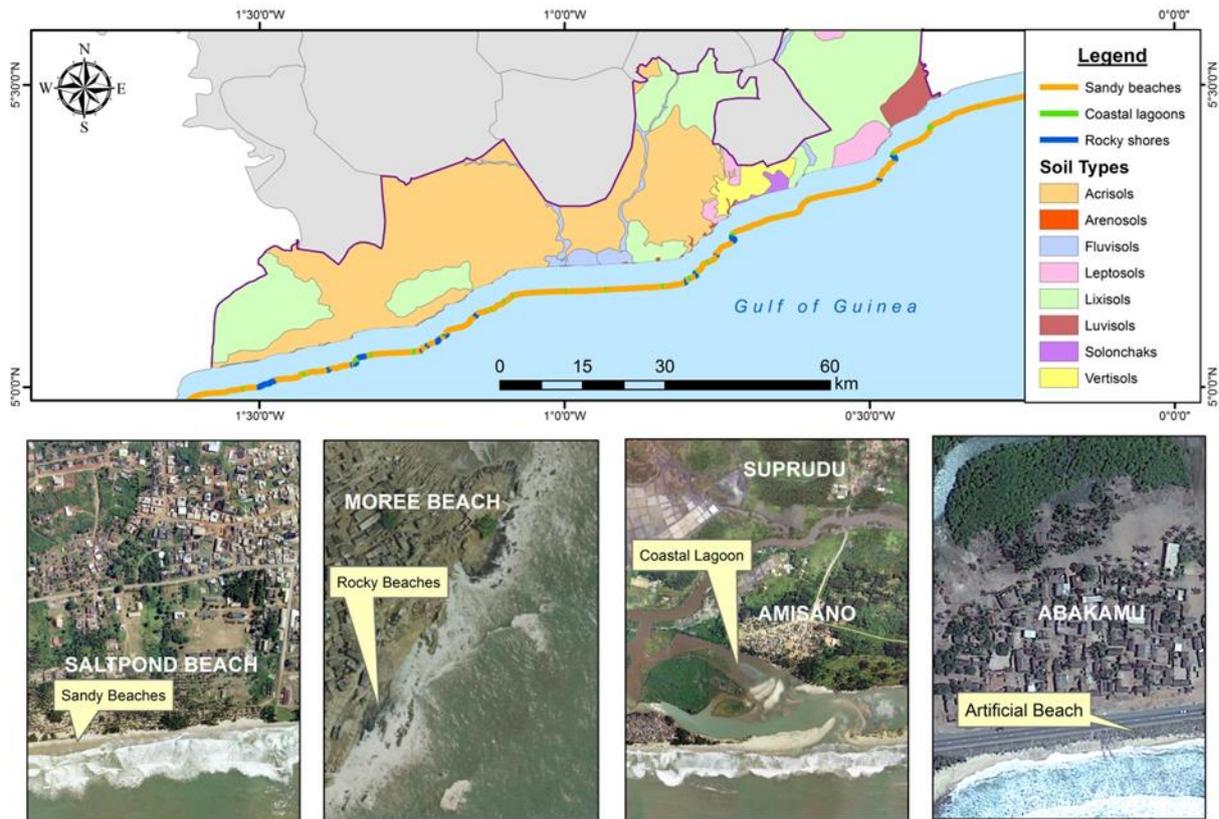
Figure 3 Types of shorelines along the coast of Central Region

Acrisols are dominant, they have low soil minerals and highly prone to leaching and erosion. Fluvisols result from years of accumulation and sedimentations. These are confined to wetlands and river course. The beach types in the coastal areas are highly impacted by the geology and geomorphic processes. Sandy beaches (Figure 3) are a common sight along the beaches with a few rocky outcrops and coastal lagoons (open and closed). A few of the beaches (Cape Coast Metropolis and KEEA) are well-built artificial shorelines financed by government to address erosion. Other districts have put in place improvised measures such as refuse, sand bags and concrete barriers at the beach front to mitigate erosion.

Wetland ecosystems are the common features along the shores of all the coastal districts. They are areas of marsh, peat land or water natural or artificially created with elevations less than six meters above sea level. The main wetland areas within the region are the Muni Pomadze wetland, Elmina wetland, Cape Coast wetland (Figure 4) and the parts of the Pra wetland. They serve as breeding grounds and habitats for fish. In addition, the presence of plants, peats, marshes in wetlands help in water filtration.

Figure 4 Wetland and mangrove forest at Kakum estuary, Cape Coast

CHAPTER TWO: PROFILE OF KEY COASTAL ISSUES IN THE REGION

The coast of Central Region is experiencing high rates of change in its shoreline, degradation of wetland habitats and increasing risk to flooding and sea erosion. In order to solve the coastal challenges in the region, it is important to have an understanding of the issues as they presently exist. The coastal issues are summarized below.

Degradation of wetlands

Population and urbanization is increasing in coastal zone of Central Region. Rate of population growth is estimated by the Ghana Statistical Service (2010) as about 3.1 per annum. High population growth and urbanization is not widely spread but confined to a few urban centers in the coastal zone. Highly urbanized centers in the zone are Cape Coast, Kasoa, Elmina and Winneba. The downside of this urbanization is limited residential facilities to accommodate the population. The effect is the rush by private investors to meet this demand, but unfortunately such efforts are being undertaken with less regard for the environment. Wetlands and natural vegetation/forest which have been designated as protection and flood risk zones has been besieged by private developers. Wetlands are now filled/reclaimed to enable the construction of physical structures (See Appendix Exercise One and Two: Mapping wetlands/ conservation areas). In the Muni Ramsar Site (Winneba), for example, the wetlands are faced with high level of encroachment problems despite the protection provided by the Ramsar convention.

It is estimated that from 2000 to 2010 built up areas increased by 40.50%; bare land was up 13.25% while closed and open forest decreased by 32.84% within the Muni wetland. This is of major concern because if the trend continues unchecked, some wetland areas will be lost forever. The implication of this goes beyond degradation of Muni to destruction of habitat and threats to cultural sustainability of Aboakyer festival.

In Cape Coast, the size of the Iture wetland is reducing, as private investors clear the wetland to accommodate the growing population of the University of Cape Coast. Built up growth from 2005 to 2011 was about $954977m^2$ pushing deep into the Iture wetland with an annual growth rate of $156,162.9m^2$. In other wetlands, degradation is not driven by residential developments only but by other economic activities like salt mining and farmlands. Nyanyano has a huge tract of wetlands converted into saltpans and farms. The entire wetland of Elmina covering about 1525348 m2 is now used for salt production with mangrove habitats now confined to the boundaries of saltpans (Figure 5).

These developments impact on the ecosystem services of the wetlands, reducing their regulating, supporting and cultural significance. Lastly, the degradation of wetlands in the region is not only limited to change of one cover to the other but also fragmentation within the wetlands. Roads have been constructed in Kakum wetland, Muni which impedes movement of mammals and flow of water within them. In addition, households cut mangrove vegetation to support the construction of structures while others use it as fuel wood. The cutting and constant contact with the wetland reduces it rich diversity and patch sizes. The effects of wetland degradation in the region is increasing vulnerability to sea erosion and flooding a situation which has to be regulated.
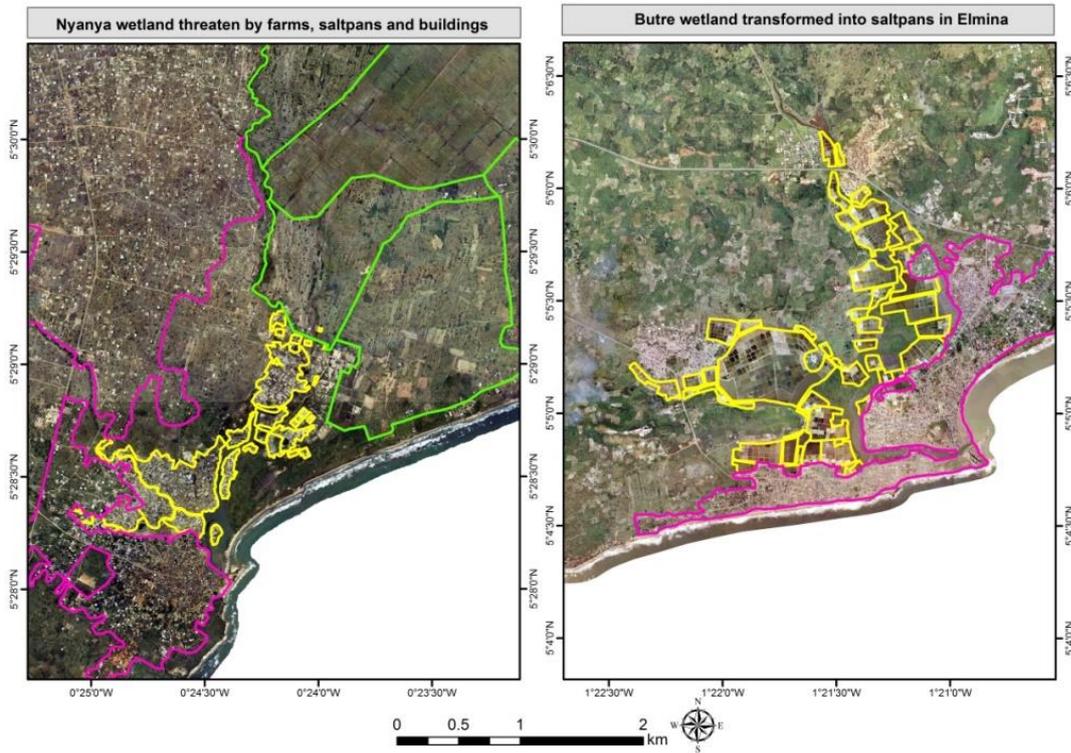
Figure 5 Wetland degradation at Nyanya and Elmina

Flooding (Riverine and sea)

Flooding is a recurrent event in the coastal zone with devastating effects ranging from loss of lives, property and break down of socio-economic activities when they occur. Flooding has become synonymous with the rainy season as high amount of rainfall are poorly drained or discharged. Storm drains are choked with sand and refuse while flow directions have been built thereby impeding the smooth flow of rains. Areas with severe riverine flooding related problems are Cape Coast (Kwaprow & Amamoma) Elmina, Narkwa, Nyanyaano, Komenda Winneba and Kasoa (Figure 6). Beyond riverine flooding, sea level rise is stimulating loads of flood events. Sea flooding and storm surges are making communities along the coast unsafe for habitation. At the micro level (community level), increasing sea flooding and sea level rise is mainly because of sand mining activities and degradation of wetlands which acted as barriers.
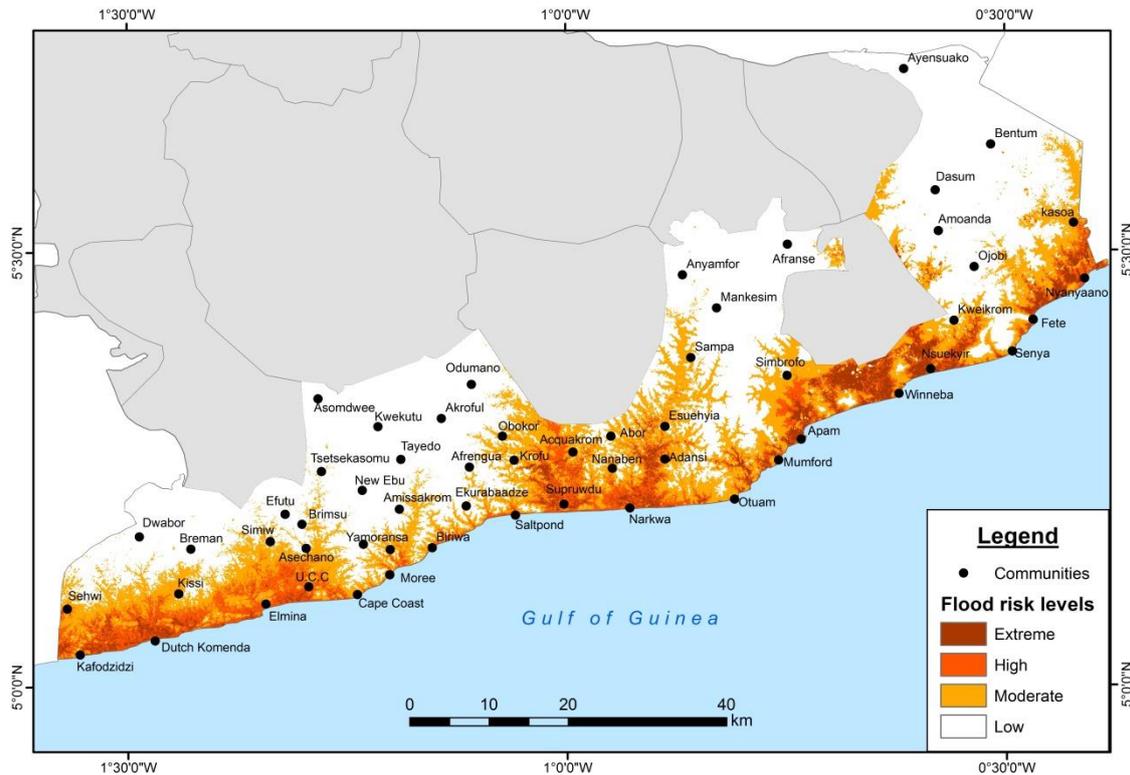
Figure 6 Areas liable to flooding in coastal districts of Central Region

Shoreline erosion

Shoreline erosion along the coast of Central Region is very intense. Net shoreline movement along the shores of Elmina from 1974 to 2012 was about -74.26 m with an annual rate of -1.84m. Dadson et al, 2016 also estimated about an end point rate for rocky beaches in cape coast around -0.61m. High erosion-prone areas are mostly sandy beaches as they are often unconsolidated and uncompact. Drivers of these increasing erosion activities can be attributed to rising sea levels, storm surges and also anthropogenic activities such areas of intensive sand mining along the beaches. Beaches are the focus of high residential growth within the region as well as the development of hotel facilities, all leading to clearing and re-modification of beach landscapes. Beach sand is the major building material for communities along the beach. Previously a small quantity of sand will have been mined for buildings and renovations by indigenes along the coast. The situation has escalated into commercialization of sand mining in the region. Beach sand has become the most preferred building material for building construction. Largely because of less regulation, monitoring and low cost in securing them. Johen et al. (2016) mapped commercial sand mining activities along most parts of the region to points where block factories are sited along the beach (Figure 7).
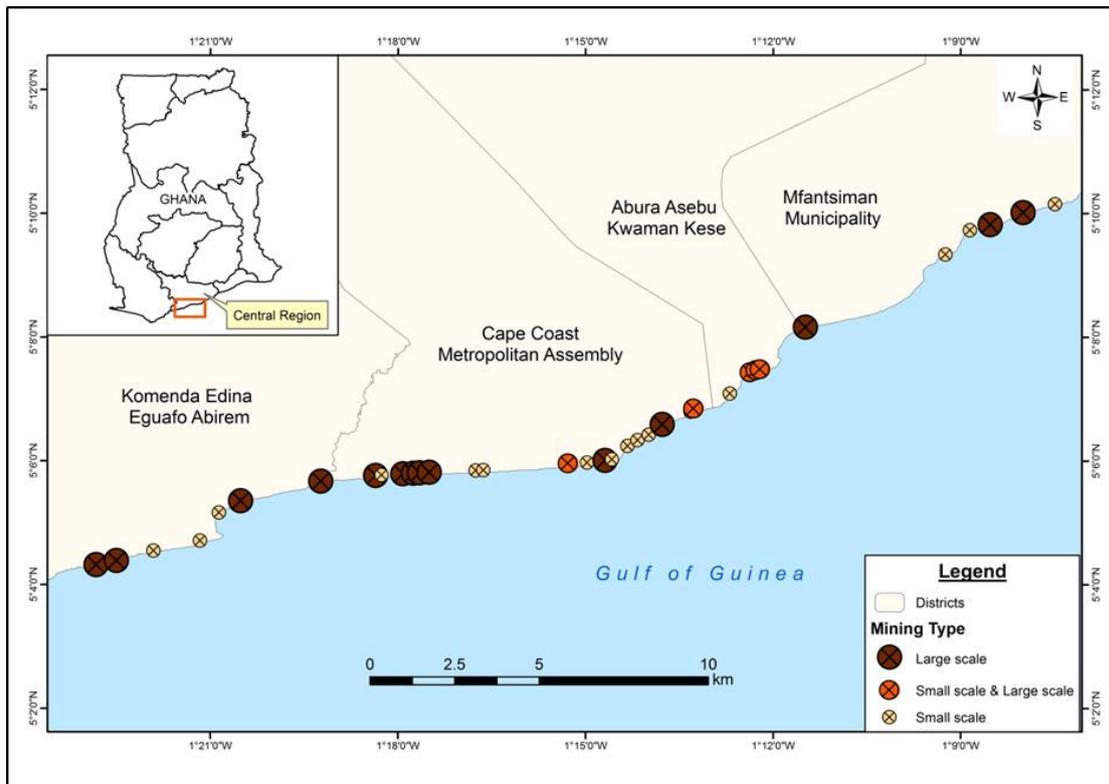
Figure 7 Sand mining areas along the coast of some districts in Central Region

Sand mining effects are evident as increase in sea flooding into accommodations and houses. Ecologically, sea erosion leaves trees such as coconut roots exposed to the direct impact of sea waves. Numerous coconut trees along the beach of central region had given way as a result of high rate of beach erosion. Management and enforcement of regulations in apprehending offenders has not been effective.

CHAPTER THREE: PLANNING APPROACHES TO COASTAL HAZARDS MITIGATION AND RISK MODELING

Mapping coastal hazards

A hazard is any potentially damaging physical event, phenomenon or human activity that may cause loss of life, injury, property damage, social, economic disruption and environmental degradation. In coastal areas of the central region, events with damaging potentials are mostly floods and sea erosion. However, natural hazards can now be monitored, modeled and planned for to reduce their impact on society.

There are both qualitative and quantitative hazard mapping techniques.

Qualitative hazard mapping

- are non-probability ways of modeling hazards.
- draws on experience, local knowledge and historical accounts of previous hazards.
- expert knowledge of community members through focus group discussions, participatory mapping (Figure 8) and interviews can be used to get in depth knowledge of the hazard.

Figure 8 Community mapping of flood areas

Quantitative hazard mapping

- employs probabilistic or a deterministic approach in modeling hazards.
- only possible with usage of computers (Hardware, software, and data) and advance tools and instruments.
- models hazards and make simulations for scenarios based on extreme conditions.

Table 1 Characteristics of coastal hazards

Hazard characteristics	Definition	Importance
Probability of occurrence	Likelihood of a hazard to manifest/ occur in the future	Estimate number of times a hazard can occur in a year Develop early warning systems and information
Triggering factors	Phenomenon which stimulates the occurrence of hazard. E.g. Excess rainfall, high temperature, high speed winds, unplanned physical development etc.	Develop early warning systems and information Mitigate the trigger
Time of onset	Delay time between the triggers and intense peak of a hazard	
Magnitude or Intensity	The damage or the energy released by a hazard	
Spatial occurrence	Includes the area the hazard was created and the areas affected by the hazard.	• Develop emergency routes • Know elements likely to be affected • Target rescue mission
Duration	Amount of time or hours a hazard persists in its affected area	
Secondary events	Other hazards events which are generated by an initial hazard	

Modeling sea erosion

Sea erosion/accretion estimation can be undertaken by adopting various methods ranging from field based on traditional land survey (beach profile), airborne photogrammetry and bathymetric survey. Beach profile measures erosion or accretion by installing vertical poles at regular intervals along the beach and perpendicular to the sea. The poles to be used should be of similar height and well demarcated for easy identification and measurements. Also the intervals between the poles should be the same for easy measurement. The planner or researcher can monitor the inward or outward movements of sea water and sands (Figure 9). This helps to understand the direct cause of erosion of a beach stretch whether change is highly under the influence of natural causes or man-made activities or both.
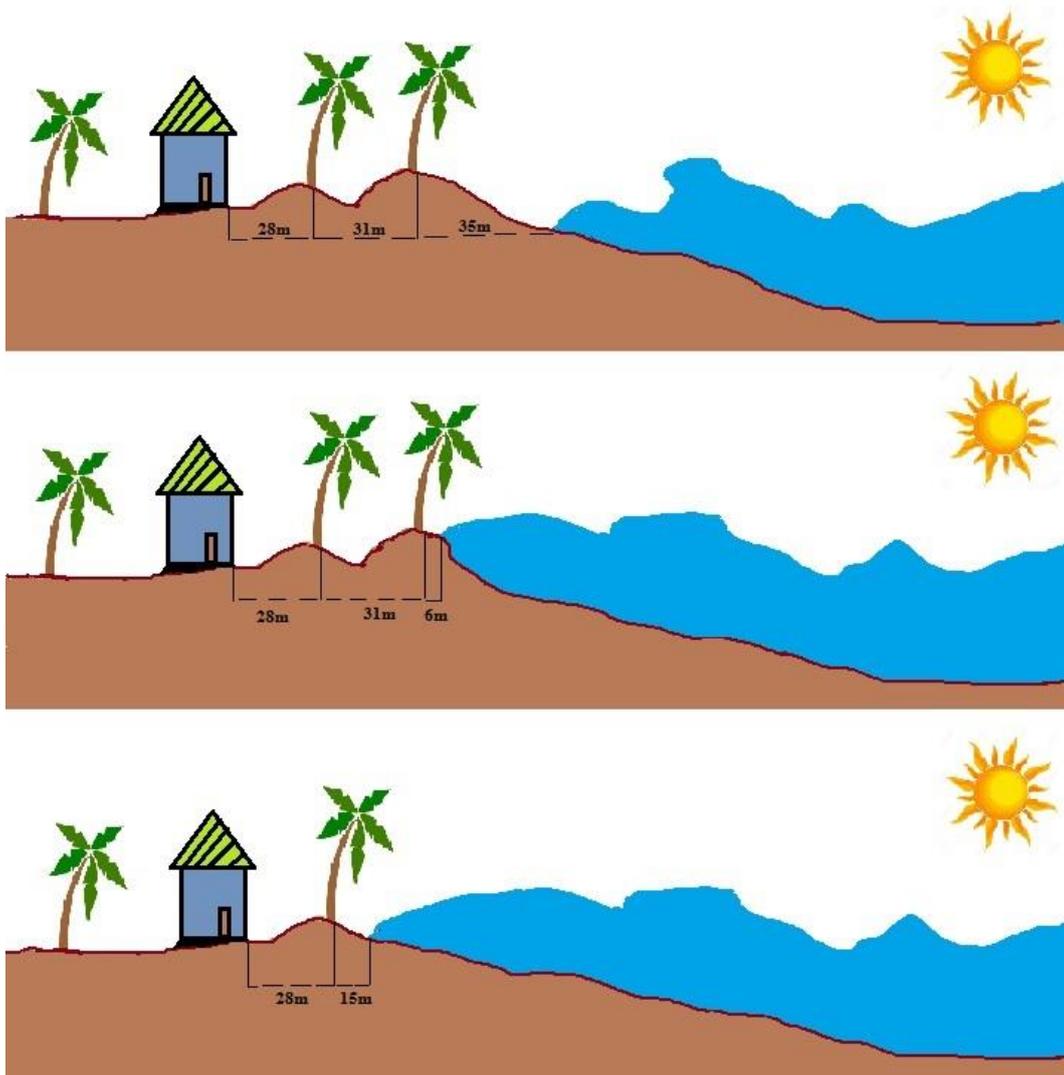
Figure 9 Monitoring sea erosion using landmarks

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It also helps planners to build mutual and friendly relationship with community members during visits. Its downside is the amount of time, number of personnel needed to cover a beach stretch and fatigue from the process of monitoring. Traditional land survey techniques are often tedious and time consuming which can have a huge toll on planners. Improved version of land survey is the installation of total stations and cameras. Total stations are used to measure the angle and distance from the sea to the land from a fixed point. Cameras give a real time understanding of sea wave's action of erosion or accretion which is more intuitive than daily monitoring of transects developed. The challenge of these methods is security of equipment's installed along the beach. In addition, geo-referencing of captured image with camera's can be a problem as cameras are placed perpendicular to the sea and defining a referencing system becomes a challenge.

Aerial photos and satellite images solve the challenge of geo-referencing as platforms are embedded with high frequency GPS. It also helps easy integration and interoperability with already spatial data, existing maps and GIS software. One great advantage is the ability to study the same beach from a historical dataset from maps giving a wider time dimension to a study then traditional methods. The downside of aerial photography is the cost of acquiring imagery as it tends to be high but with the advent of unmanned aerial vehicles (UAV) cost

can be reduced. Also the open access of Google Earth makes it easy to get free images or map shorelines for different years (See Appendix Exercise Five: Shoreline mapping).

Shoreline Management

Soft protection

Soft protections are measures which uses natural vegetation and sand in dissipating wave energy reaching the beach. Adoption of soft protection measures are the best options in areas where wave energy is not strong and can be dissipated easily.

Beach nourishment or beach filling*:* In beach nourishment, large quantities of sediments are added onto eroding shorelines to increase beach width and slow erosion. It is seen as a process of constantly adding to the base beach by allowing for compacting and integration of base sediments and added sediments (Figure 10).
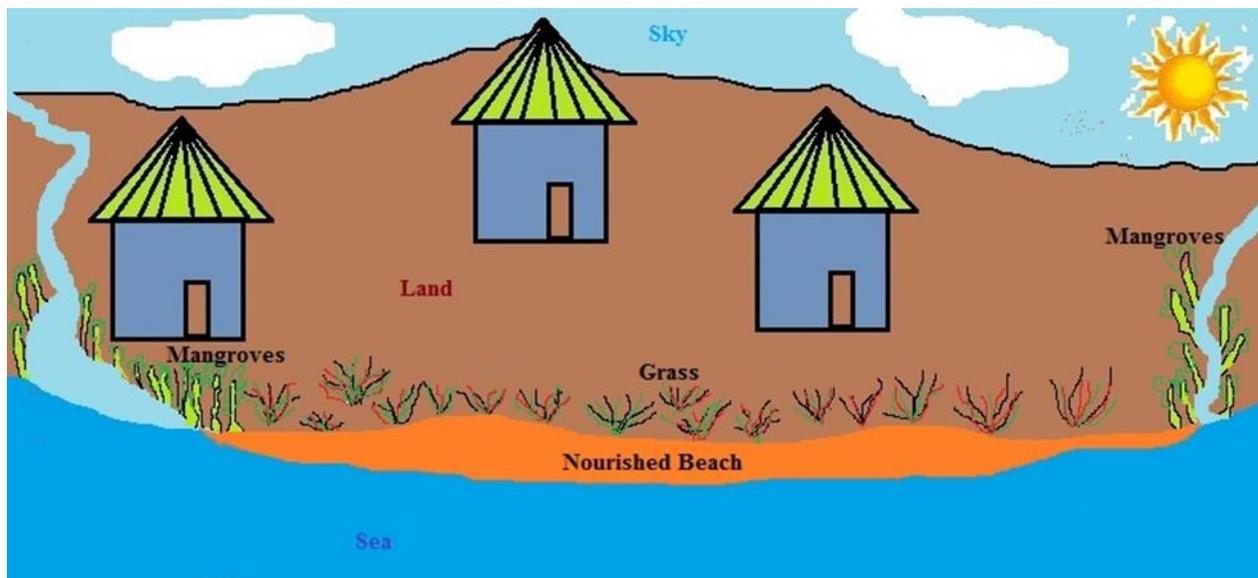
Figure 10 Beach nourishment

Hard protection

Hard and physical protection measures are the last options when soft measures have failed. The construction of hard protection is advantageous when sea wave action is very high with huge implications on properties and local economy. As it will help safeguard the shore community and properties and life. Much caution has to be adopted in constructing these hard protection measures as series of consultation has to be undertaken with community members to understand the impact of sea erosion and which specific measure to adopt. There are various hard protection measures such as sea defense wall, groynes, revetment and breakwater, each with its weakness and strength.

Sea wall*:* These are physical concrete structures built parallel to the sea (Figure 10). They are used as the last resort to combating the impact of sea erosion if all other methods have proven unfruitful. Walls constructed are as good as the composition and mixture of sand, cement and stones. A well-constructed sea defense can last for over 40years and has the ability to cut short erosion activities at the shorelines placed. In constructing sea defense, the characteristics of the sea waves in the area has to be considered as the highest wave during high tides and wave energy. Also the wall should well be grounded to the land to increase its resistant ability against sea water. Wall should be constructed an elongated entity to increase is resistant capacity (Figure 11).

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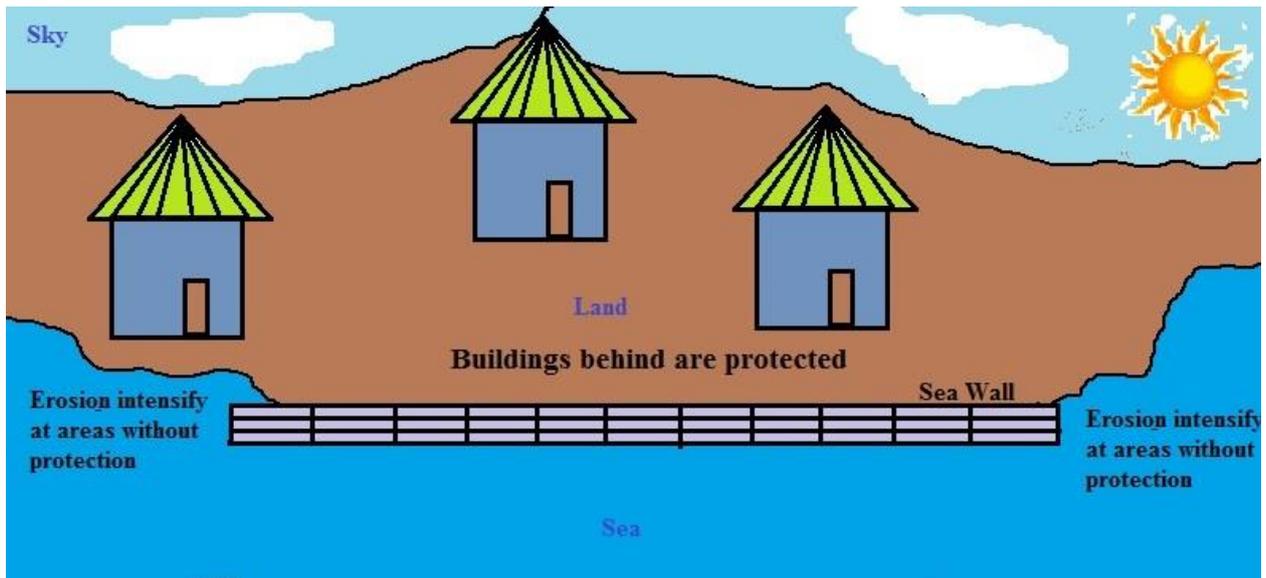
Figure 11 Sea defense wall

Effects associated with sea defense are that it rather increases erosion activity at the ends. All sea sands in front the defense are all going to be washed away reducing accessibility to shoreline. This has implications for the aesthetic valuation of the beach and can affect tourism.

Groynes: are concrete structures built perpendicular or oblique to the sea (Figure 12). They usually extend sea wards to help in sediment deposition in between the groynes. Groynes are the most effective measure to increase sediments and improve access to be beach. Constructed groynes needs to be high to trap sediments while being long enough for sediments to be accumulated within.
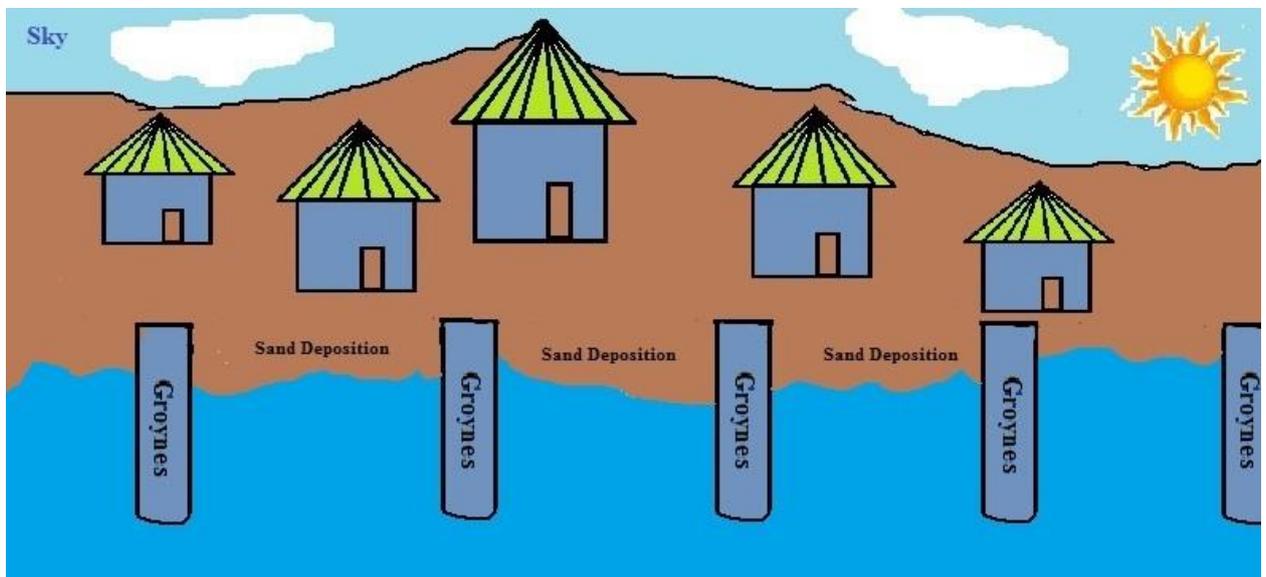
Figure 12 Groynes

Spacing between groynes is very important as too wide can reduce their ability to trap sands or increase the number of years to accumulate sands. It is recommended that the distant between groynes should be three times the length. Despite the advantage of groynes over sea defense in trapping sands they also can increase erosion activities at zones beside it as it will distort sediment budget by receiving deposit only without eroding.

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Revetments: These are materials that are well arranged in a sloping manner to the sea (Figure 13). They mostly consist of sands, gravels, wire mash and even with vegetation constructed parallel to the shore. They serve as a line of defense against wave actions and also can help reduce sea inundation if its sloping is steep.
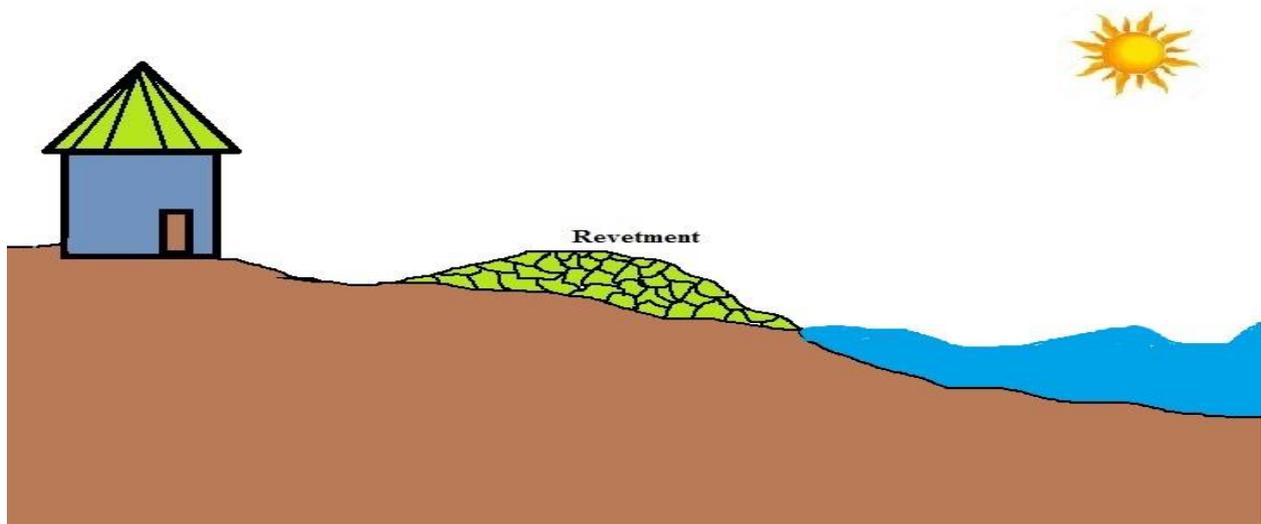
Figure 13 Revetment

When revetments are not properly constructed then it becomes easy for gravels to be washed or rolled into the sea. It is important to support them with wire mash in areas where sea action is high. Also areas with revetments are more likely to have little sandy beaches as the sea waves erode them faster.

Breakwaves: Materials placed offshore to reduce or dissipate the direct impact of sea waves approaching landward (Figure 14). Material used as wave breaks can be concrete blocks, gabions, rocks or huge metallic structures. The advantage of break waves is that they can also help the growth of coral reefs and improve aquatic diversity. Breakwaves must be placed strategically to intercept the action of the waves and areas with intense wave action.

Figure 14 Breakwater

Also they should not be placed too close to shore as waves broken will spill on land to erode the beach. Same way it should not be placed too far from shore as small waves can be formed

beyond them after they are intercepted. A major disadvantage of breakwaves are that they can increase beach width behind them while increase erosion at other areas.

Risk Mapping

Mapping elements which are likely to be at risk to natural hazards is the first step in disaster management. Different levels of classification exist for identifying elements at risk but the basic categorization has always been physical, economic, social and environment (Table 2).

Table 2 Classification of elements at risk

Categorization of elements at risk	Specific elements
Physical elements	**Infrastructure,** for example: roads, railway, bridges, harbors, airports etc. **Critical facilities**, for example: emergency shelters, schools, hospitals, nursing homes, fire brigades, police **Utilities**: Power supply, Water supply **Services**: transport, communications **Government services**: all levels - national, provincial, local **Machinery and equipment** **Historical structures and artifacts** **Cultural**: sacred lands, artifacts, monuments
Societal elements	Vulnerable age group categories Low-income groups Landless/Homeless Disabled Gender Single parent households
Economic elements	Business and trade activities, Access to work, Agricultural land, Impact on work force, Productivity cost Opportunity cost
Environmental elements	Environmental Resources: air, water, fauna, flora Biodiversity Landscape

Source: Asian Disaster Preparedness Center (ADPC)

Creating database for elements at risk

Data on risks is essential in decision making, planning, rescue missions, risk communication and relief exercises. Unavailability of data presents a challenge in the process of effective planning and disaster management. Recommended solution is to consult other government agencies responsible for mapping basic infrastructure data. . Statistical services has large datasets of communities at enumeration level which is detail enough for mapping population likely to be affected by a hazard. Survey departments and physical planning units are noted to have depositories of buildings footprints and land uses good for risks mapping. Instances where building footprints do not exist for an area it can be generated through mapping. Mapping can take the form of digitizing from a Google image (See Appendix Exercise Five:

Mapping buildings) or orthophoto in any GIS platforms (consult Land Use and Spatial Authority Street Naming Manual and Spatial Planning Framework).

Figure 15 Building footprints

Building footprint dataset (Figure 15) by Land Use and Spatial Planning Authority or Survey Department (Ghana) might not contain building characteristics which are very important in estimating the risks of a building to natural hazards. This demands field work to update building characteristics information. Basic building characteristics for risks studies are building heights, foundation height, number of floors, construction material, age of building, number of entrance to building etc. (Figure 16).

Figure 16 Building characteristics

Building construction material can range from raffia, blocks, bricks and plastics; they influence the level of vulnerability of the building and that of the contents (appliance, room furniture and other items). The building material also has impact on lives within them, blocks and bricks are good materials resistant to floods but can be dangerous to life during hazards like earthquakes. Buildings with high foundation above surface are more likely to protect

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building contents. Number of entrance of buildings affects the safety of people as this negatively impact exit during emergency cases.

Land use map at district   Land use map at community level
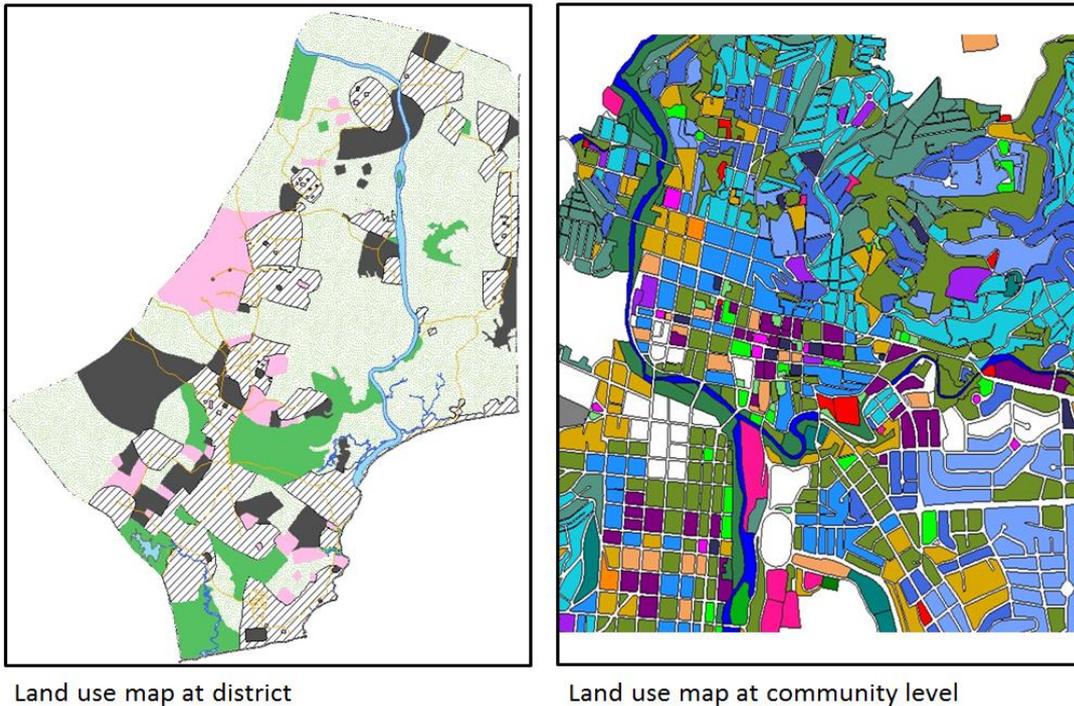
Figure 17 Land use map at community and district levels

Also another challenge with available datasets is their resolutions and also their intended use. In the case of land use maps, data can be mapped at global scale, national, regional, district and communities (Figure 17). The scales of the land use have effects on the estimation or quantification of possible elements at risk. Community level land use maps are detailed enough to depict elements at risk. District level land use maps are not appropriate as they are likely to generalize land use categories.

Identification of priority coastal areas for structure plan preparation

Degradation of the ecology, hazard, vulnerability and risk along the coastal of Central Region is a threat to the sustainability of ecosystem services and human habitation. Attention in the form of technical response, funds, man power is needed at any locality, community and district to increase resilient levels. Unfortunately, resource constrain limits the ability to devote the same attention to all the coastal areas in the region. Priority must be given to areas with rapid land cover/ ecological change, high number of hazards and large number of persons affected by hazards. A spatial multi-criteria evaluation was undertaken using overlay function in ArcMap 10.1. Results indicate that areas within very high priority areas are Winneba, Nsuekyir, Apam, Cape Coast, Elmina, Saltpond, Otuam and Nyanyaano (Figure 18).
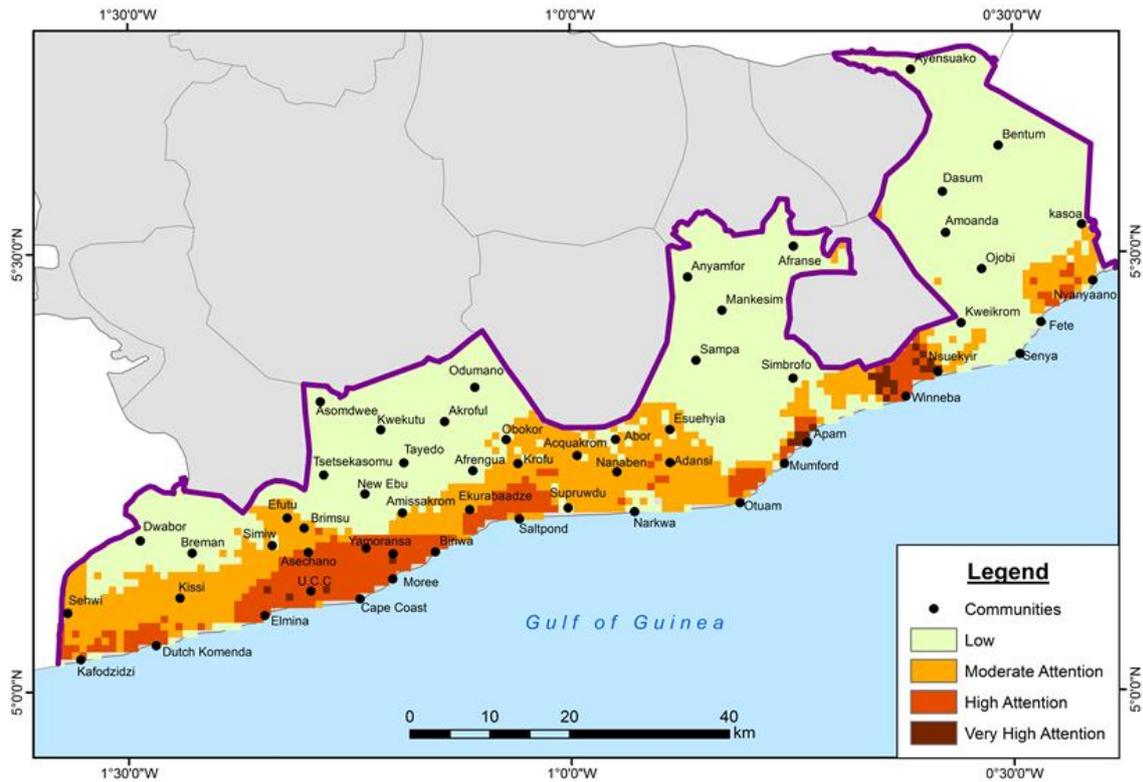
Figure 18 Priority areas for spatial planning

In these areas there exist local plans to spearhead physical developments but this is enough considering the rate of urbanization and frequency of hazards. Spatial plans give a broader scope to regulating and monitoring development which local plans are limited in this respect. Also spatial planning moves away from just demarcating of parcel of lands to integrating economic, social and ecological aspects in plans development. Low priority areas where Narkwa, Senya and Fete even though they were closer to the sea and are more likely to experience coastal hazards. Senya and Fete were areas within low risk areas while Narkwa was in high risk area but population wise persons likely to be affected by hazards is low. Low priority areas do not necessarily mean spatial planning is not needed in these areas but in the face of constraints the areas rated of very high and high concern must be given the most attention.

LOOKING INTO THE FUTURE

This toolkit provides an introduction to coastal hazards, risks, vulnerability and geospatial mapping tools. The toolkit will serve as source of information for preparation of tiered spatial plans in coastal districts in the central region. And as development intensifies along the region's coast, the toolkit will be a source of information to guide decision making and orient data collection to inform development permitting and regulation. The information and exercises annexed to the toolkit can be expanded over time and also adapted to address specific district needs as planners and users of this information develop new skills and knowledge in coastal planning and management.

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APPENDIX 1: GEOSPATIAL MAPPING EXERCISES

The following exercises are based upon installation of Google Earth Pro, which is now available for free, and QGIS open source software.
Exercise One: Capturing Data from Google

1: Practical exercise (Capturing data from Google Earth and data interoperability)

Per the sources of data available to coastal zone managers in Ghana.

1. Download Google Earth Pro (www.google.com/earth/download/gep/agree.html)

2. Download QGIS (www.qgis.org/en/site/forusers/download.html)

3. Log in (Using a Google account and GETFREE as the password)
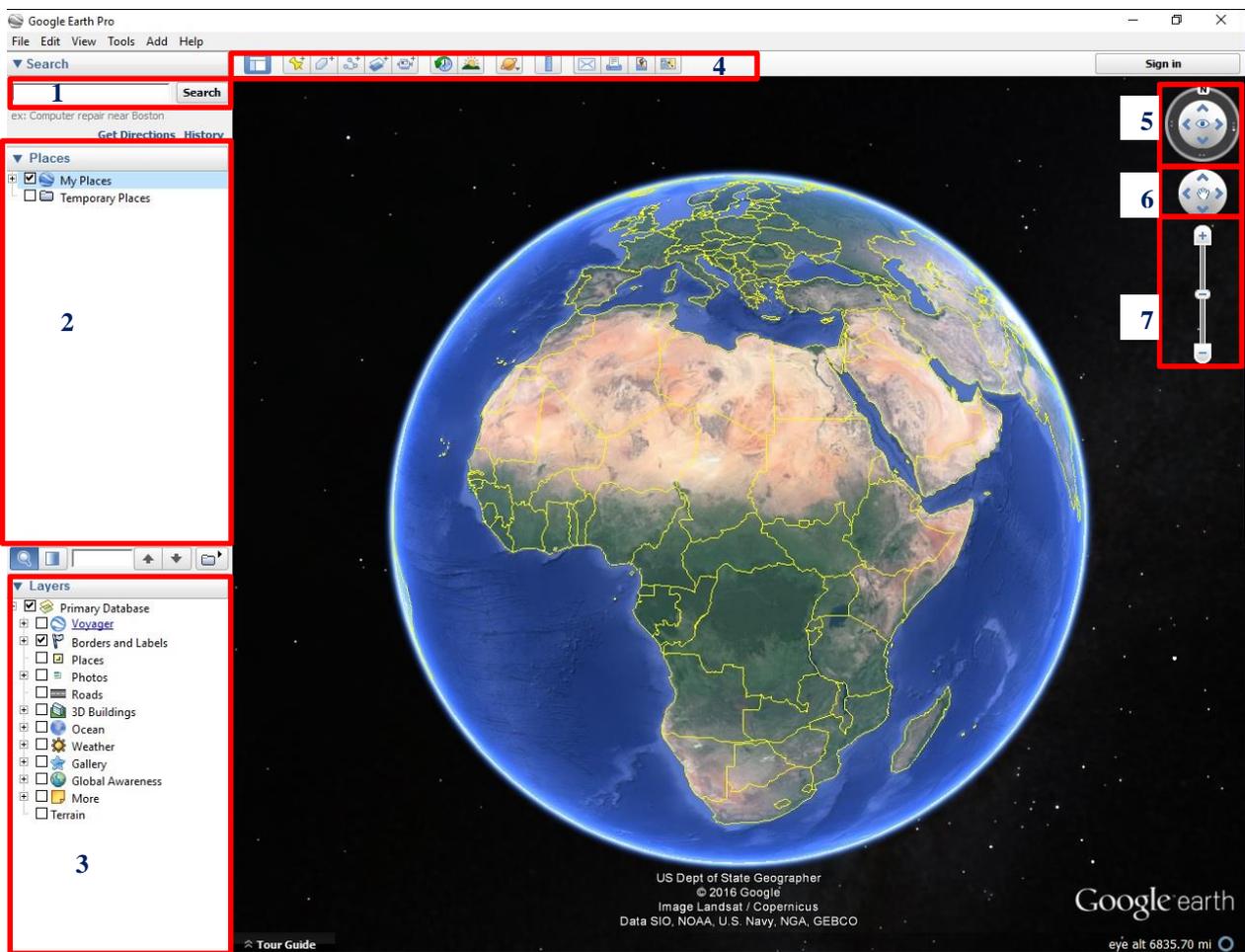
Figure A.1 Interface of Google Earth

Parts of the interface 1 (Search box: Querying for location/places), 2 (My place: Organization of mapped data), 3 (Layers: Displays the tiles and data on Google earth), 4 (Tools), 5 (Orientation: Direction), 6 (Panning), 7 (Zooming In+ and zooming out-).

4. Zoom to area of interest (Search using your search box)

(Example: Search for Elmina)

23
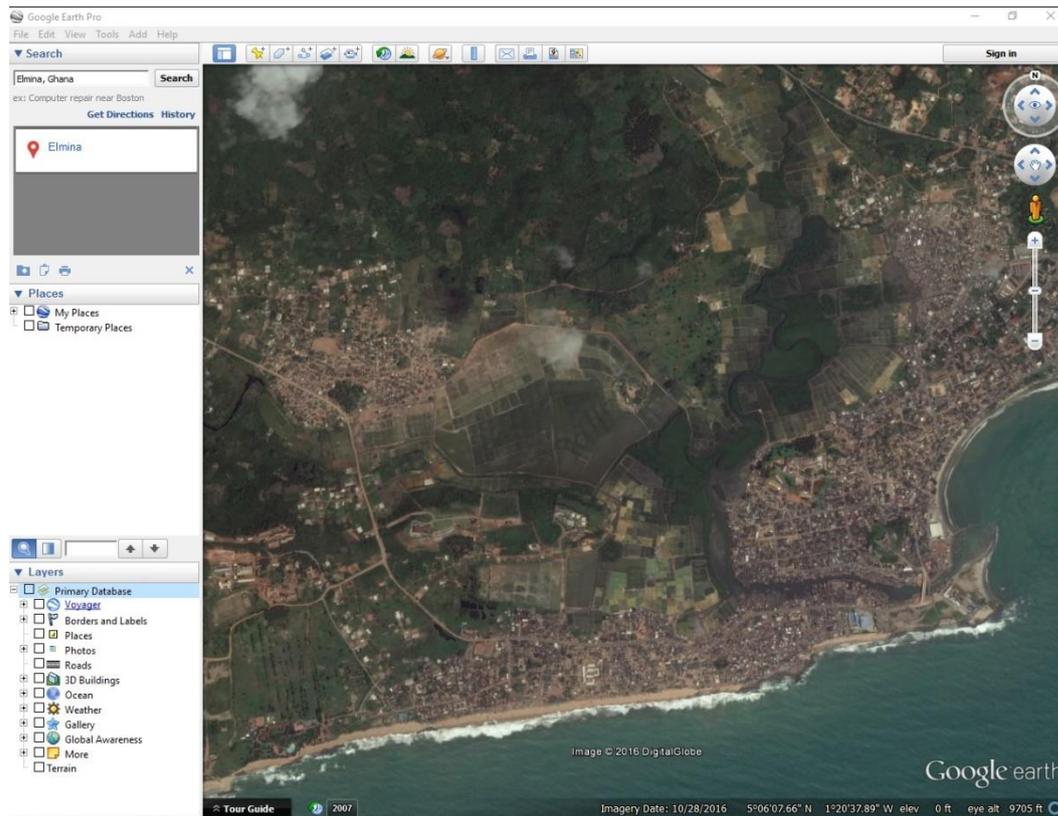
Figure A.2 Global Earth showing area of interest (Elmina)

Explore the image using 6 (Panning), 7 (Zooming) and 5 (Orientation –make sure the North point is always facing up)

5. Generate control points (which will serve as reference for georeferencing image).

    a. Create a folder under My Places (2): Right click on **My Places**, select **Add** and select **Folder** (Name the folder: Elmina)

    b. Right click on the folder created and select **Placemark**
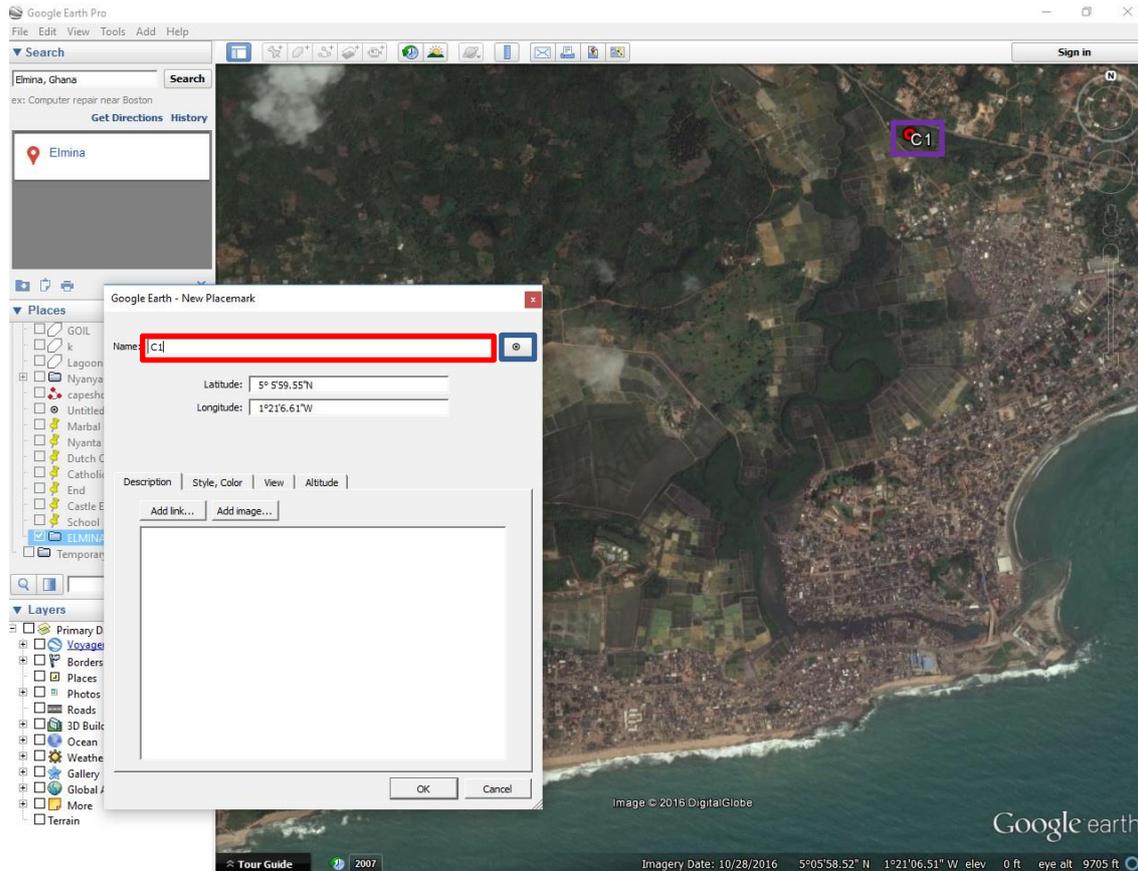
Figure A.3 Adding control points to area of interest

-Type name of point ☐ - Change the symbol ☐ - Point on photo ☐ (Use pan tool to move the point to the desired location)

    c.   Repeat, process [b] until you get a minimum of 4 points
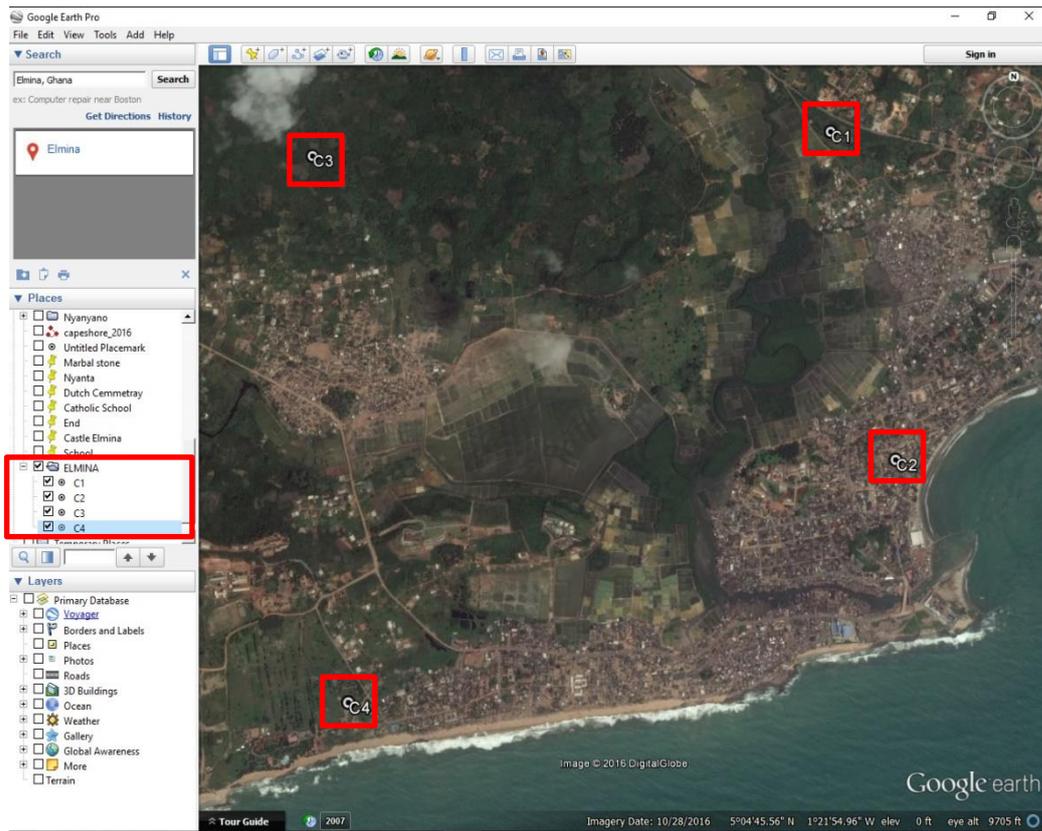
Figure A.4 Control points on area of interest

      d.   Points should be well over the area of interest (Should be shown on the map and within your folder [**Elmina**] under **My Places.**

6.   Save the control points and image

      a.   Right click on the folder Elmina and select **Save Place As**

      b.   Locate a working folder or create one to save the points

7.   Save Image

      a.   Click on **File**, select **Save** and select **Save Image**
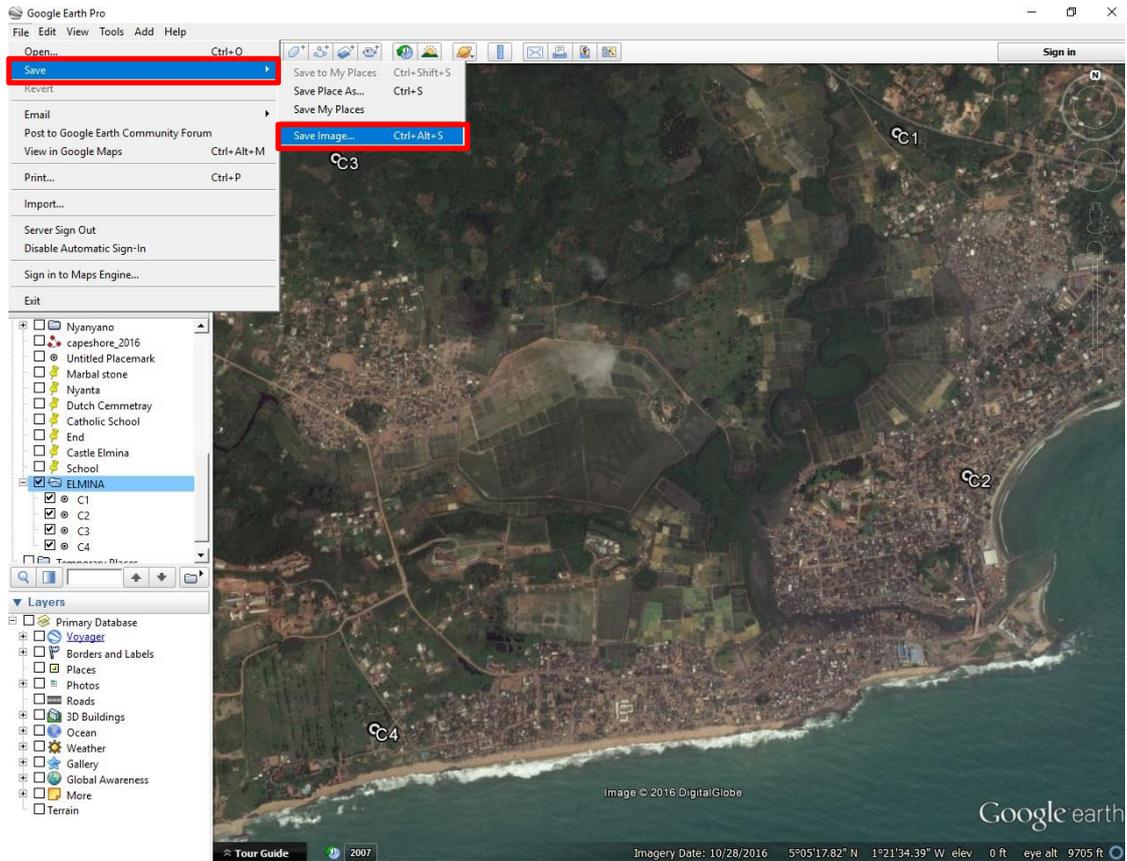
Figure A.5 Saving image of area

      b.   Select the highest resolution (Maximum 4800*4074) beside **Map Options**

      c.   Click on **Save Image** (Elmina) and locate a working folder

8.   Georeferencing data in QGIS software

      a.   Open QGIS software

      b.   Load set the spatial reference of the software environment (Select **Settings**,
then **Options** and make sure the coordinate is in the coordinate of the source
data-in this case is World Geodetic Systems **WGS1984)**
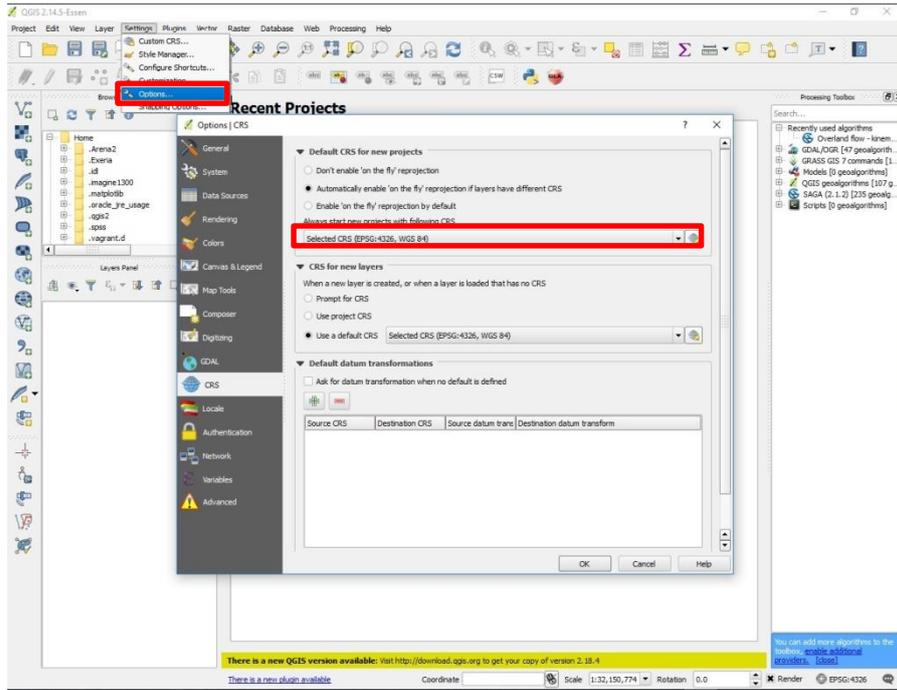
Figure A.6 Setting coordinates of the software for geo-referencing

c. Load the **Control Points** saved from Google Earth
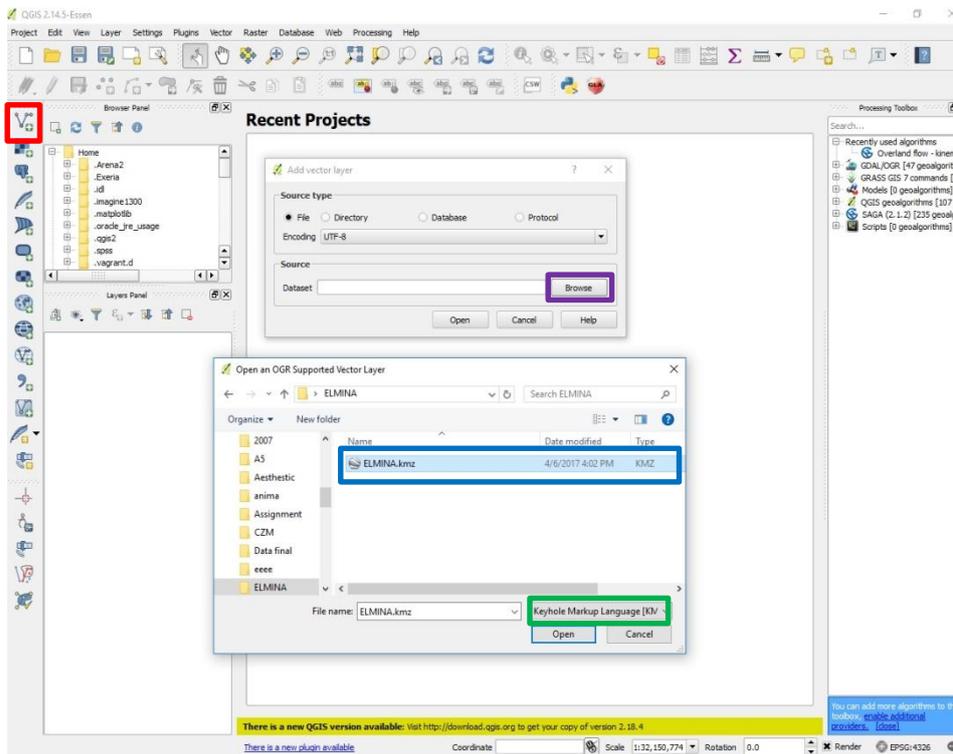
Figure A.7 Loading data into QGIS

[red box] Click **Add Vector**   [purple box] Click on **Browse** to locate your add

[green box] Change data format to Keyhole markup Language (Kml)

[blue box] Select the data **(Elmina)**

d. Vector data displayed
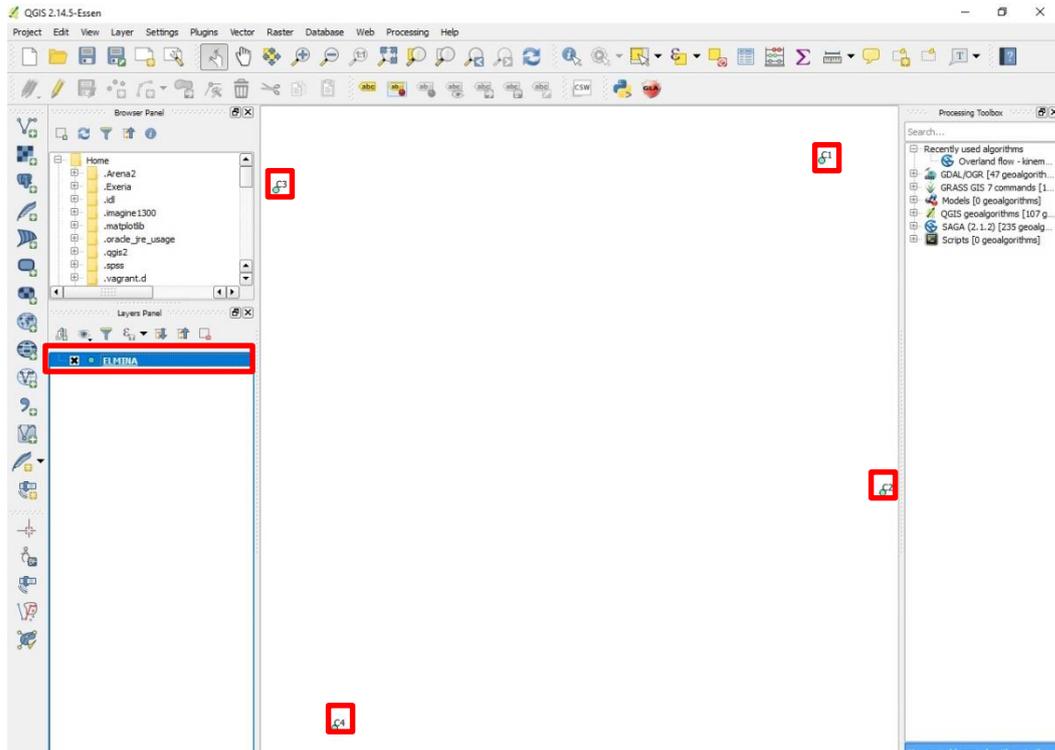
Figure A.8 Display of control points

e. Load the image saved (**Elmina. Jpg**) into Georeferencer
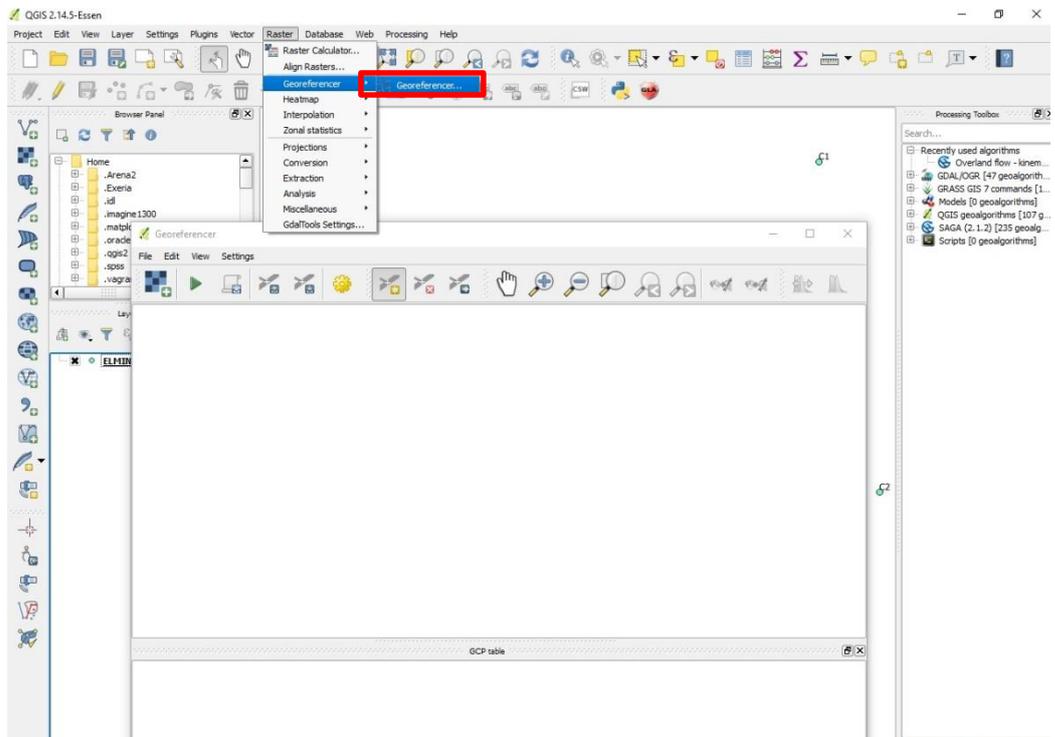
Figure A.9 Starting the Georeferencer

f. Select **Raster** on the File Menu, and then **Geo-referencer**

g. Load the image by selecting the **Raster** and locating the image **Elmina**
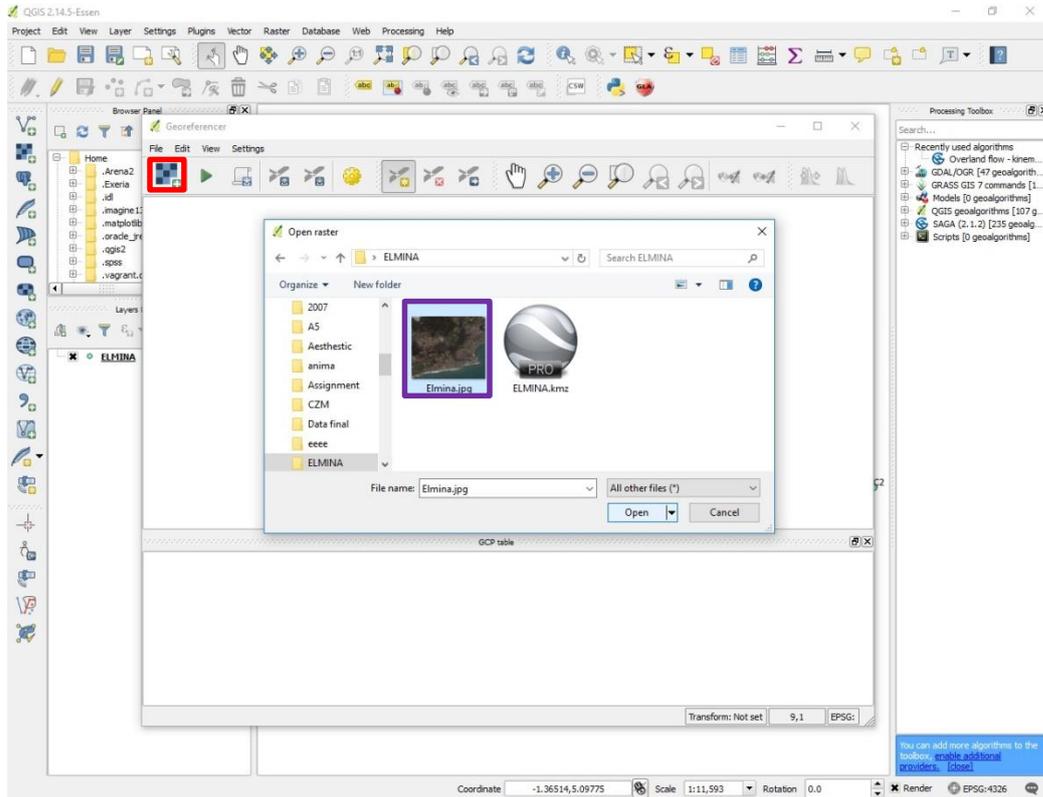
Figure A.10 Loading image in Georeferencer

⬜ Click on Raster tool   ⬜ Select the image

h. Start Georeferencing by adding control points
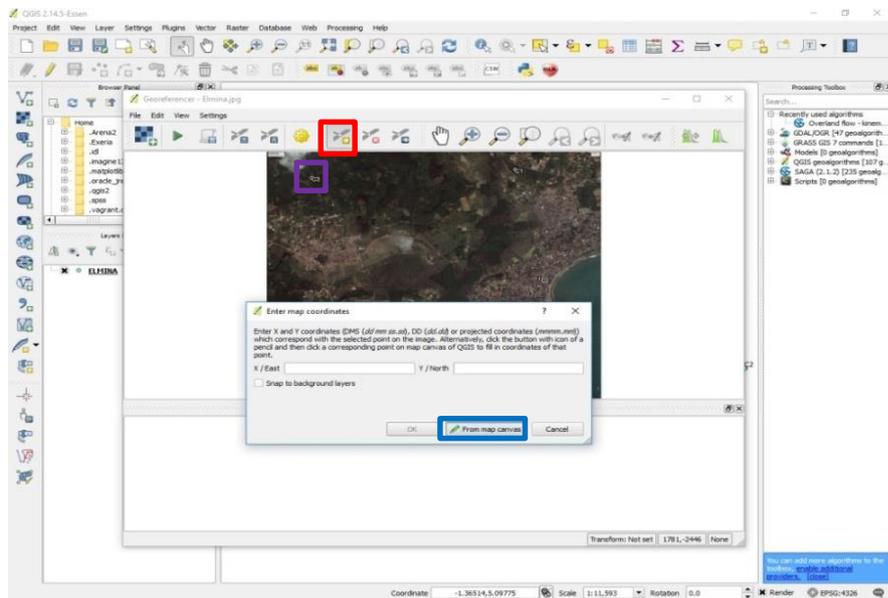
Figure A.11: Adding georeferencing points

⬜ Select **Add** button   ⬜ Click on the point on the image   ⬜ Select

From map Canvas

    i.   Select the corresponding point (c3) in the QGIS Data view
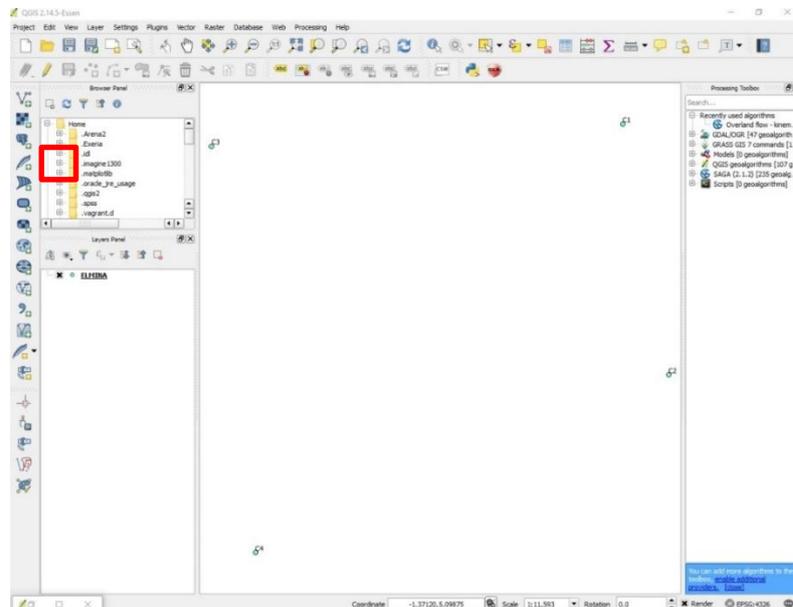
Figure A.12 Capturing the coordinates from the vector data

    j.   Ok it on the Enter map Coordinate window. Repeat h and j until all the points have coordinates

    k.   Select on settings once all control points on the image has been corresponded with its vector in the QGIS data view
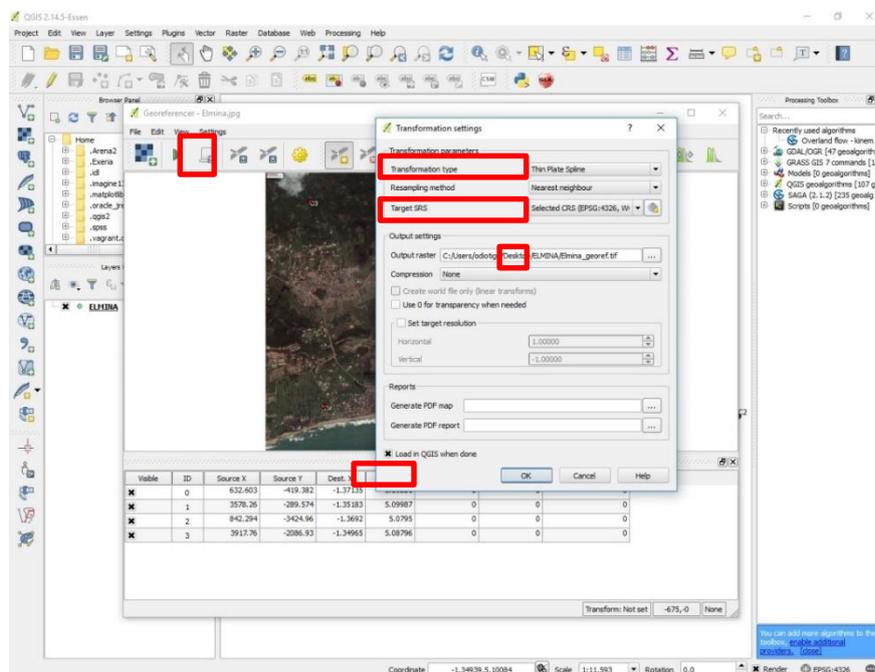
Figure A.13 Setting georeferencing parameters

    l.   Click on Play or Run for georeferencing to be effected. (Image is now georeferenced and it will over lay with the vector data
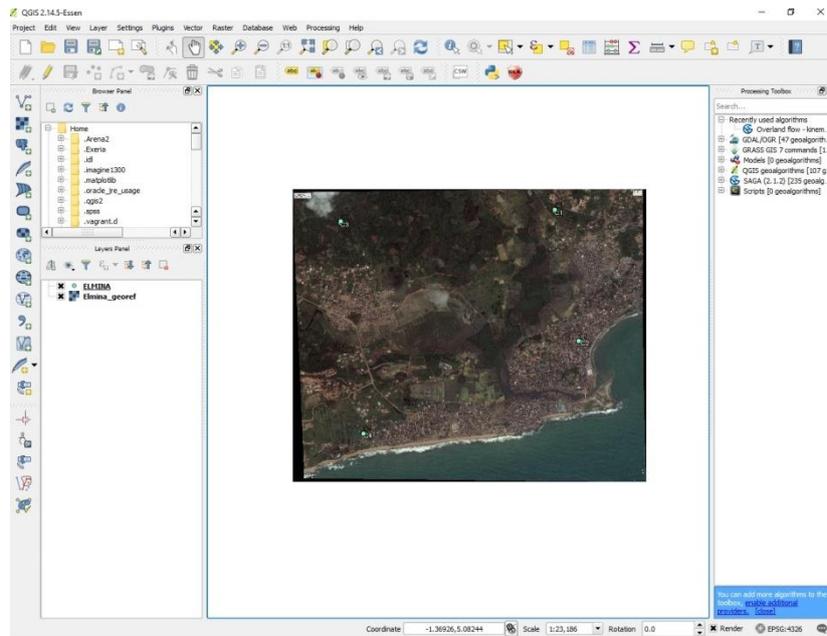
Figure A.14 Georeferenced image and vector data

m. Drag the vector data **Elmina** on top of **Elmina_georef** (Image is georeferenced and can now be worked with spatially)**.**

Exercise Two: Mapping conservation areas (using Qgis)

Identifying conservation areas are places.

Opening image and exploring

      a.   Open **QGIS**

      b.   Click on the add **Raster** and locate the **Elmina_georef**
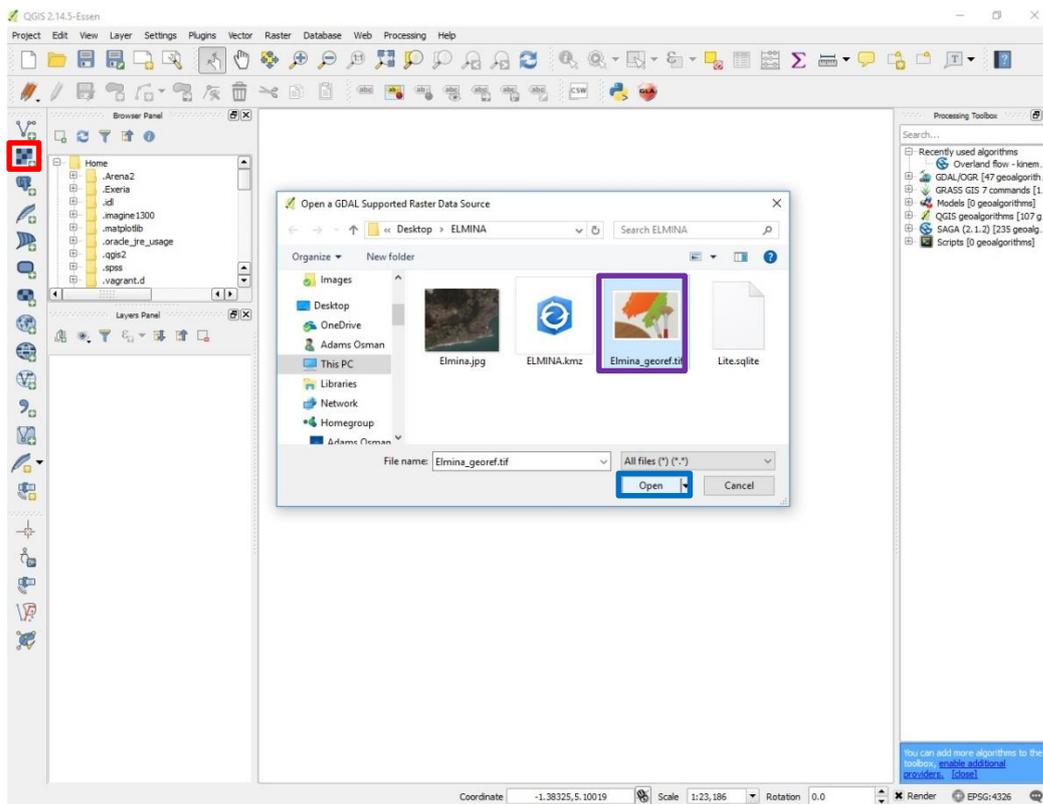
Figure B.1 Opening raster layer

▢ Click on add raster   ▢ select raster image   ▢ Click open to add

1. Creating layer

      a.   Select **Layer** on file menu

      b.   Select Create Layer and then New Shapefile Layer
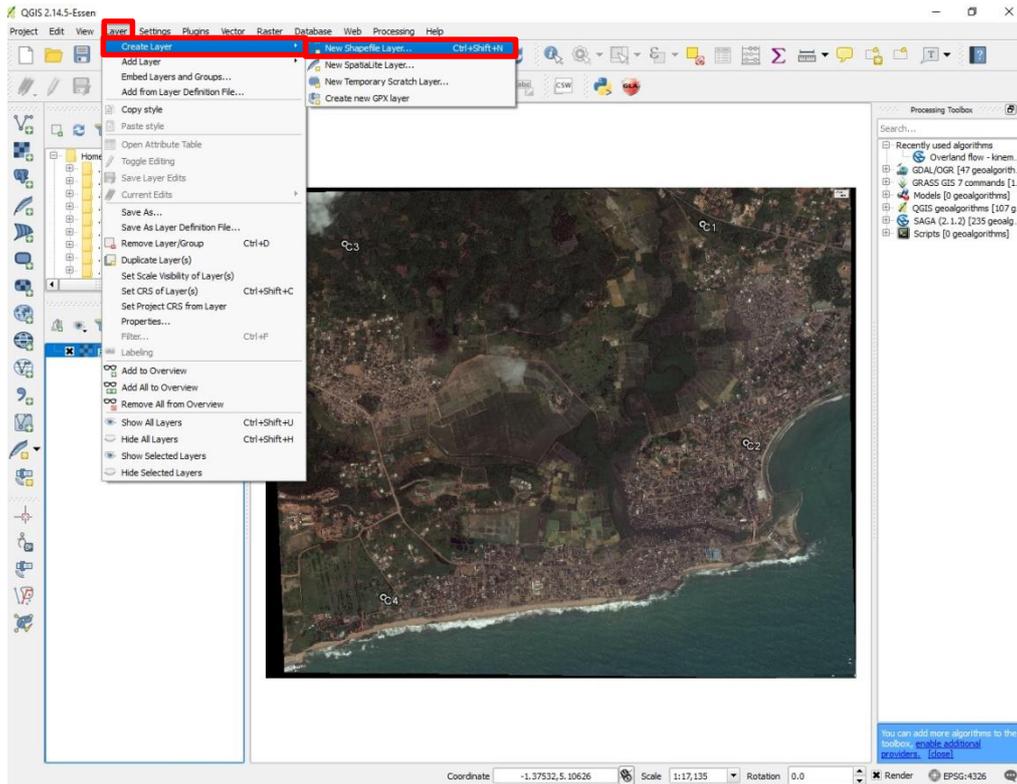
Figure B.2 Creating shapefile

   c. Select data type (Point, Polygon, Polyline/line)

(Point is for modeling discrete units such as wells,

(Polyline is for linear features like roads, footpaths, rivers)

(Polygon is for features with area like forest, water bodies, buildings etc.)

   d. **Add attribute column of the data.** (This section involves adding attributes
     one will be interested in populating about the feature. Area is generically
     going to be generated but other entities has to be specific by the technician)
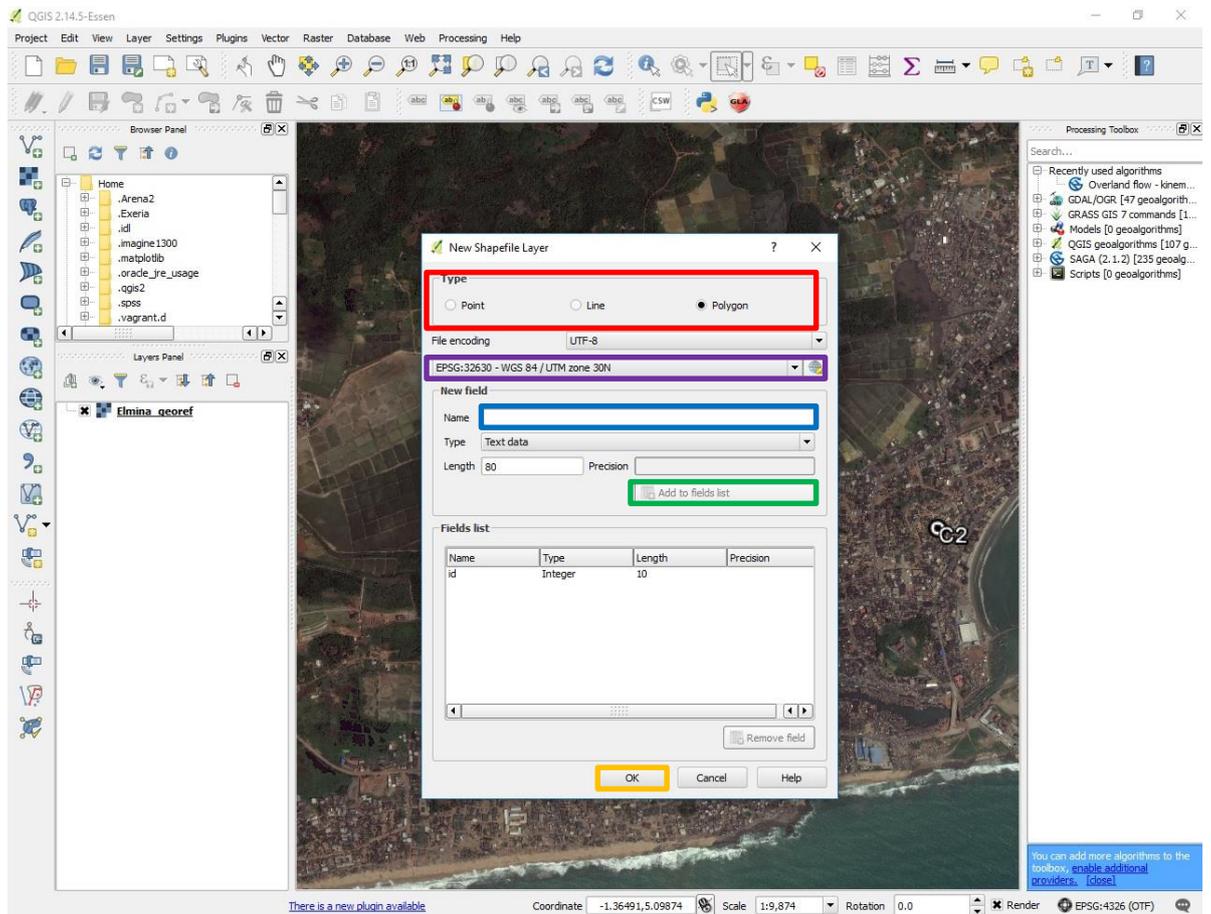
Figure B.3 Creating data and adding attribute columns

▭ Select type of data ▭ Change coordinate to UMT 30N ▭ Attributecolumn
▭ Add to list ▭ Ok to save as **Mangrove**

     e.   Save the layer in your folder (Elmina)

Repeat the whole of step 2 and create layers for **Saltpans** and **Benya Lagoon**

2. Digitizing and buffering conservation zones

     a. Note the **Mangroves layers** should be display in the **Layers Panel**

     b. Make sure you have zoom in well to the mangroves (Use the **Magnify Tool** to enlarge the mangrove areas by creating a box around it)
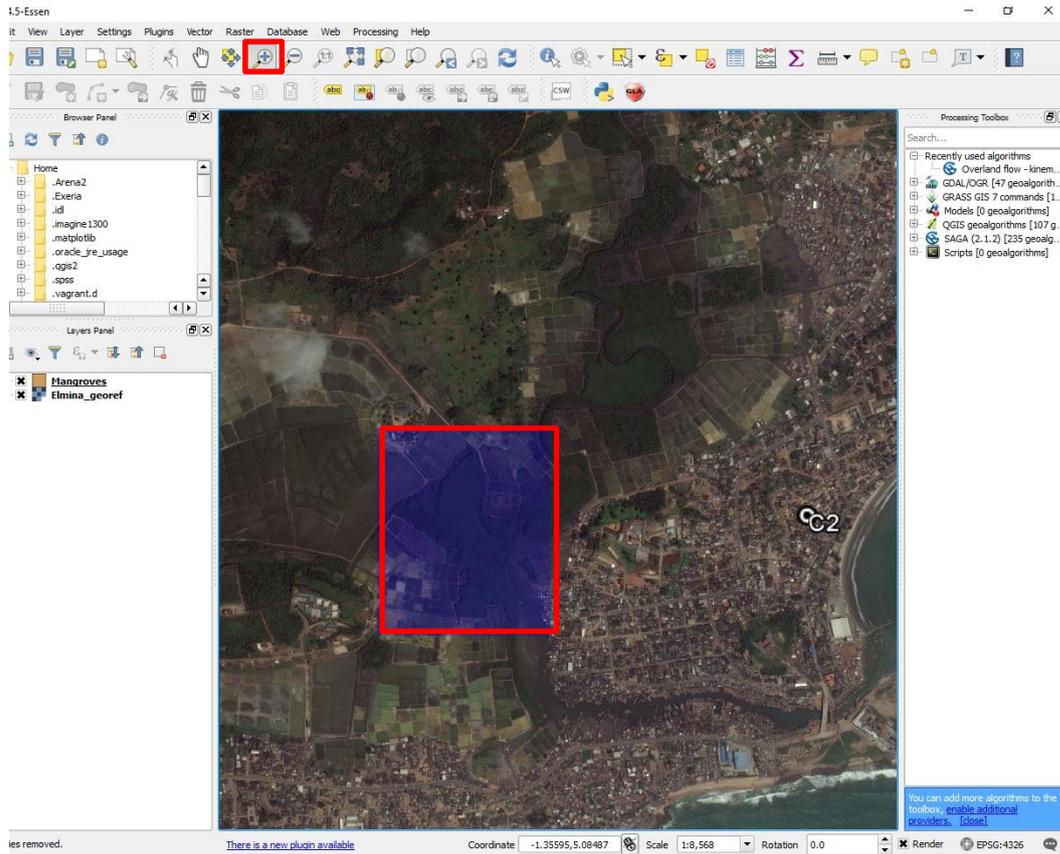
Figure B.4 Enlarging mangrove areas

Use these tools to zoom in, Zoom out and Pan

   c. Right click on the layer **Mangroves** and select **Toggle Editing**

d. Select **Digitize polygon** to begin digitizing
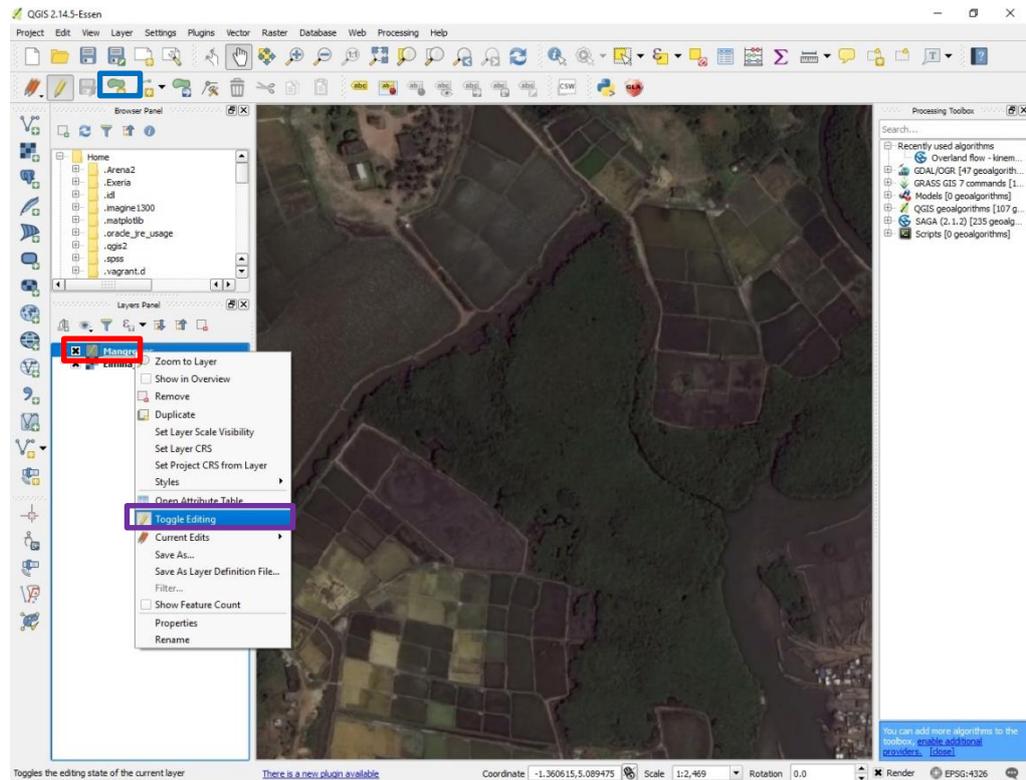
Figure B.5 Starting digitizing

☐ Right click on layer (Mangroves) ☐ Select Toggle Editing ☐ Select **Add feature**

e. Digitize by clicking (adding points along the edges of the feature/mangrove)

Note: Use the delete key on the keyboard to remove a wrong vertex.

Use the curser on the keyboard to navigate when digitizing
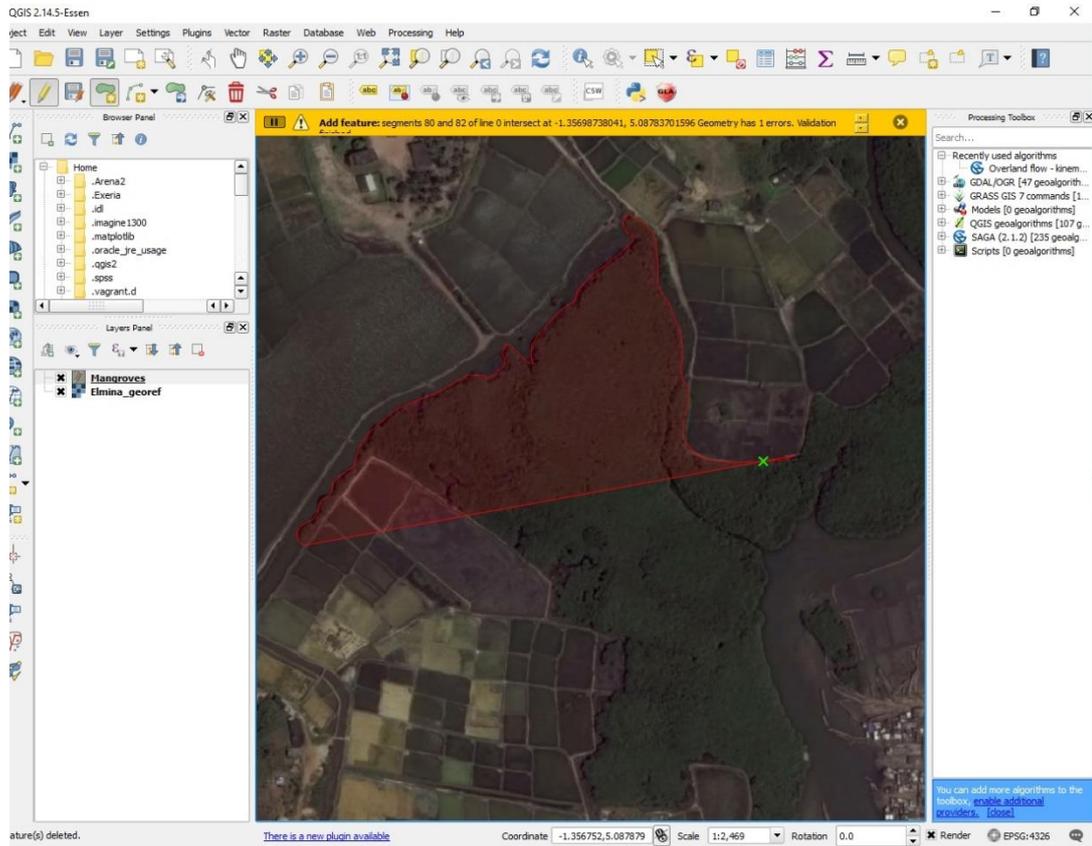
Figure B.6 Digitize the feature

Note: Use the cursor on your keyboard to navigate when digitizing.

 f. Right click when the Mangrove patch has been transverse and give an Id to the feature

Note: The quality of the feature mapped is dependent on the how well the image is zoomed and the number of vertices places along its boundaries
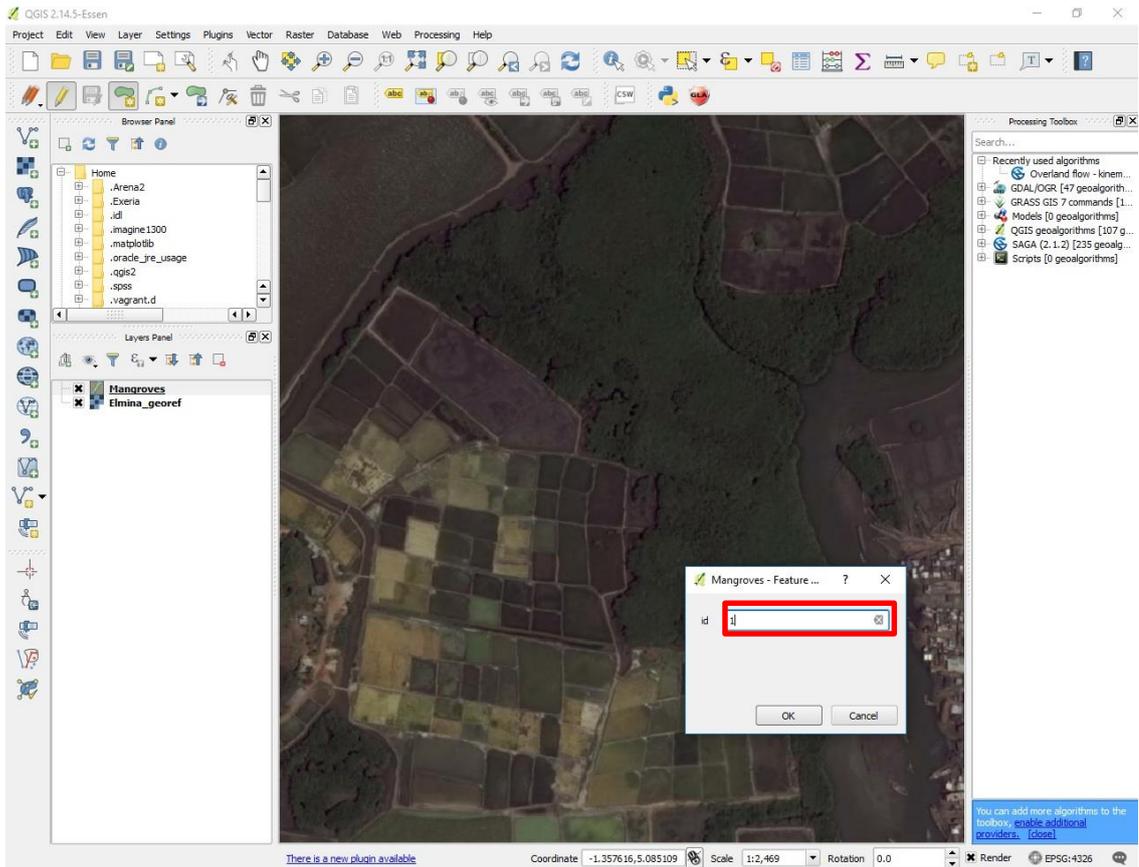
Figure B.7 Saving digitized feature

Identify the feature 1 and do same for other features
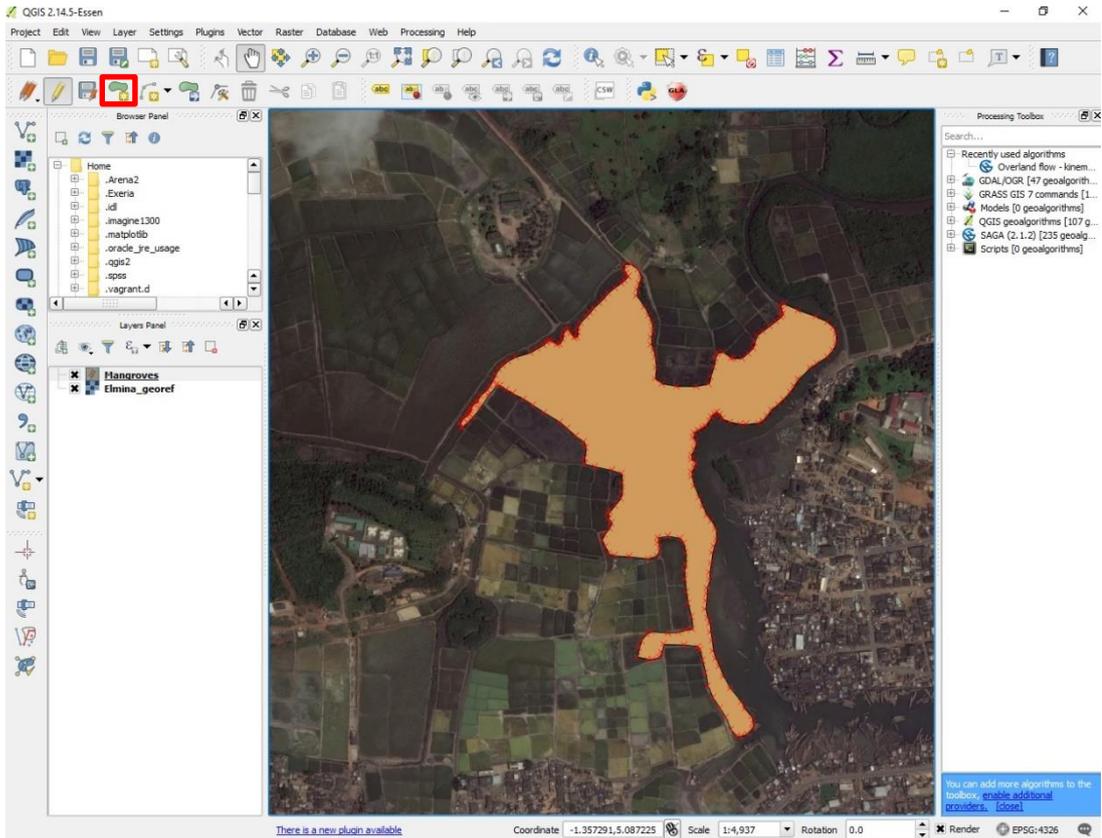
Figure B.8 Mapped mangrove patch

g. Click on Add features to digitize other mangrove patches

h. Click on save to make sure all features digitized are saved in layer

40
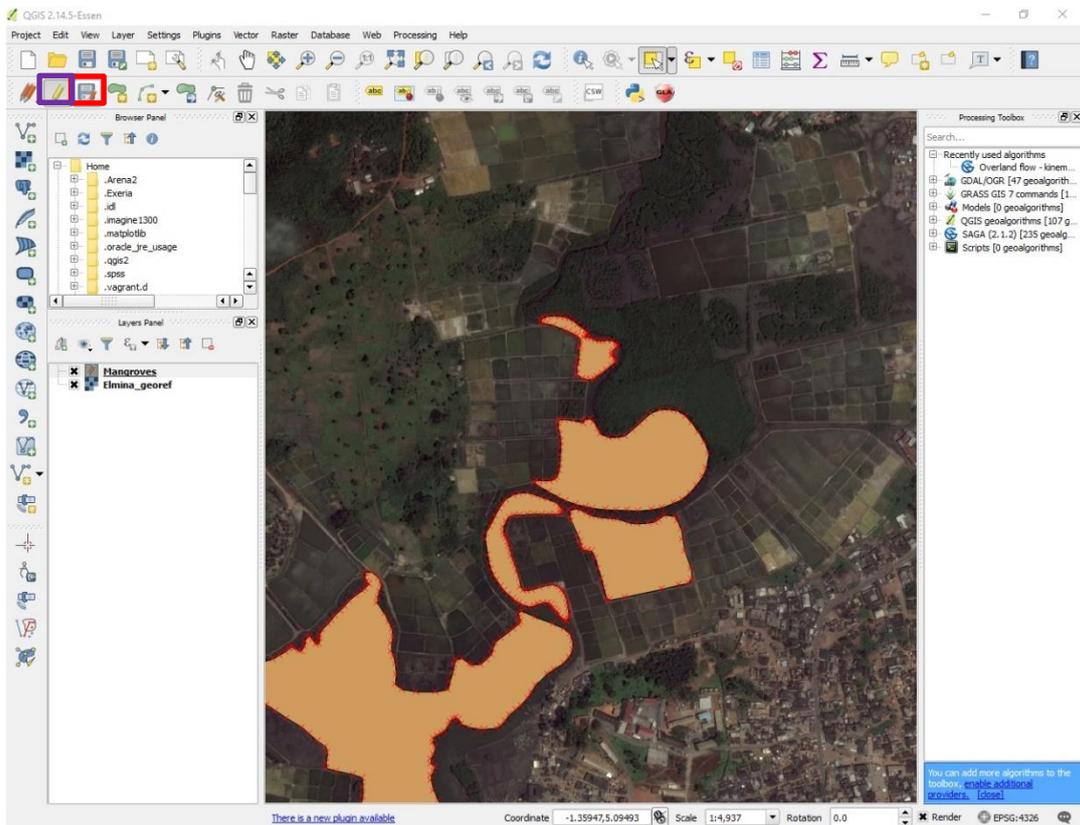
Figure B.9 Saving digitized features and stopping Toggle

☐ Save edits   ☐ Stop Toggle Editing when done

    i.   Delete feature by selecting it clicking the delete button or key (Only
necessary if a feature is captured wrongly)
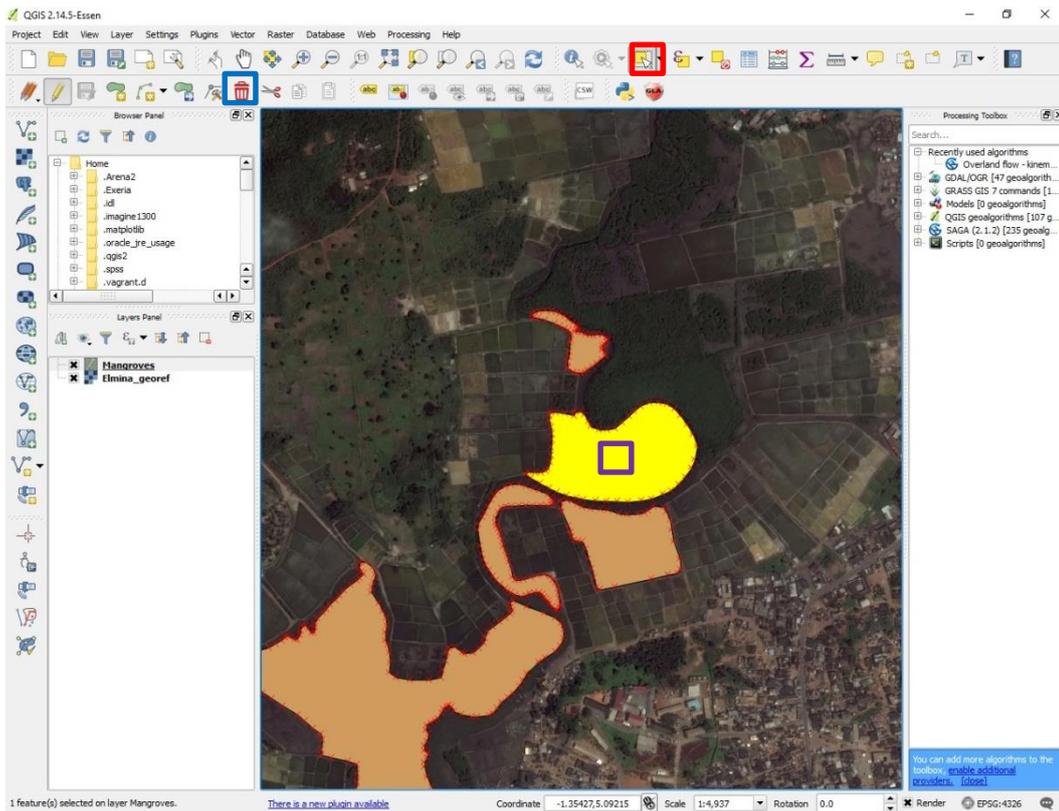
Figure B.10 Deleting or cleaning digitized data

☐(red) Click on select   ☐(purple) Click on the feature to delete   ☐(blue) Select delete or use the key button on the keyboard

Step 2 and 3 can be used to digitize any feature of interest such as buildings, water bodies, saltpans, roads etc.

Map all other features of interest using Steps 2 and 3. Digitize features like buildings, water bodies, saltpans, roads etc.

Exercise Three: Buffering

1. Map the shape of the feature (River, road, wetland, building etc.) interested in buffering (Using steps in Exercise Two) or Load an already mapped shapefile of a feature
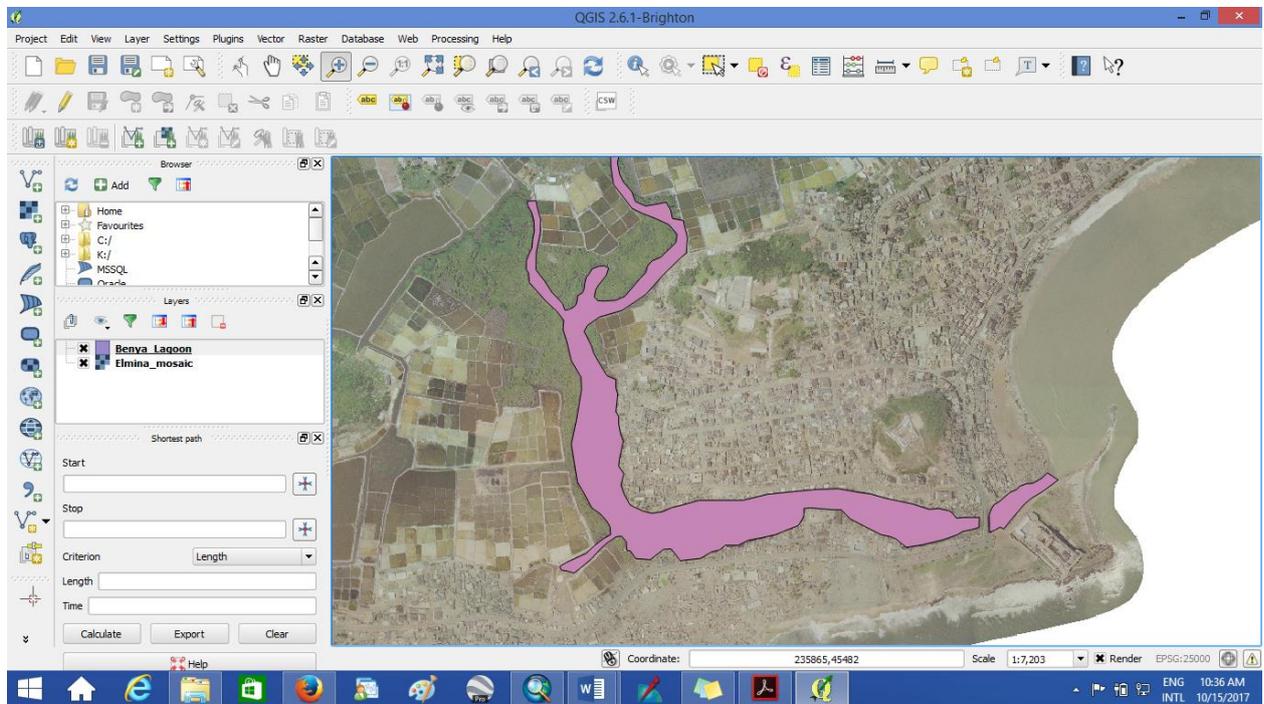
Figure C.1 Loaded or mapped feature

2. Select the function "Buffer" from the "Vector" tools under "Geoprocessing"
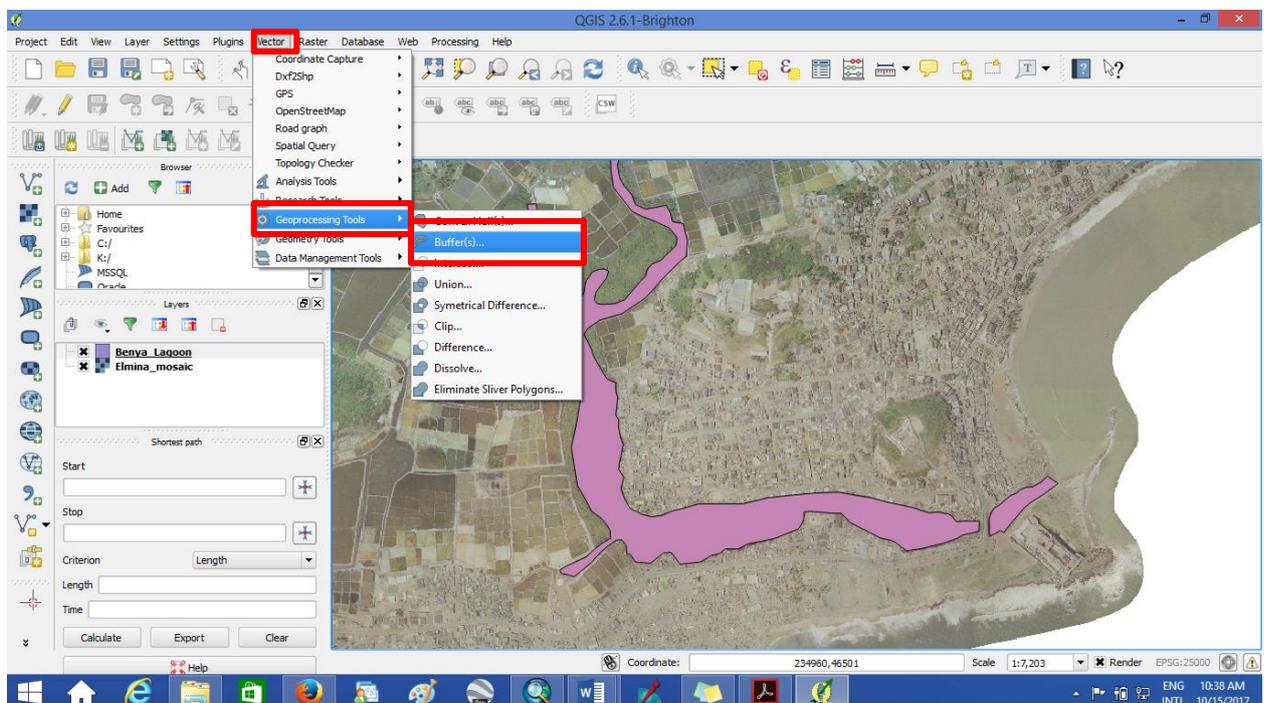
Figure C.2 Selecting the buffering tool

3. Fill in the necessary parameters and Ok. Input as the feature shapefile, Buffer distance as the area to cover or restrict development, Output as the new shapefile to be created: name and location

Note: Please input half of the figure needed, E.g.: If needed buffer is 300 then 150 will have

to be inputted
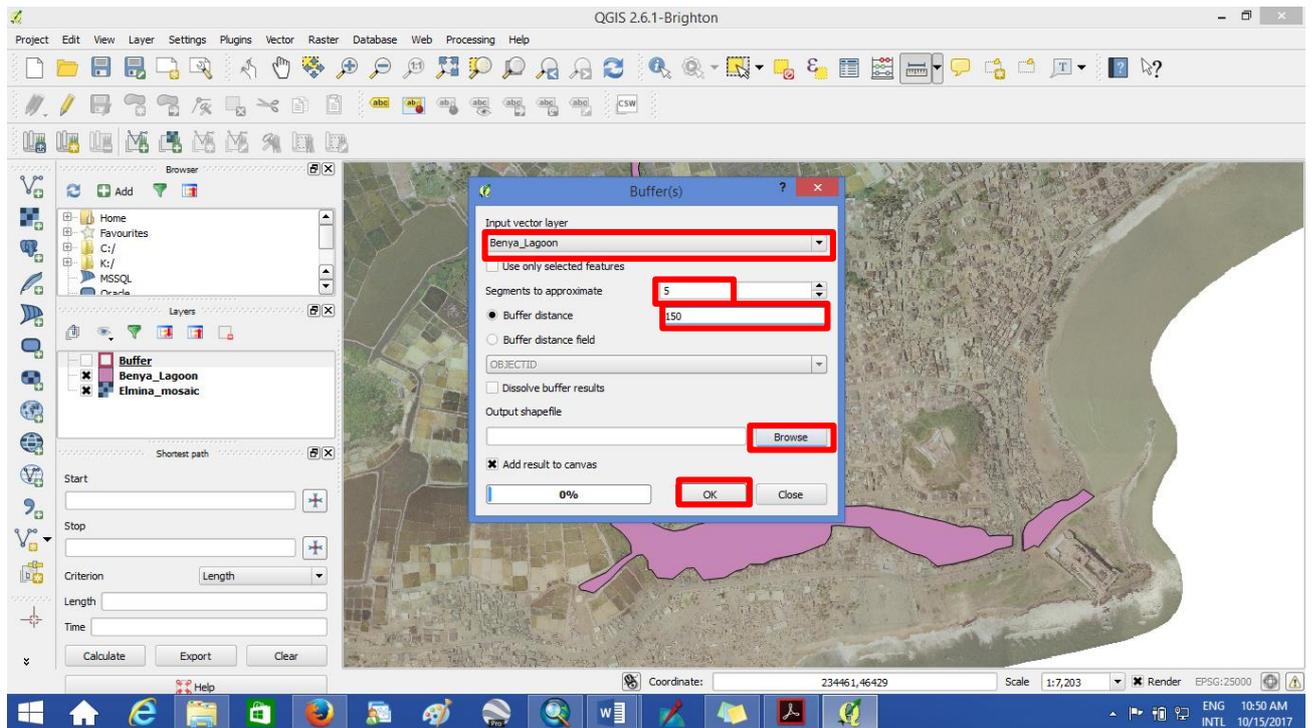
Figure C.3 Filling parameters for buffering

4. Change the style of the feature to see areas within the buffer (Double click on the new buffer

layer, select simple fill, and click on fill to change the color to transparent and Ok)
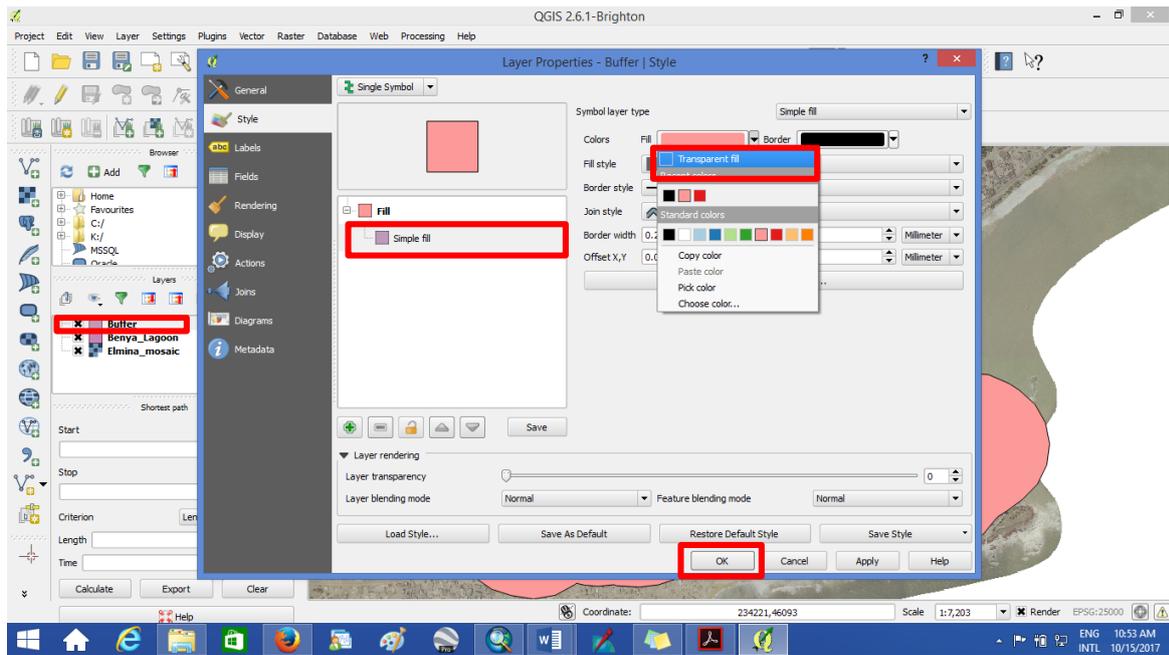
Figure C.4 Change the style of the buffer area

Exercise Four: Mapping low elevation areas

1. Download Aster Digital Elevation Model for your district

    a) Visit www.earthexplorer.usgs.com
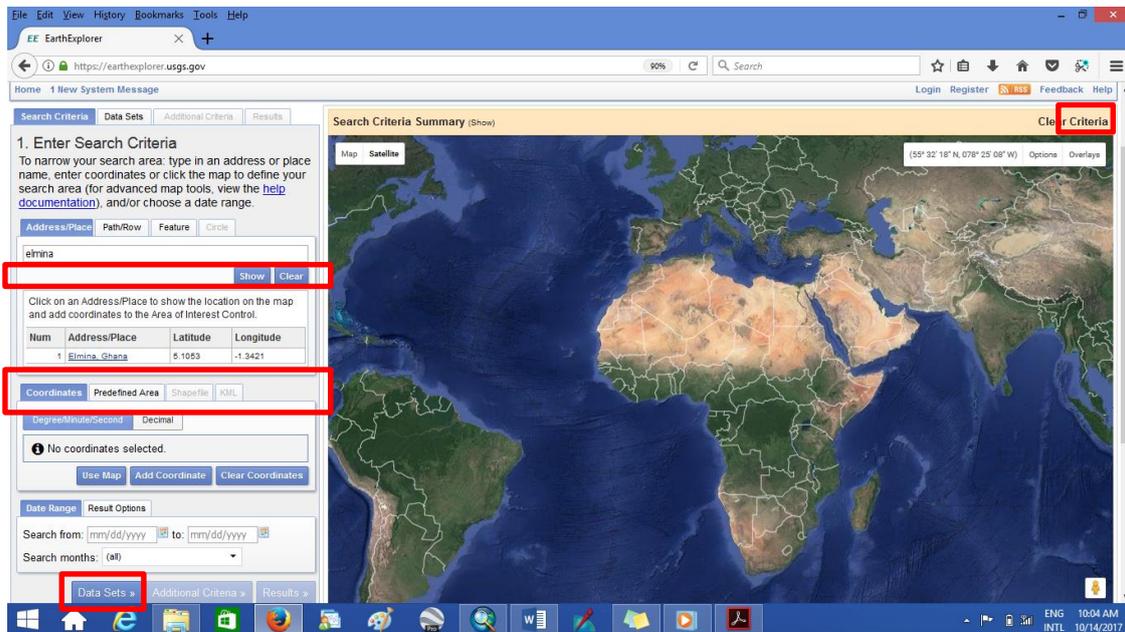
Figure D.1 Searching for location of interest

2. Create an account by clicking on register in the page

3. Enter the location of the area you are interested (Elmina)
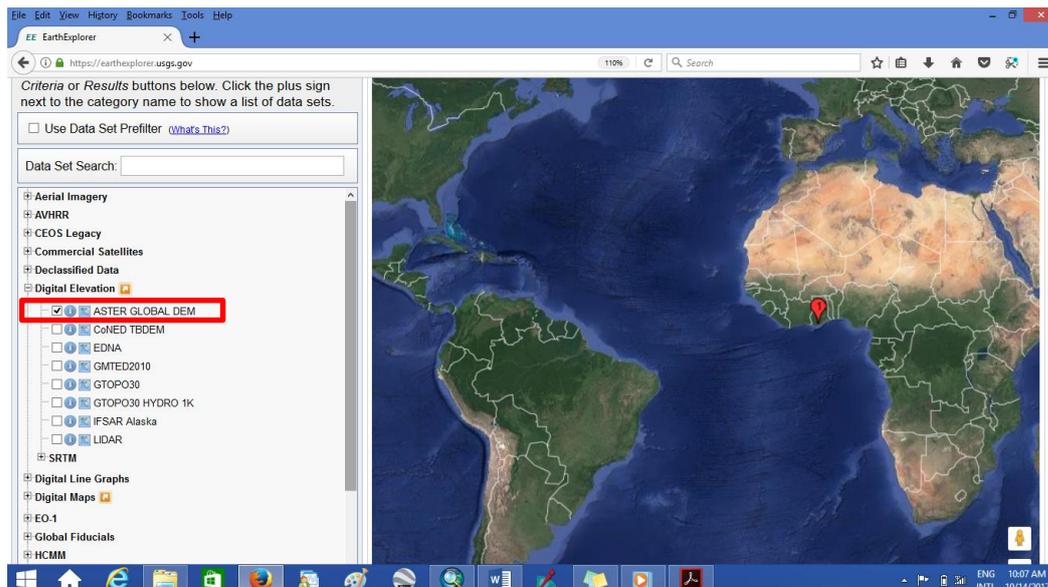
Figure D.2 Selecting AsterDem

4. Select Digital Elevation and choose ASTER GLOBAL DEM

5. Select "Results" to show images at the area of interest (Elmina)
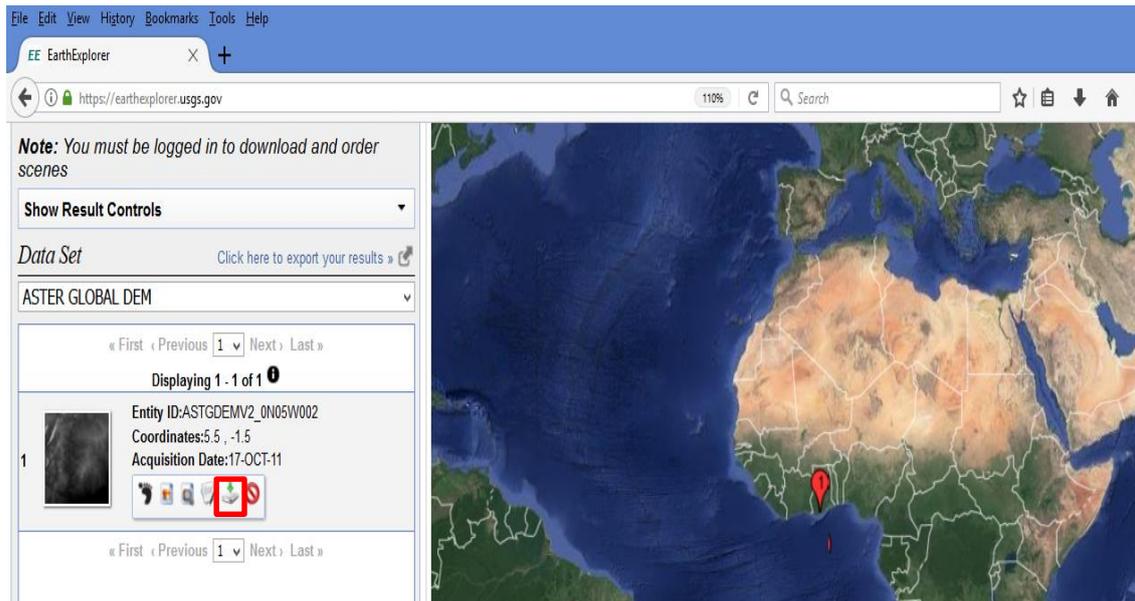
Figure D3 Download image

6. Download image to working folder (Elmina) and extract with WinRAR
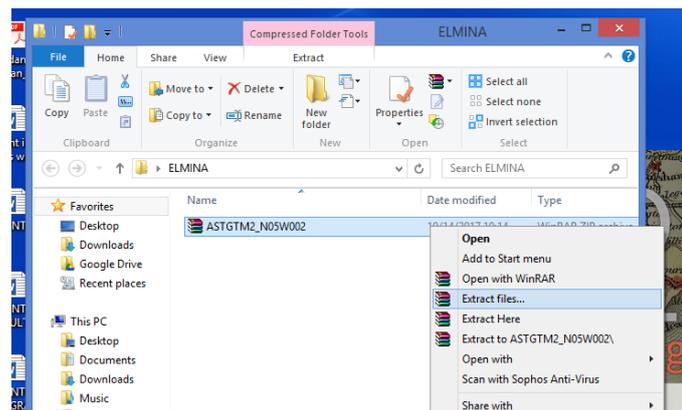
Figure D.4 Select location to store the downloaded image

7. Open the folder in QGIS to view the image downloaded

8. Open the folder in QGIS to view the image downloaded
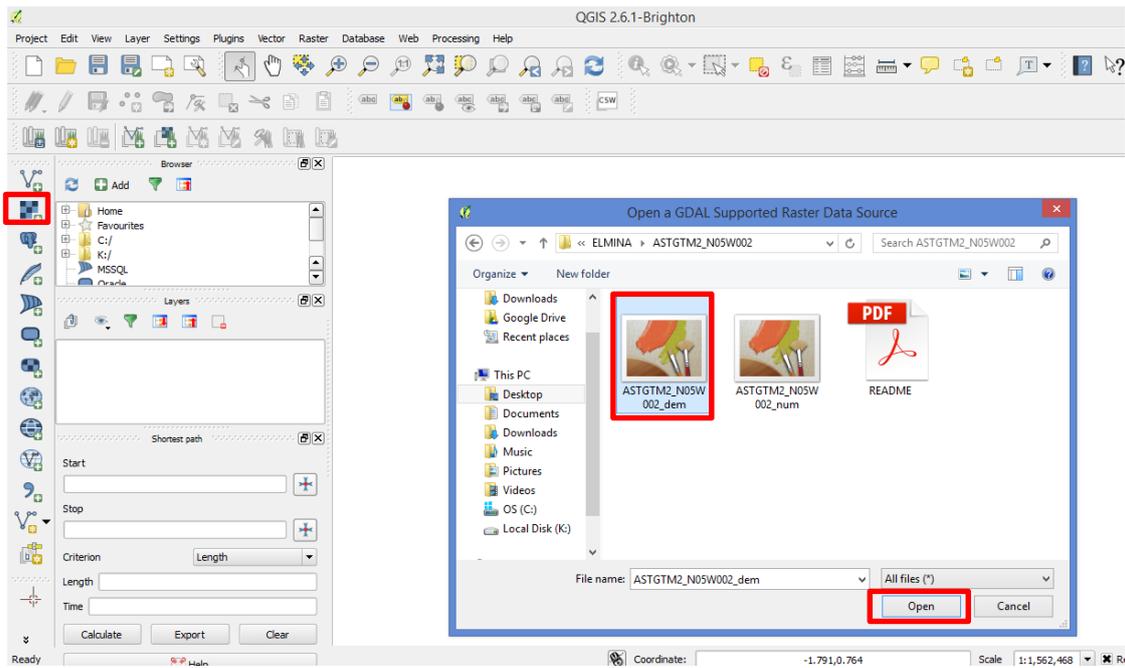
Figure D.5 Loading downloaded image

9. Add the layer of the district to clip/subset the image (This is to help get only elevation data covering the district of interest)
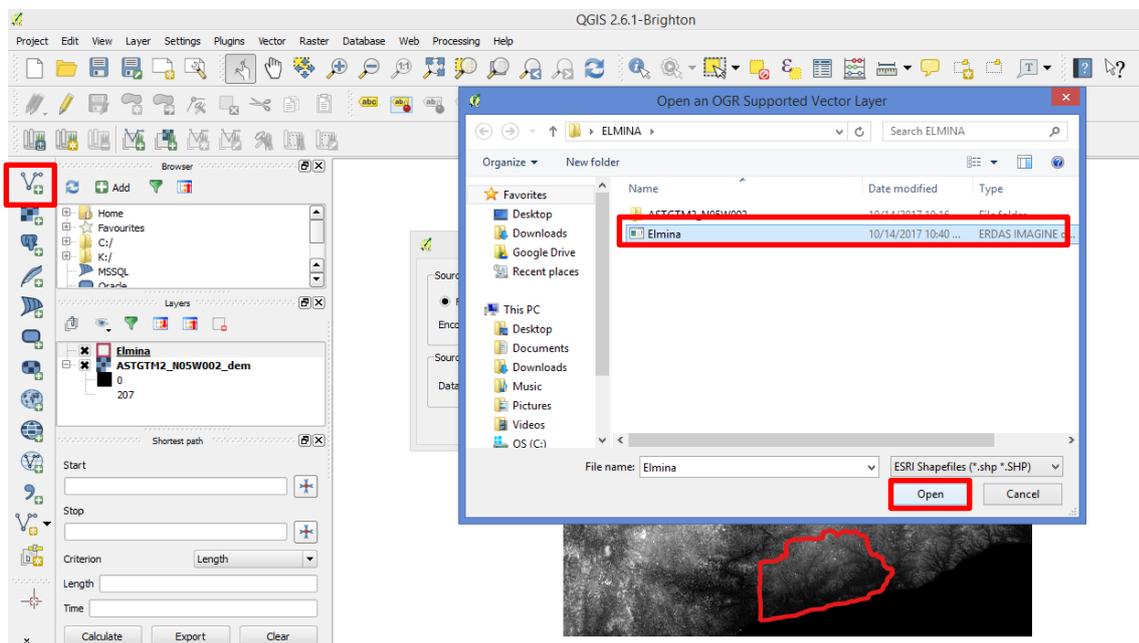
Figure D.6 Adding district layer

10. Clip the Aster Dem with the district shapefile layer
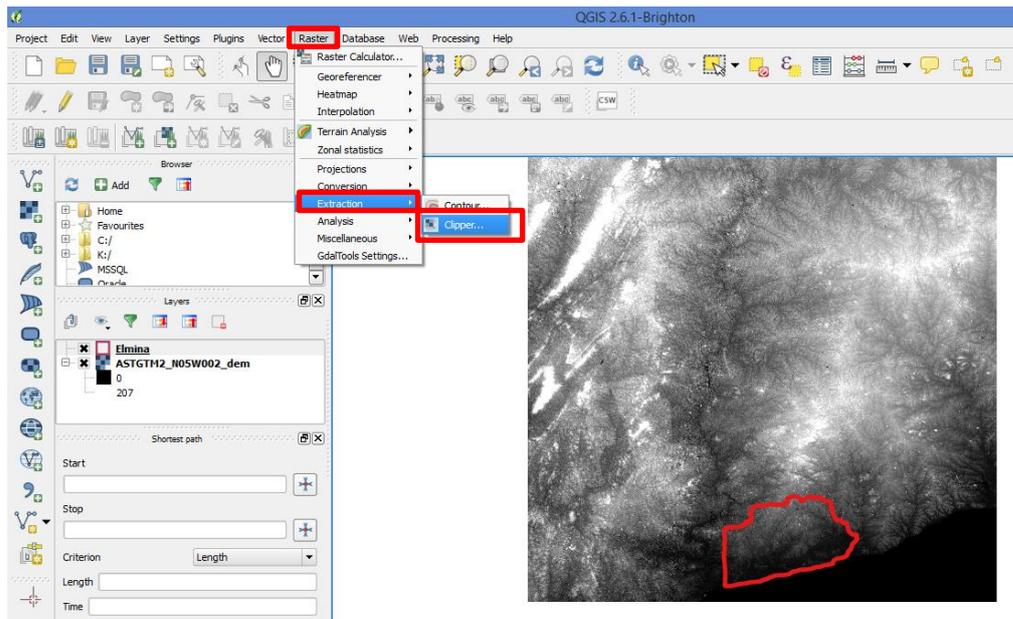
Figure D.7 Clipping Dem of district 1

11. Select "Raster", select "Extraction" and then "Clipper", fill in the following parameters and "Ok"
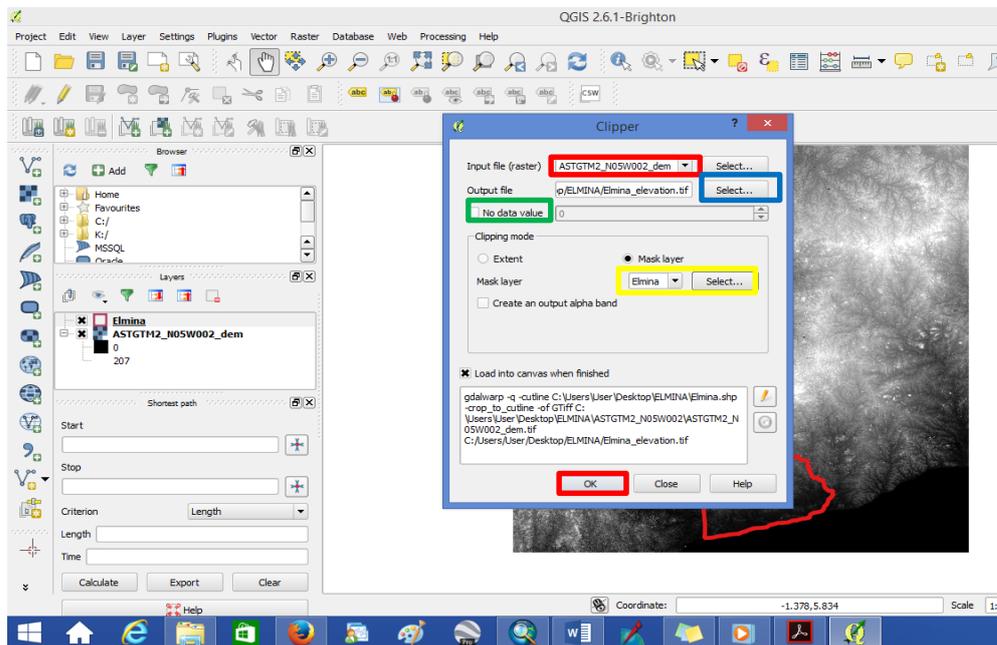
Figure D.8 Clipping Dem of district

Aster Layer   Select output folder (Elmina)   Check   no   data

value

Mask layer (Make sure the layer is the district of interest)
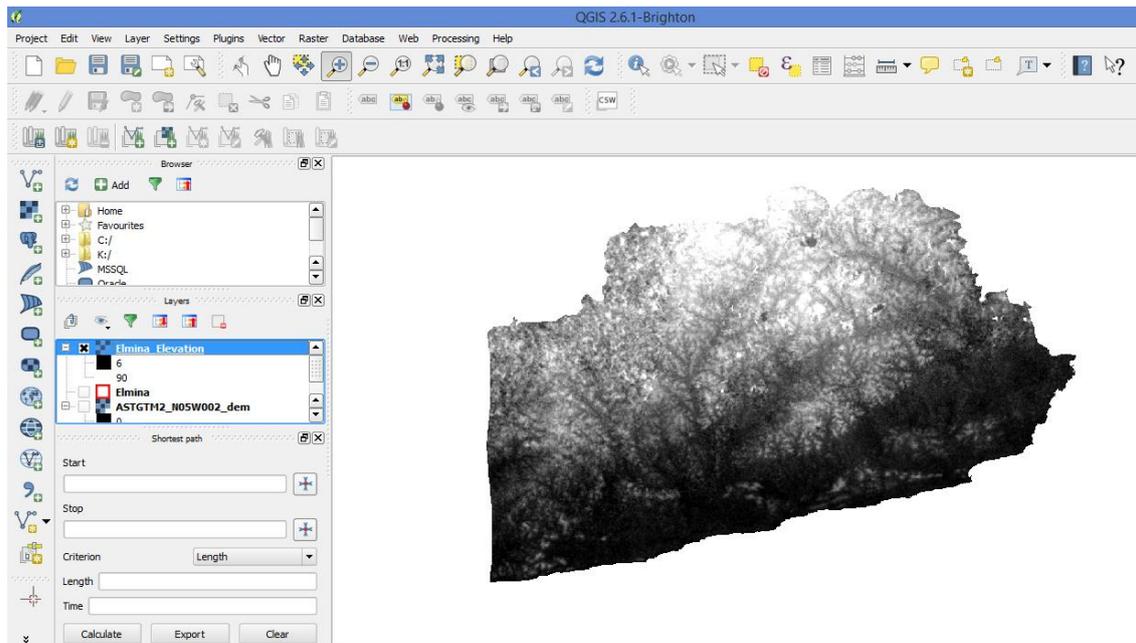
Figure D.9: Digital Elevation Model of Komenda Edina Eguafo Abrem

12. Change the color of the elevation to identify low areas
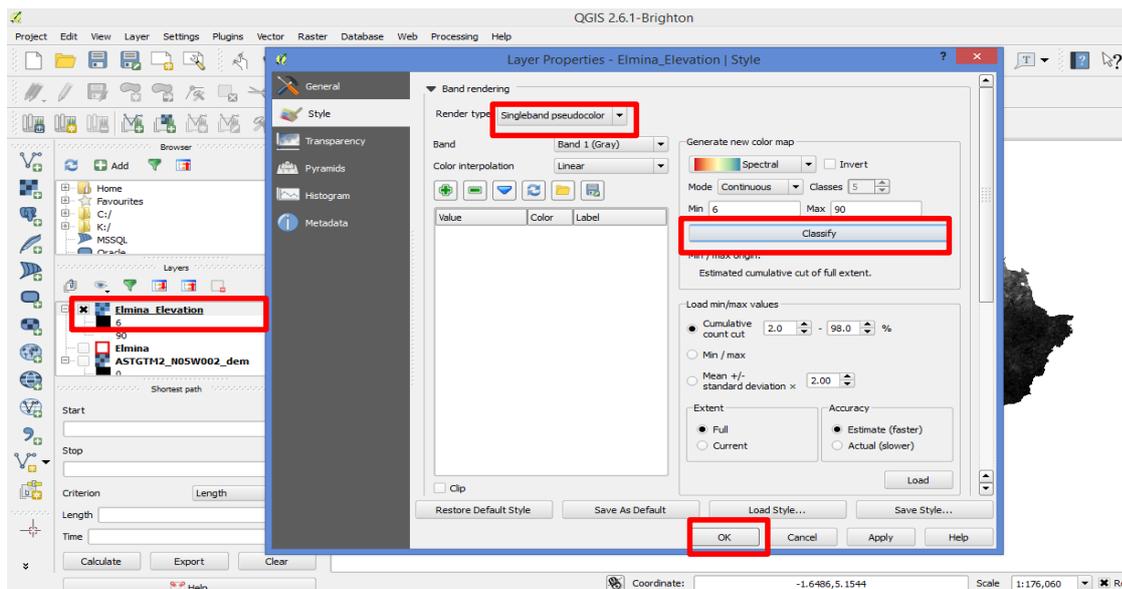
Figure D.10 Changing color of elevation 1

13. Double click on the Clipped Image (Elmina Elevation), Change the "Rander Type" to Singleband Pseudocolor , Select "Classify" and Ok
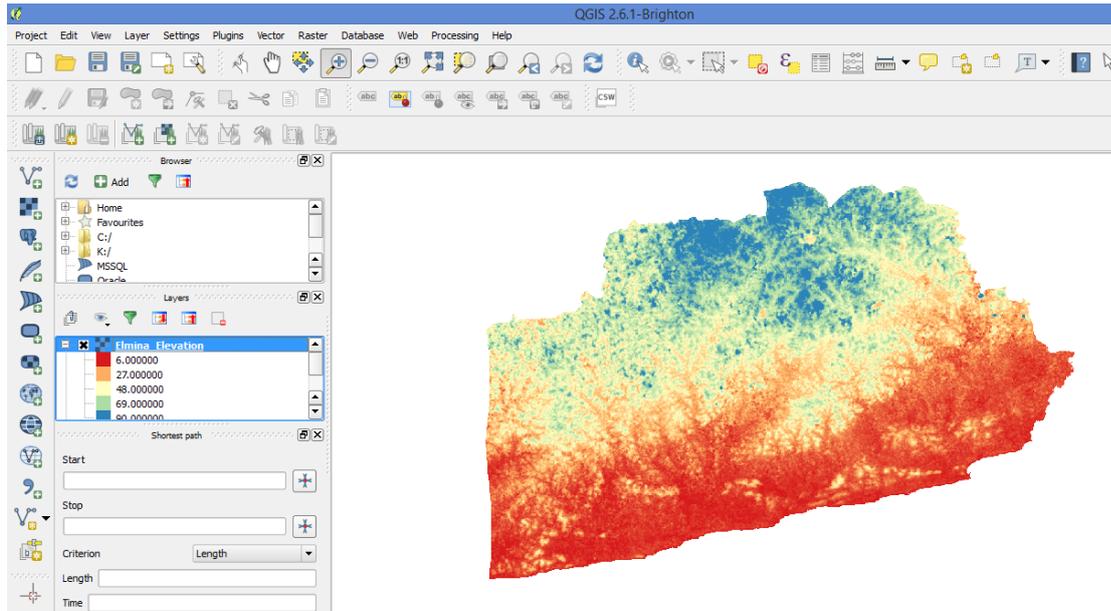
Figure D.11 Elevation map of KEEA Districts

Exercise Five*:* Modeling shoreline erosion using GIS

Shorelines for 1974 and 1994 can be generated from toposheets either soft or hardcopy by securing it from Ghana Survey Department. If a hardcopy is secure then the toposheet has to scan under about 300dpi and georeferenced. Google Earth can be used to digitize shorelines for each district.

1. Open Google Earth

2. Search for your area of interest using the Search

3. Select the timer to know the various years of images for the area (Use the slider to
   change for various years)
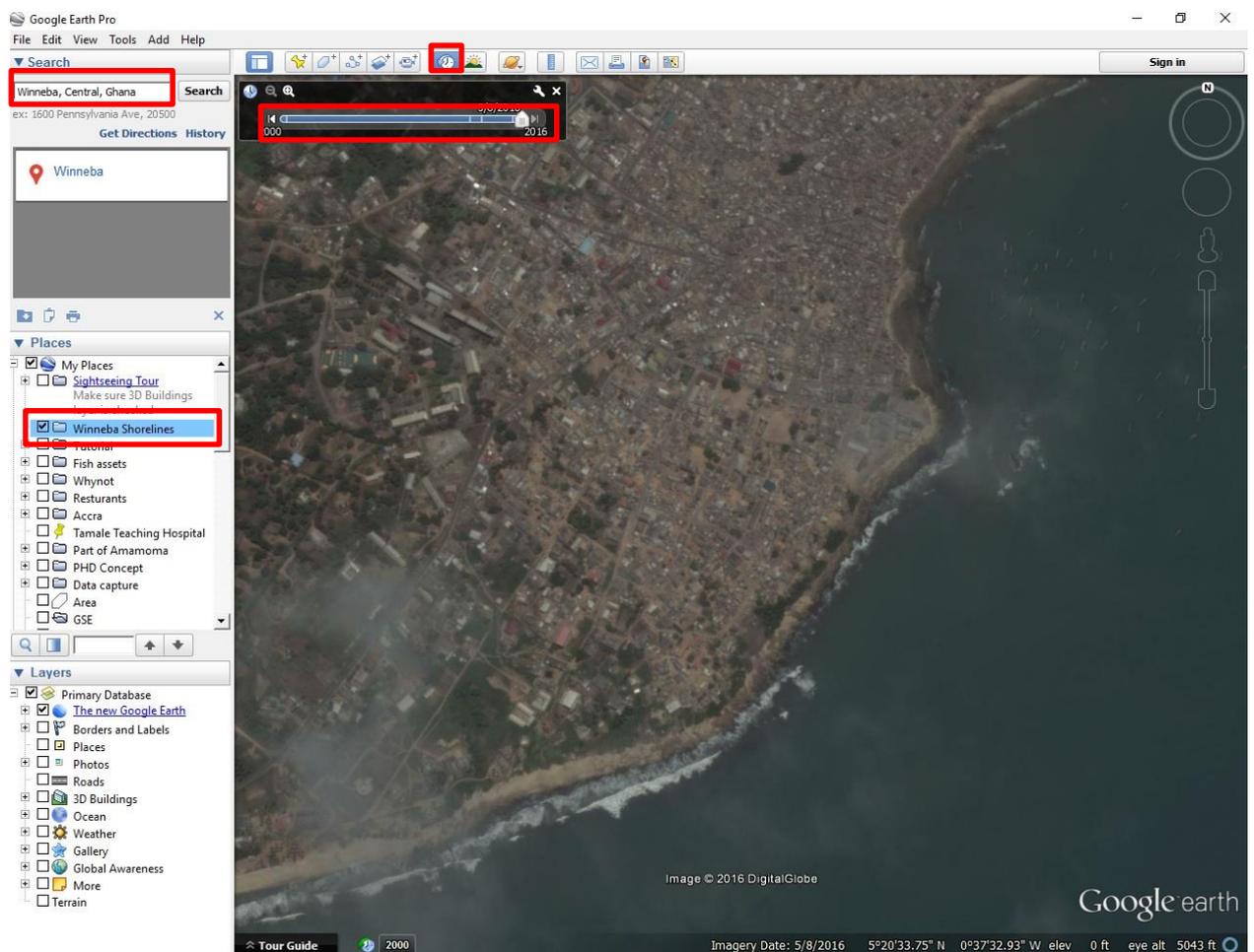
Figure E.1 Searching for area of interest and images for shoreline digitizing

4. Create a folder (Winneba Shorelines) to contain the various shorelines to capture

5. Use the Navigation tools to explore the beach and how the shore is configured

6. Right click on the folder Winneba Shorelines and select Add, Path (Modeling features
   as line) and name the feature per the year of the image being viewed (Shoreline_2016)
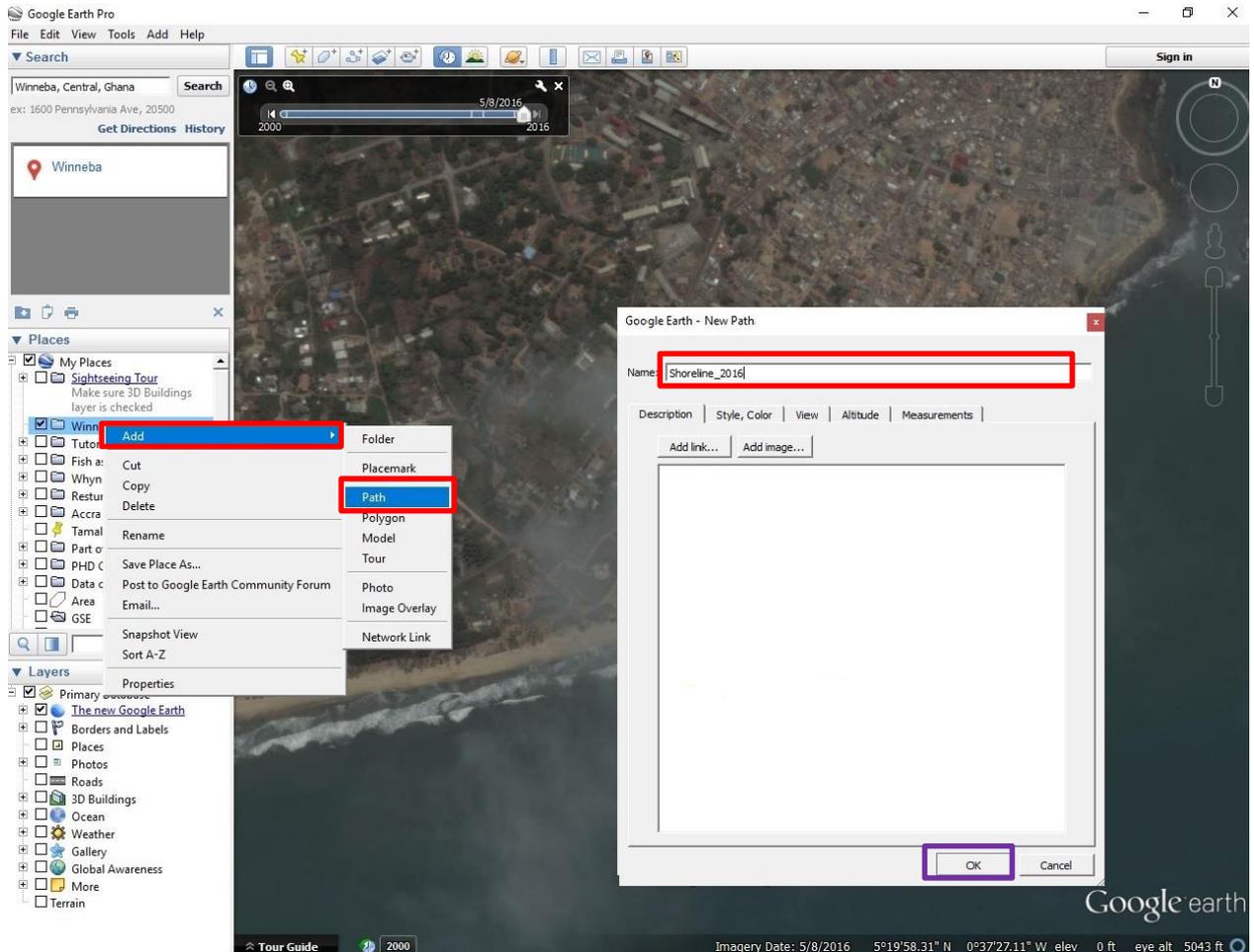
Figure E.2 Creating shoreline layer

☐ Please on Ok after Step 9

7. Move the Edit Path window to get a better view of the shoreline and also depend on the Navigation Tools to zoom to the shore

8. Digitize or trace the shoreline (the land which just boarders the sea) clicking on it.
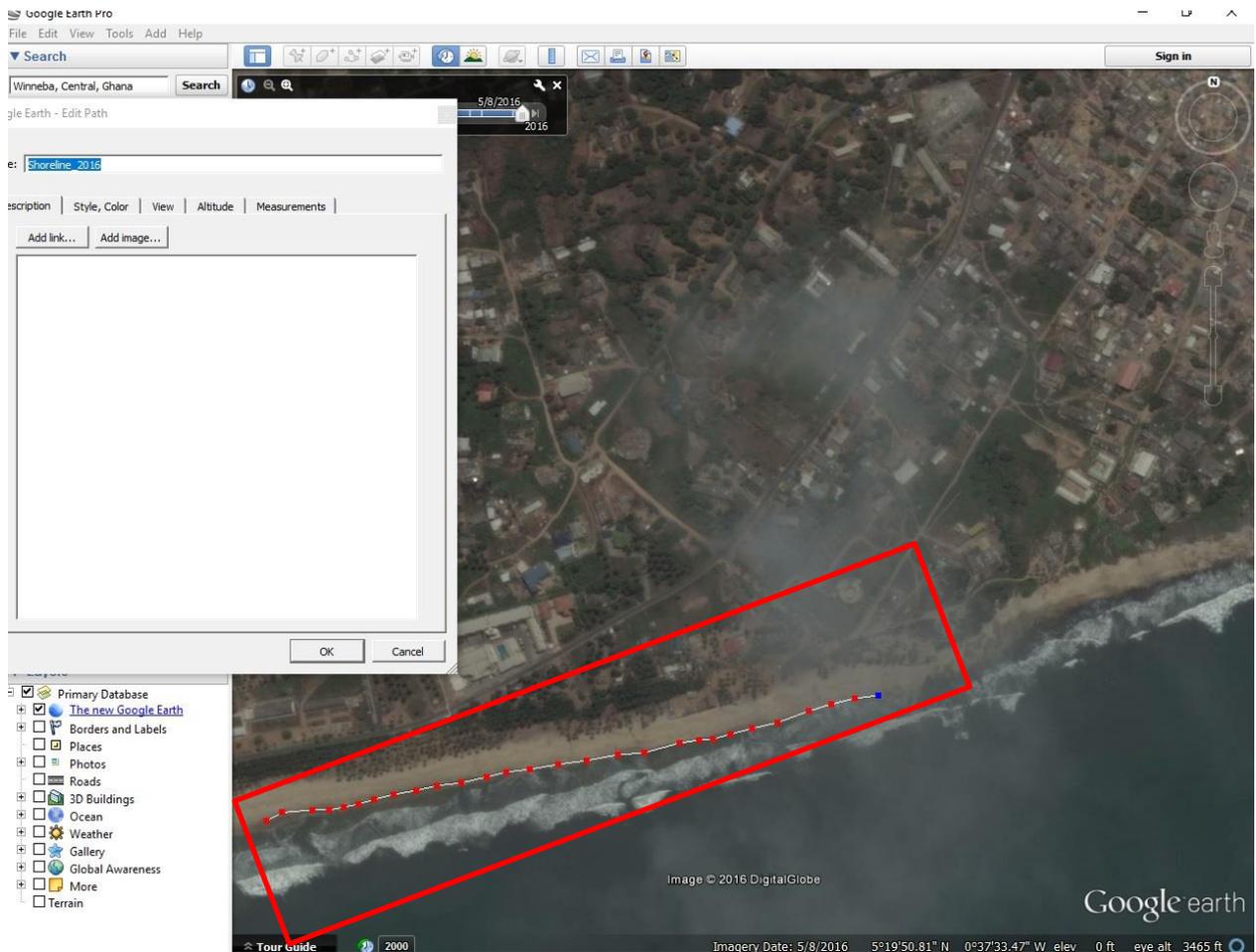
Figure E.3 Digitizing the shoreline

9. Continue until the entire shoreline for the district is covered and click ok on the Edit Window.

10. Use the Timer to change the image date to a different year (2013) (Fig. E.4)
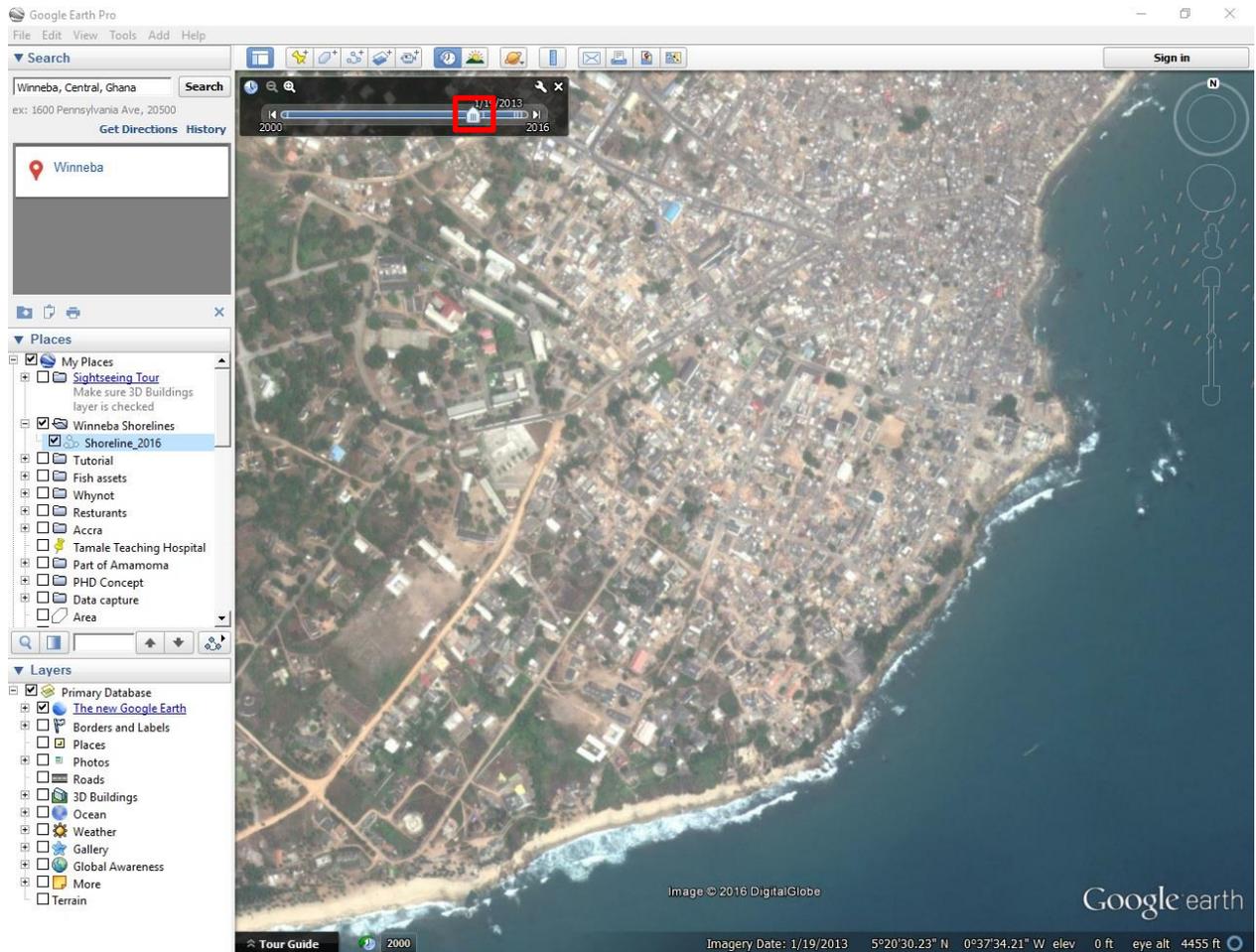
Figure E.4 Changing the year of the image

11. Create a new shoreline (Shoreline_2013) using Step 7, 8 and 9.

12. Change the Timer again to an older image (2000).

13. Create a new shoreline (Shoreline_2000) using Steps 7, 8 and 9.

14. Save the shorelines by right clicking on Winneba Shorelines

APPENDIX 2 LAUNCH OF THE TOOLKIT

Aim of Meeting: as part of the Sustainable Fisheries Management Project, Spatial Solutions and Hen Mpoano were tasked to prepare an Integrated Coastal Management Toolkit (ICM Toolkit) to assist planners in the Central Region on how management of the coastal areas of region can be done jointly and comprehensively. The toolkit which started in February 2017 and completed in September 2017 was prepared in collaboration with planners in the region. October 31st 2017 was earmarked for the launch and handover of the ICM Toolkit to the region.

Proceedings of the Launch: the launch of the toolkit took place at the Central Regional office of the Land Use and Spatial Planning Authority. The activities for the day started at 9:30 AM and ended at 12 noon. It was attended by the Regional Director of Planning and all the Coastal Districts Planners, representatives from Spatial Solutions and Hen Mpoano. In all there were about 27 attendees who has been part of the process from the initial stages.

The meeting was started by Peter Owusu-Donkor of Spatial Solutions who highlighted on the importance of the document and the process of preparation which was done on collaboration and consultation basis. He mentioned that similar model document have been prepared for the Western Region which has not been utilized as expected. He pleaded with the planners to consider this as an important document that will assist in the management of the coast.

Stephen Kankam of Hen Mpoano did a presentation on the toolkit and elaborated more on the key points in the document emphasizing more on the importance of the sample areas that were selected for the study and how features in those areas are clear representation of what is prevailing in the coastal areas. He also used empirical evidence of what has happened in other parts of the world which informed some of the proposals made in the document. He again emphasized the importance of making good use of the document. The document was then launched after the presentation and ten (10) printed copies were handed over to the Regional Director Mr. Matey Korley. In addition, soft copies on compact disc were distributed to all present.

The Regional Director gave a closing remark in which he mentioned that the region is grateful for the document as well as all other SFMP effort to make land use planning in the region meaningful. He gave an assurance that the document will be put into good use for the overall benefit of the region. The meeting came to an end at 11:30 which was followed by light refreshment.
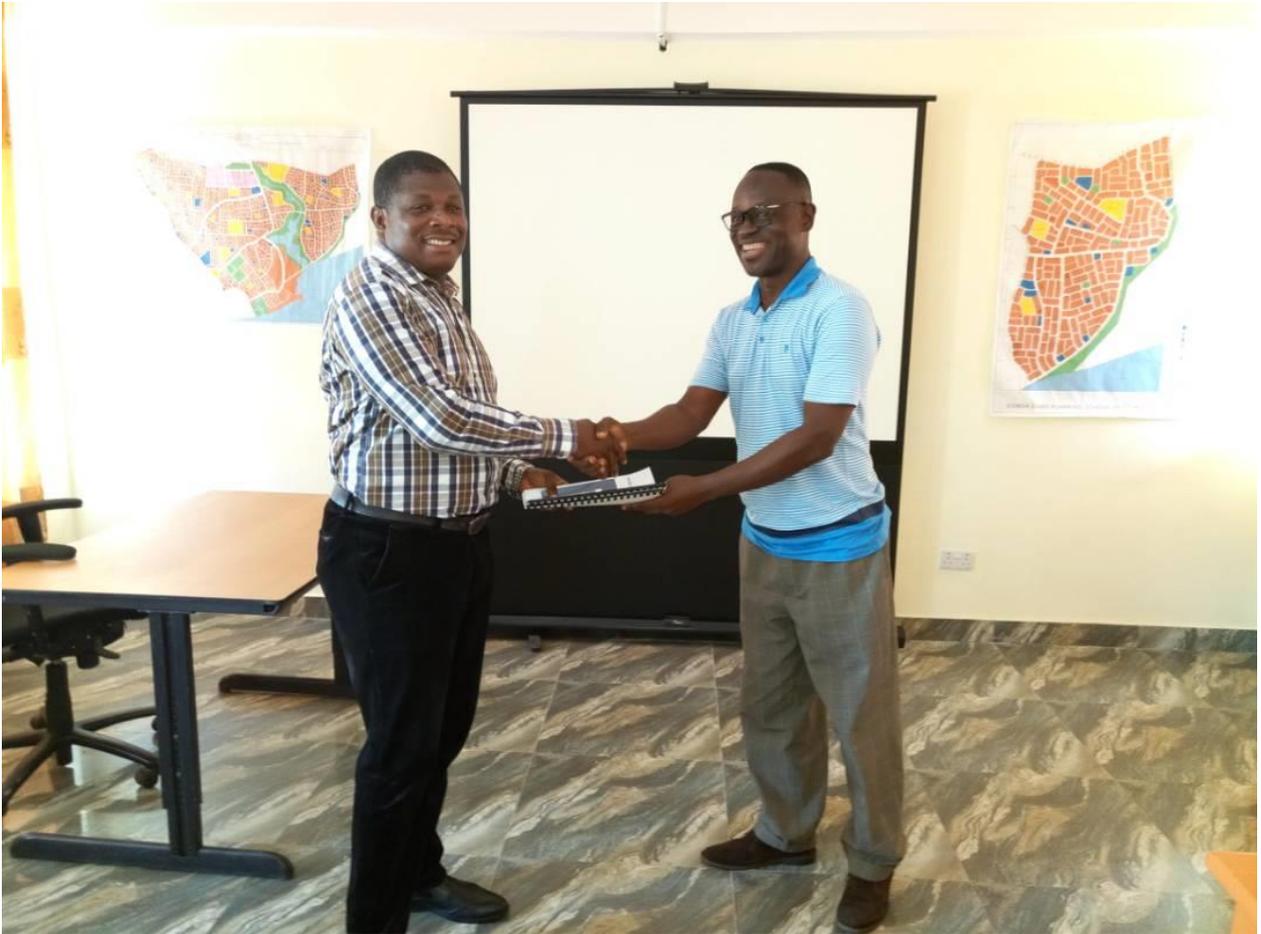
Figure 19 Presentation of Toolkit to Central Region Director of TCPD

Figure 20 Mr. Peter Owusu Donkor explaining the toolkit preparation process to planners

Figure 21 Stephen Kankam explaining content of toolkit to planners