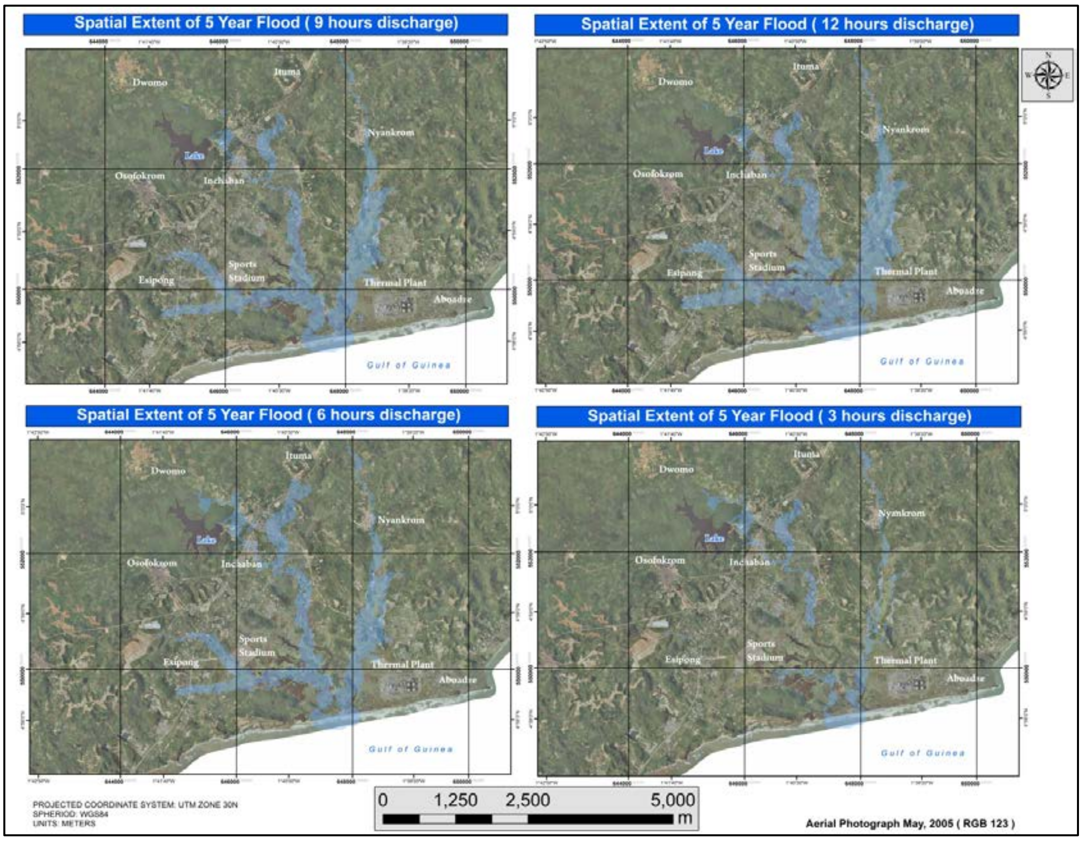
USAID
FROM THE AMERICAN PEOPLE

Report On Phase II Tasks I, II, III and IV, Integrated Coastal and Fisheries Governance Project/ Department of Geography and Regional Planning, University of Cape Coast Collaboration



Hɛn Mpoano

The University of Rhode Island Graduate School of Oceanography

Coastal Resources Center

Friends of the Nation

WorldFish

sustainametrix

This publication is available electronically on the Coastal Resources Center's website at http://www.crc.uri.edu

For additional information on partner activities:

WorldFish:	http://www.worldfishcenter.org
Friends of the Nation:	http://www.fonghana.org
Hen Mpoano:	http://www.henmpoano.org
Sustainametrix:	http://www.sustainametrix.com

For more information on the Integrated Coastal and Fisheries Governance project, contact: Coastal Resources Center, University of Rhode Island, Narragansett Bay Campus, 220 South Ferry Road, Narragansett, Rhode Island 02882, USA. Brian Crawford, Director International Programs at brian@crc.uri.edu; Tel: 401-874-6224; Fax: 401-874-6920.

Citation: Department of Geography and Regional Planning, University of Cape Coast (2013) Report On Phase II Tasks I, II, III and IV, Integrated Coastal and Fisheries Governance Project/ Department of Geography and Regional Planning, University of Cape Coast Collaboration. USAID Integrated Coastal and Fisheries Governance Program for the Western Region of Ghana. Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island. 65 pp.

Disclaimer: This publication is made possible by the generous support of the American people through the United States Agency for International Development (USAID)/Ghana. The contents of this report are the responsibility of the Integrated Coastal and Fisheries Governance (ICFG) Program and do not necessarily reflect the views of the United States Government. Associate Cooperative Agreement No. 641-A-00-09-00036-00 for "Integrated Coastal and Fisheries Governance (ICFG) Program for the Western Region of Ghana," under the Leader with Associates Award No. EPP-A-00-04-00014-00.

Cover Photo: 5-Year Frequency Flood hazard in Anankwari Basin

Cover Photo Credit: Department of Geography and Regional Planning, University of Cape Coast

Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

Coastal Resources Centre – Ghana (CRC-GH) under the USAID sponsored coastal resource conservation program Hen Mpoano, entered into contractual agreement with the Department of Geography and Regional Planning (DGRP) to provide geo-information and cartographic services which would facilitate CRC-GH's objective of promoting improved coastal land use and fisheries management in the six coastal districts of the Western region of Ghana.

In line with the terms of reference, CRC-GH requested from DGRP, to carry out the following activities:

- Develop General reference maps for the six coastal districts;
- Prepare Land use Maps for Shama District;
- Conduct Vulnerability Assessment and Generate Flood Risk Maps for focal areas in Shama (Inchaban and Anlo Beach); and
- Identify, Classify and map shoreline features In Shama District.

This report captures the details of activities undertaken by the DGRP in respect of the issues under the four key activities. It also summarizes the respective deliverable products produced under each task.

2 TASK I BOUNDARY RESOLUTION, GENERAL REFERENCE AND FOCAL AREA MAPS

2.1 Rationalization of District Boundaries

CRC-Ghana tasked the DGRP to produce general reference maps for the six coastal districts showing annotated settlements, roads, water bodies and areas liable to flooding. In addition, DGRP was to produce poster size thematic maps for CRC's focal areas. As part of the process to generate the general reference maps, DGRP was also to make attempts to resolve the unclear political and administrative boundaries observed among the six coastal districts of the Western region of Ghana. The objective of the boundary resolution exercise was to provide provisional boundaries for the districts involved.

2.2 Methods Used

In preparing the general reference and focal area maps, secondary information were collected from the districts and other sources. These included existing topographic and thematic maps and legislative instruments (LI) establishing the districts. In addition, primary data in the form of relative location of settlements were obtained from knowledgeable local stakeholders such as Chiefs and community leaders, drivers, National Disaster Management Organization (NADMO) personnel, agric extension officers among others. In the Districts with boundary problems, planning officers and Key stakeholders were mobilized for consultation and dialogue to rationalize the boundary issues. The data obtained from the exercise were used to resolve the boundary problems and also to prepare the general reference and thematic maps of focal areas.

2.3 Specific Products Generated

General reference maps showing annotated settlements, water bodies and areas liable to flooding were composed in color for the six coastal districts. In addition large format thematic maps of CRC-GH's focal areas namely Anlo Beach –Shama District, Anankwari Catchment Area –Shama District, Cape Three Points – Ahanta West District and the Greater Amansuri Area – Ellembelle and Jomoro Districts were generated (See Table 1). Minor corrections are being made, and the final products will be delivered to the Districts after final comments are received and corrections effected.

In the case of the Sekondi–Takoradi Metropolitan Assembly and Shama district, consensus could not be arrived at since major assets such as the Esipon Sport Stadium and a secondary school are located in an area which is being claimed by both local authorities. However, it must be emphasized that the maps generated are not surveyed boundaries and should be considered as provisional boundaries subject to change. The specific deliverable accompanying task I are summarize in table 1.

Table 4: Summary of deliverable products generated for Task I

NO	TYPE OF PRODUCT	QUANTITY	HARD COPY	SOFT COPY	REMARKS
1	Reference map – Ahanta West	2	YES	JPEG & PDF	
2	Reference map – Ellembelle	2	YES	JPEG & PDF	
3	Reference map – Jomoro	2	YES	JPEG & PDF	
4	Reference map – Nzema East	2	YES	JPEG & PDF	
5	Reference map – Sekondi/Takoradi	2	YES	JPEG & PDF	
6	Reference map – Shama	2	YES	JPEG & PDF	
7	Focal area map – Anlo Beach	1	YES	JPEG & PDF	
8	Focal area map – Inchaban	1	YES	JPEG & PDF	

Source: DGRP, October 2011

3 TASK II LAND USE MAPPING IN SHAMA DISTRICT

3.1 Introduction

Spatial planning seeks to analyze and influence the distribution of activities in terms of their location, connection between places, manipulating relationships between places and to coordinate activities between spatial scales so as to promote sustainable economic development (Hague et al, 2006). Spatial planning also emphasizes an integrative approach that seeks to harmonize policies which influence how land is modified with the objective of ensuring that, land is developed to meet social-economic, ecological balance, public safety and health, convenience, comfort and happiness(Hiraskar,1993). Land uses in Shama district has been influenced by the pace of land development in the District. To assess the current land use in the district to aid spatial planning, a participatory mapping approach of was adopted.

3.2 Methods used

A participatory approach was adopted for the land use mapping facilitated by CRC Ghana and Friends of the Nation. The participatory mapping process began with the formation of a Technical Working Group consisting of key stakeholders such as officials of Shama District Assembly, chiefs, opinion leaders etc, to oversee the spatial planning exercise.

Preparatory work done by the working group included the development of a land use classification scheme and sensitization of community members in the district.

To facilitate participatory land use mapping exercise Shama District was divided into four to coincide with the existing traditional areas. For the purpose of the field work these four areas were named as Shama North, Shama East, Shama West and Shama South. The four areas were further partitioned into 17 clusters, with each cluster having a minimum of two and a maximum of four settlements.

For each of the settlements visited, key stakeholders were identified. Participants from each stakeholder group were selected based on the following criteria: Occupation, age and sex. The number of participants in a group ranged between 10 to 15.

Digital ortho photos of the Shama district taken in 2005 were printed at a scale of 1:2500 (and later 1:5000) on bond paper size A0 and these were overlaid with transparent film. Selected stakeholders examined the printed ortho photos and this was used as a basis for delineating land use units on the transparent film based on discussions and consensus arrived at. Land use codes were assigned to areas delineated using the classification scheme. In instances where new uses or additional information were provided, these were recorded on the trailing edge of the transparent film. Current and preferred land use information was recorded on separate transparent films.

The recorded information was photographed using a digital camera and imported into ArcGIS 10.1 software. These images were geoferenced using the affine transformation method at a root mean square (RMS) error of 0.003 which is within the acceptable error threshold. The delineated land use units were captured using an on-screen digitizing approach and appropriate land use codes were assigned to each land use. Polygon topology was enforced throughout the data capturing process reducing the amount of editing that was required.

The edited data was used to compose current and preferred land maps for the Shama District. A total of 160 randomly selected points were used for field verification and validation of the land use classes. Out of this number, 21 points had been misclassified giving an accuracy of 86.80 percent. Field verification information was used to update the current land use map of Shama District.

3.3 Results and specific product generated

As can be seen from table 2, Shama district is predominantly rural. Land use data obtained from the participatory mapping exercise showed that nearly 75 percent of the land use is agriculture with community services and residential areas registering less than 1 percent and nearly 10 percent (9.82) respectively as indicated in table 2.

Land use preferences as indicated by surveyed community members suggest that, the nearly 26 percent reduction in agricultural land use and the land gained from this reduction be preferably converted into built up areas comprising community services (17.7%), industrial uses (31.6%) and residential areas (36.5%) with natural areas taking 14.9 percent.

Existing built up areas in Shama District are characterized by poor quality housing and haphazard land development arising out of unenforced multiplicity of planning laws, unclear institutional mandates, weak institutional capacities and corruption. Therefore the suggestion to convert agricultural land to mostly built up area raises concerns on how vulnerable these new built up areas will be to hydro-meteorological hazards such as flooding which commonly occurs in the Shama District.

As summarized in Table 3, the main deliverable products emanating from task II are 'present land use' and 'preferred land use' maps for Shama district.

Table 5: Major land uses for Shama District

Land use type	Area (sq.km)	percent
Agriculture	130.10	74.57
Community service	1.05	0.6
Industries and businesses	1.85	1.06
Residential	17.12	9.81
Natural Areas	24.06	13.79
Reservoir	0.29	0.17
Total	174.37	100.00

Source: Field Data (2011)

Specific products generated for Task II

NO:	TYPE OF PRODUCT	QUANTITY	HARD COPY	SOFT COPY	REMARKS
1	Present Land use Map	2	YES	PDF & JPEG	
2	Preference Land use Map	2	YES	PDF & JPEG	

Table 6 Summary of specific products and deliverables for Task II

4 Task III: VULNERABILITY ASSESSMENTS: SHAMA FOCAL AREA

4.1 Background and Objectives

Development through growth of settlement in the Shama Focal area has brought changes within the environment. Settlement programs and strategies adopted by residents, meant to enhance their well being, tend to ignore the existence of such important natural environmental component, as the urban watershed. For example, construction of houses/residential quarters, service centers (shops, lorry packs and gas stations) in areas marked by nature as drainage courses, tend to, prevent percolation and therefore confine flow of water, leading to spread of flow generating floods that cause a lot of damage to property and human life.

Flooding is characterized by high discharges and water levels leading to damage to properties. Flood events are caused by occurrence of intense, long-duration rainfall, failure of a dam or embankment system, high tides, storm surges and by human activities, including the operation of flood control systems.

Floods are part of the natural cycle of things and have both positive and negative aspects. On the positive side, floods distribute large amounts of water and suspended river sediment over vast areas. In many areas, sediment deposited by floods replenishes valuable topsoil components to both rural and agricultural lands and depositional features such as levees and sand bars can keep the elevation of a land mass above sea level. However, construction of flood control systems on river channel slowly reduces that amount of sediments to sustain the height of these levees or sand bars.

Flooding becomes a problem when it occurs in areas of large-scale human settlements within the landscape. Floods disrupt normal drainage systems and overwhelm sewer systems. Thus, raw or partially raw sewage spills from pit latrines and septic tanks are common in flooded area. Additionally, if the flood is severe enough, destruction of buildings/ware houses that contain harmful materials can cause the release of these materials into the local environment. Frequent flooding in urban settings disrupts many people's lives each year and personal tragedies do occur (Nyarko 2002).

Of all the disasters, flooding is the most damaging and costly natural hazards experienced in the Shama Focal area. Annually, during rainy season, with intense rainfall over a long duration, Shama focal area experience or record serious floods, that has lead to significant destruction of properties and loss of life.

To find solution to the periodic flooding, from the engineering point of view, the focus has been on structural designs and improvement of drains. During a flood event structures are not the only ones affected, peoples livelihood are lost. Hence, there is a need to explore new ways in detecting areas that are likely to be affected by a flood event and advice national and local authorities accordingly.

4.2 Inchaban and Shama watershed flood risk assessment

The objectives of the assessment were to:

1) Map out areas that are susceptible to flooding; and
2) Determine properties that are vulnerable to flooding in Shama Focal Area.

The Inchaban and Shama vulnerability map indicates the location of sites where people, natural environment or property are at risk due to flooding processes that could result in loss of livelihood, death, injury, pollution or other forms of destruction.

The vulnerability maps will:

- Allow for improved communication about risks and what is threatened;
- Facilitates better visual presentations and understanding of the risks and vulnerabilities so that decision-makers can see where resources are needed for protection or to site a facility; and
- Help decide on appropriate mitigating measures to prevent or reduce loss of life, injury and environmental consequences before a disaster occur.

4.3 Data Collection

Fieldwork in the Shama Focal Area was undertaken to collect data as an input into a model. Data collection process involved field observation, field measurement and satellite image processing/interpretation. Some of the data collected include rainfall, land use, soil characteristics, and drainage size. Rainfall data for the area from 1970 to 2010 was collected from Ghana Meteorological Agency. Stream discharge information was estimated from the intensity, frequency and duration curve from the Hydrological Service Department. The drainage channel cross section was measured in the field using a dumpy level, a tape and a staff gauge.

Using supervised classification of satellite images and field observations, land use types in the study area were classified as settled area, water-body, floodplain, forest reserve, and partly used area. Rainwater flowing over the land surface that exceeds infiltration becomes surface runoff to recharge the drainage system. Runoff generation within the study area comes from a variable (expanding and contracting) or partial area (fixed area). Models have been developed to estimate runoff since it always poses a problem when measuring it. Considering the difficulty in measuring runoffs for the study area, the typical runoff coefficient (Table 4) extracted from Viessman and Lewis (1996) based on land use type was used in its estimation.

Table 4: Runoff Coefficient for various land cover units

Description of Area	Runoff Coefficient
Agriculture	0.18
Industrial and Business	0.30
Natural area	0.18
Reservoirs	0.18
Residential	0.40
Community service	0.40

Source: Viessman and Lewis (1996)

As a result the land use type (Figure 1) was adopted to determine runoff coefficient for the study area. Hence, the estimate made, using the runoff coefficients, showed that residential area assigned a runoff coefficient of 0.40 does experience moderately high runoff rates. While unimproved areas such as agriculture and natural areas were assigned a coefficient of 0.18. In this study, different runoff coefficients were assigned to the different land use classes (Table 4).

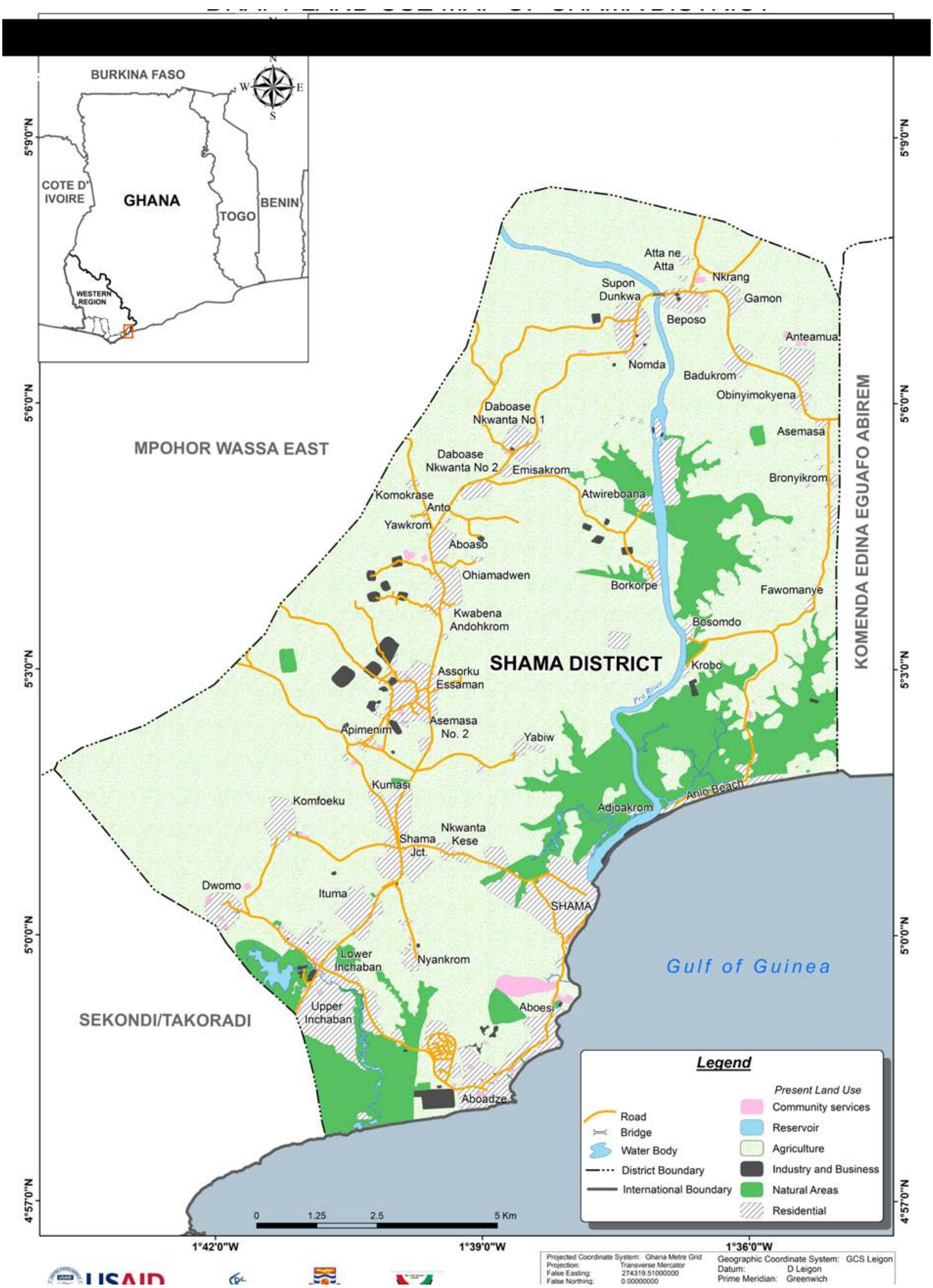


Figure 1 Land use map of the Shama Focal Area

4.4 Topographic data

In the absence of detailed topography survey data and accurate Digital Elevation Model (DEM) from the Ghana Survey Department, the alternative Advance Space-Borne Thermal Emission and Reflection Radiometer – Global Digital Elevation Model (ASTER-GDEM) product with a resolution of 30m from United States Geological Surveys (USGS) was the only reliable source for topographic extraction of the Shama Focal area. Like any other spatial data, ASTER-GDEM was taken as a true representation of the topography of the Shama focal area after it was corrected with ground control points obtained using differential GPS. Within the area, the highest point is about 89 meters above sea level.

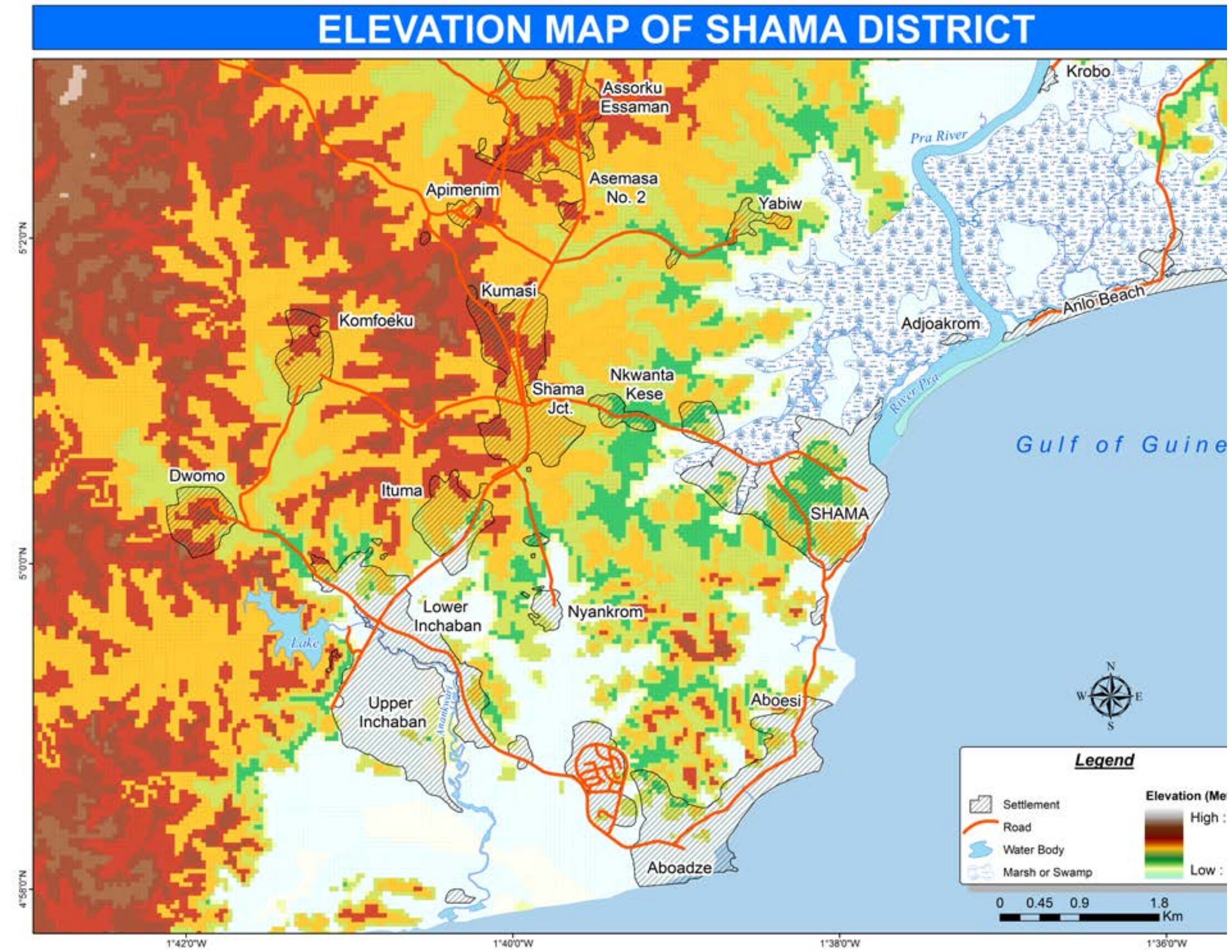


Figure 2 Elevation Map of the Shama Focal Area

4.5 Models

The software used for the study are ArcGIS 10.1 and SOBEK from Delft Hydraulics in the Netherland for processing of data and flood modelling. The study was divided into 3 main phases. The first phase focused on the pre-processing of the data to be used for the flood model and simulation. This entails the construction of a Digital Surface Modelling (DSM) based on the prepared DEM, Road Network and built-up maps.

A Digital Surface Model (DSM) was generated to define the topography of the floodplain and served as a 2D surface model input data for the flood modeling. The DSM for the study area was generated following the steps:

- Pre-processing of the digital elevation model (DEM) from ASTER-GDEM and integrating it with man-made terrain including road network and built-up maps;
- Transforming land cover into surface roughness; and
- Flood frequency analysis.

The SOBEK 1D2D flood model is used to simulate 6 recurrence intervals flood events as the second phase of the study. The final phase of the study involved the generation of flood inundation maps corresponding to the simulated return periods of flood events under the flood characteristics on spatial extent and flood velocity and warning time. The steps taken to simulate flood risk and vulnerability map is shown in Figure 3.

4.6 **Summary of Results**

The SOBEK 1D2D flood model was used to simulate six (6) return periods of flood events (2, 5, 10, 25, 50 and 100 years) for the Shama and Inchaban catchment. By definition, a return period also referred to as a recurrence interval is an estimate of the time interval between events of a certain intensity or magnitude. The return period could also be translated to exceedance probability which is the probability that a flood event of certain magnitude will be exceeded or has the chance of occurring. The return periods (2, 5, 10, 25, 50 and 100 years) has an exceedance probability of (0.5, 0.2, 1, 0.04, 0.02 and 0.01) respectively.

From the result (Figure 4), comparison between 2 years and 100 year return period indicates that flooding increases with high return period. It's important to note that tides have effects on flooding at the coastal region. For instance, during high tides, with a corresponding increase in water level generates backwater effect at the estuaries of the rivers. The backwater effect process generates floods at the low lying coastal areas. Simulation result of the extent and area of flood coverage at different time steps for the respective return period is presented in Figure 7. From figure 7, coastal area gets flooded with an intense rainfall event of short duration no matter the return period.

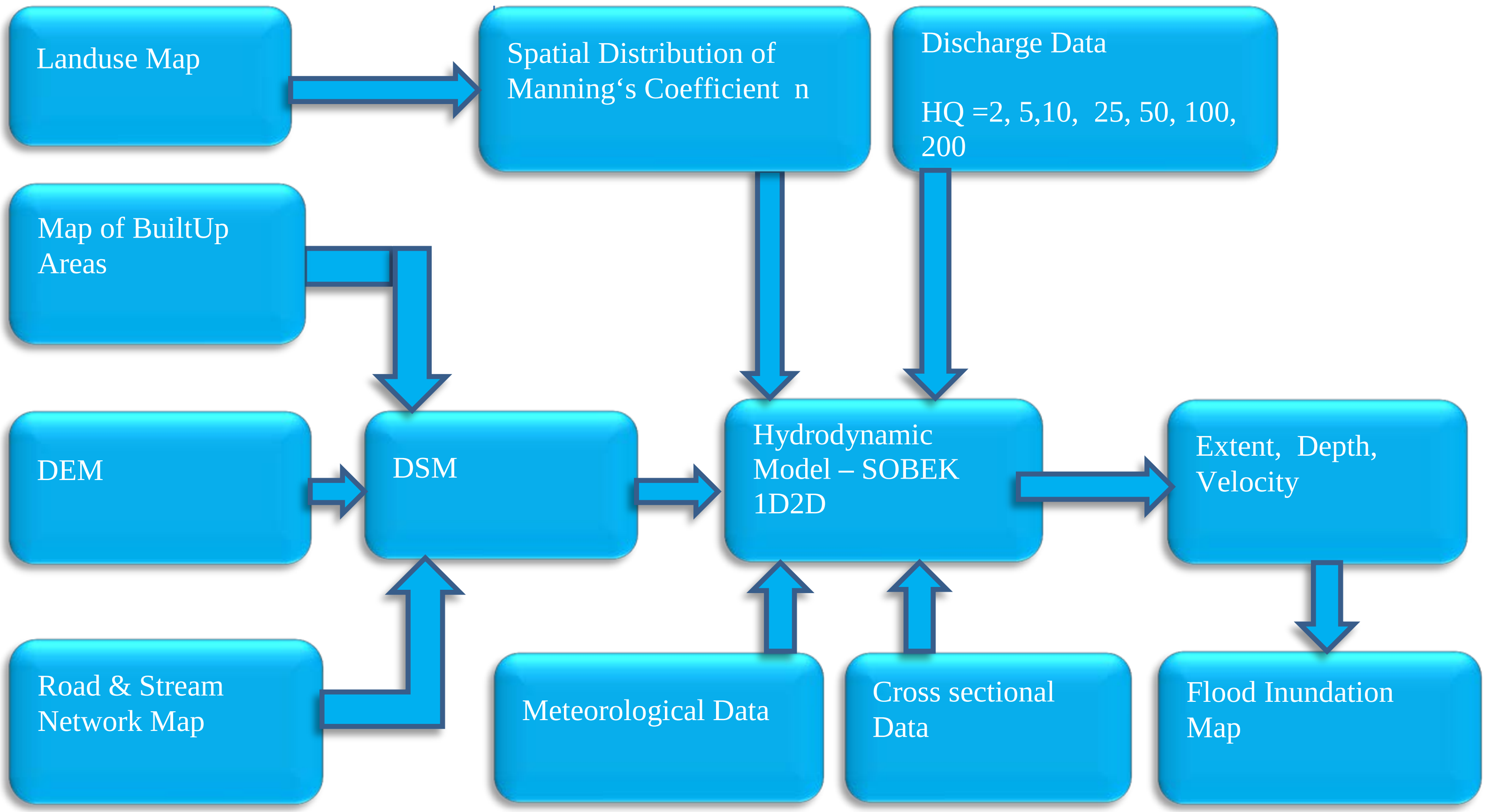


Figure 3: Study Methodology Flowchart

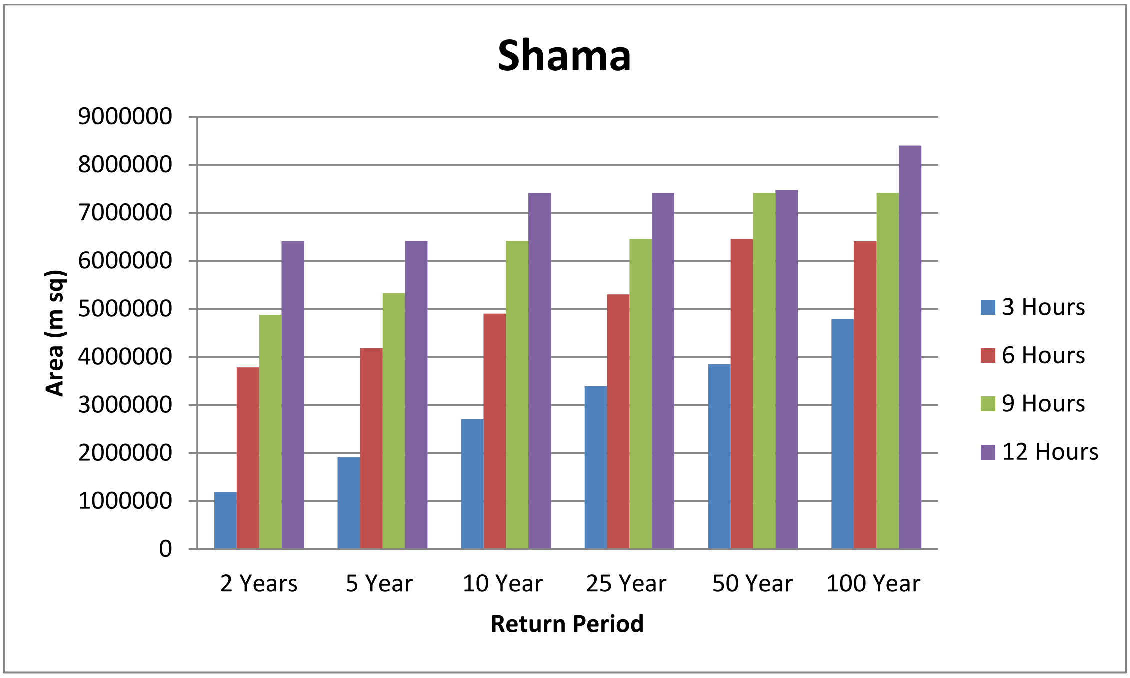


Figure 4: A comparison of areal extent of flood inundation at different return periods.

In general, the maximum extent of inundation is observed to be increasing with high return period and water depth measured within the main channel is high compared to the floodplains for all the return periods. High depth of flood occurring at some sections within the Shama Focal Area can be attributed to the backwater effect created by reduced flows due to embankments, diversions, difference in topographic elevation, other human activities that impede smooth flow of water and the presence of the coastal wetlands. The highest depth simulated is about 10.20 m and occurred in the flood with return period of 100 years.

In flood prevention, wetlands play an important role, they store water during heavy rains, slowing runoff and reducing flood peaks. However, the topographic settings of the wetlands and drainage characteristics does not permit the fast evacuation of flood water from the upstream tributaries, this often result in more muted flood response.

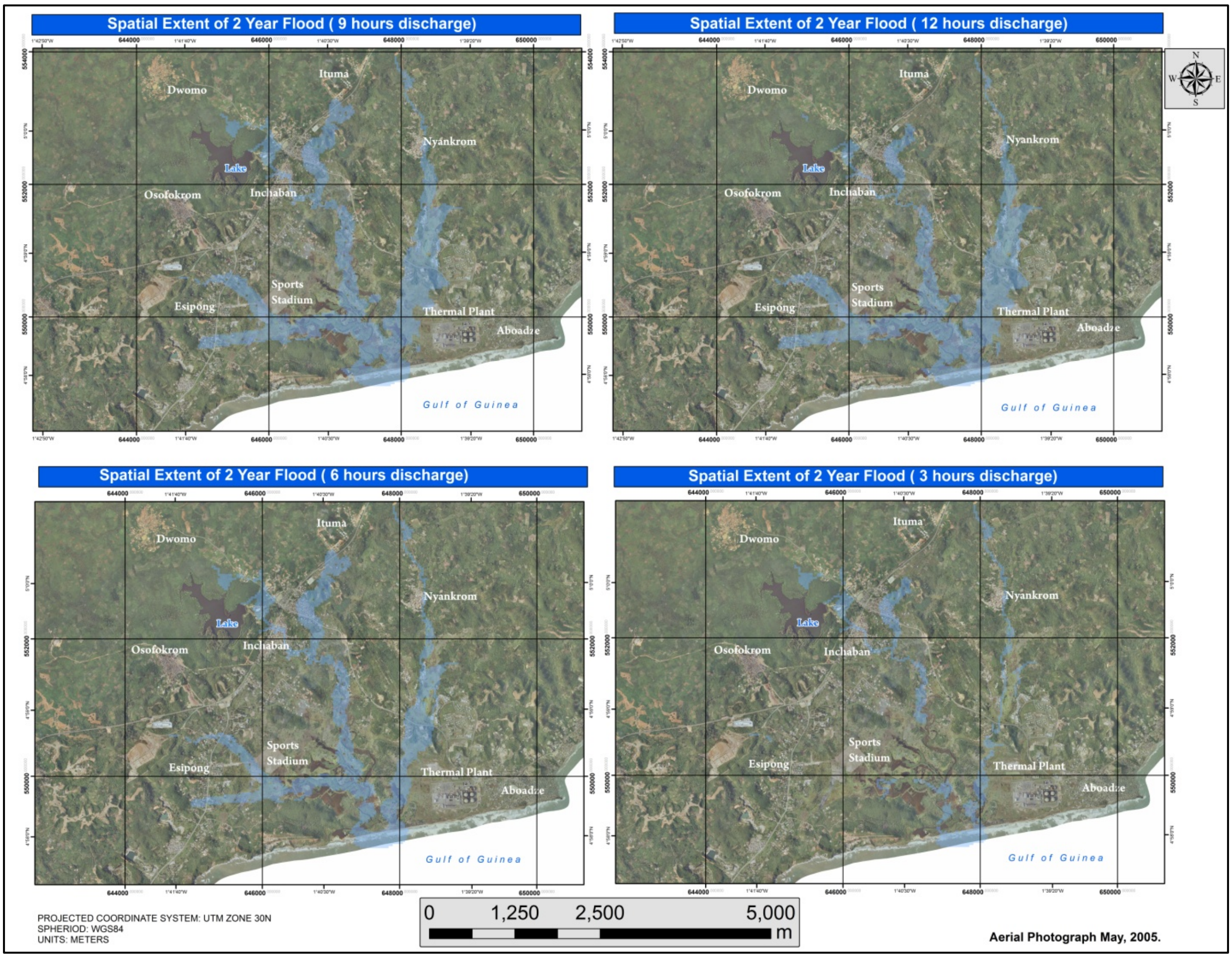


Figure 5 Inchaban Catchment 2 YEAR FLOOD

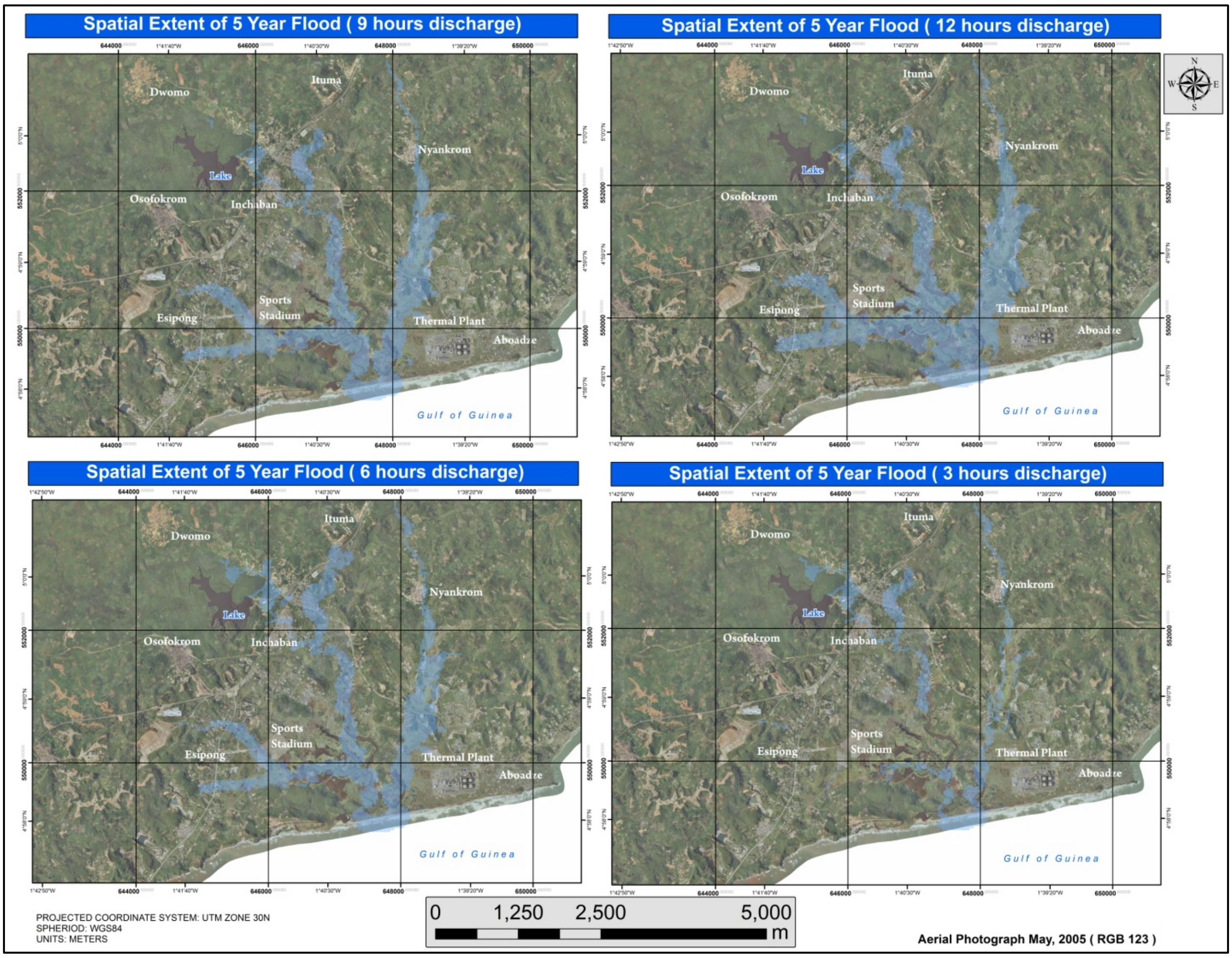


Figure 6 Inchaban Catchment 5 YEAR FLOOD

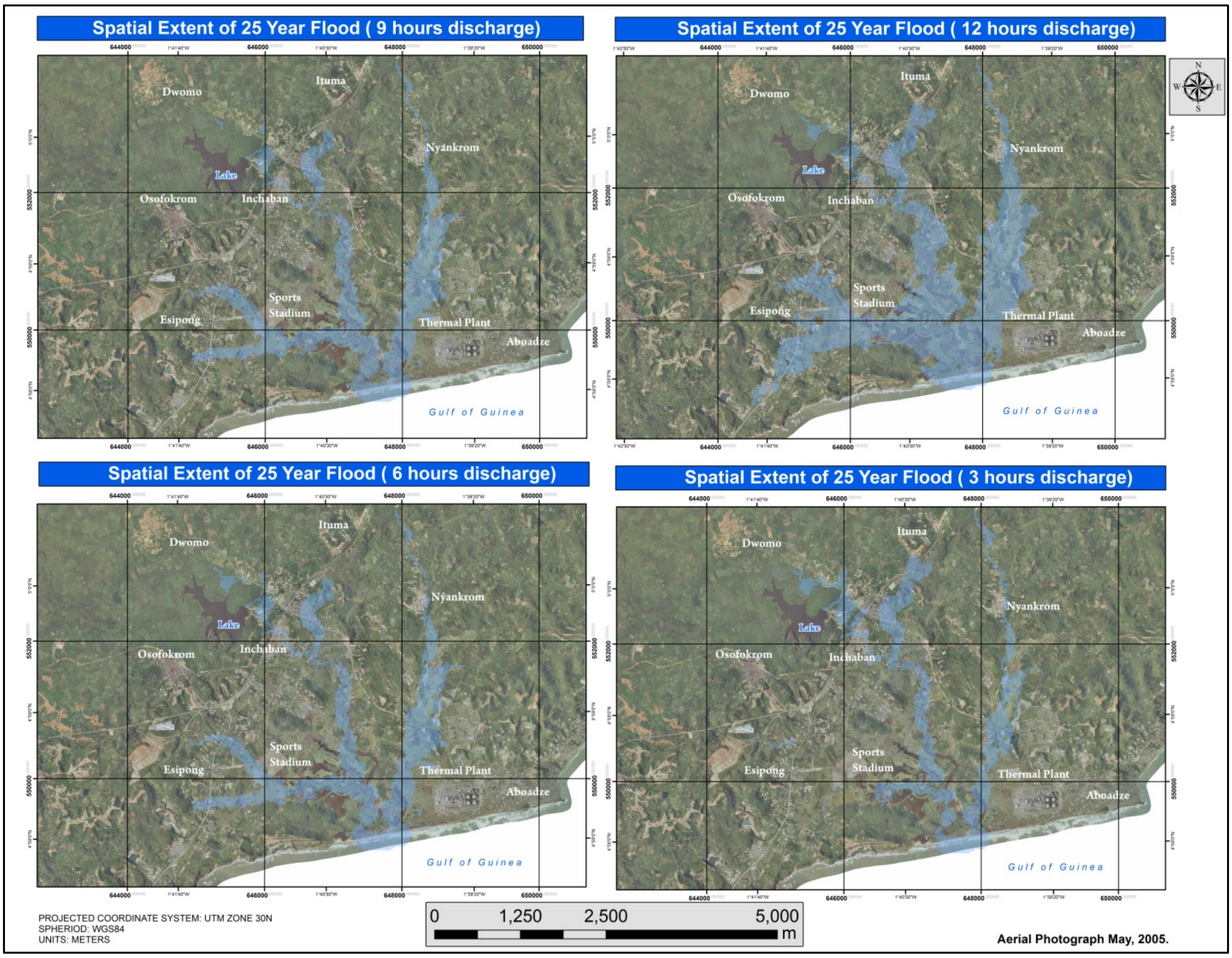


Figure 7 Inchaban Catchment 25 YEAR FLOOD

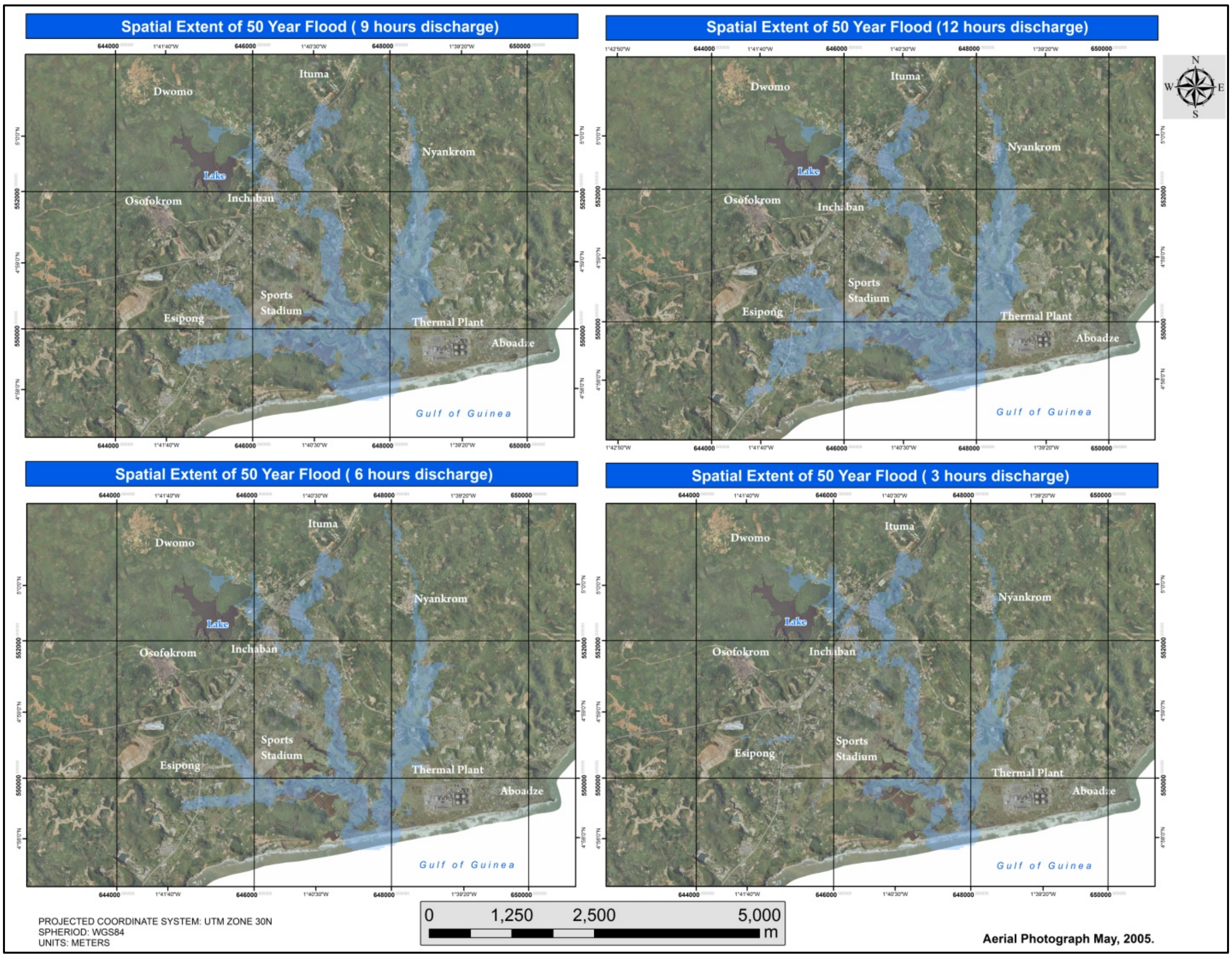


Figure 8 Inchaban Catchment 50 YEAR FLOOD

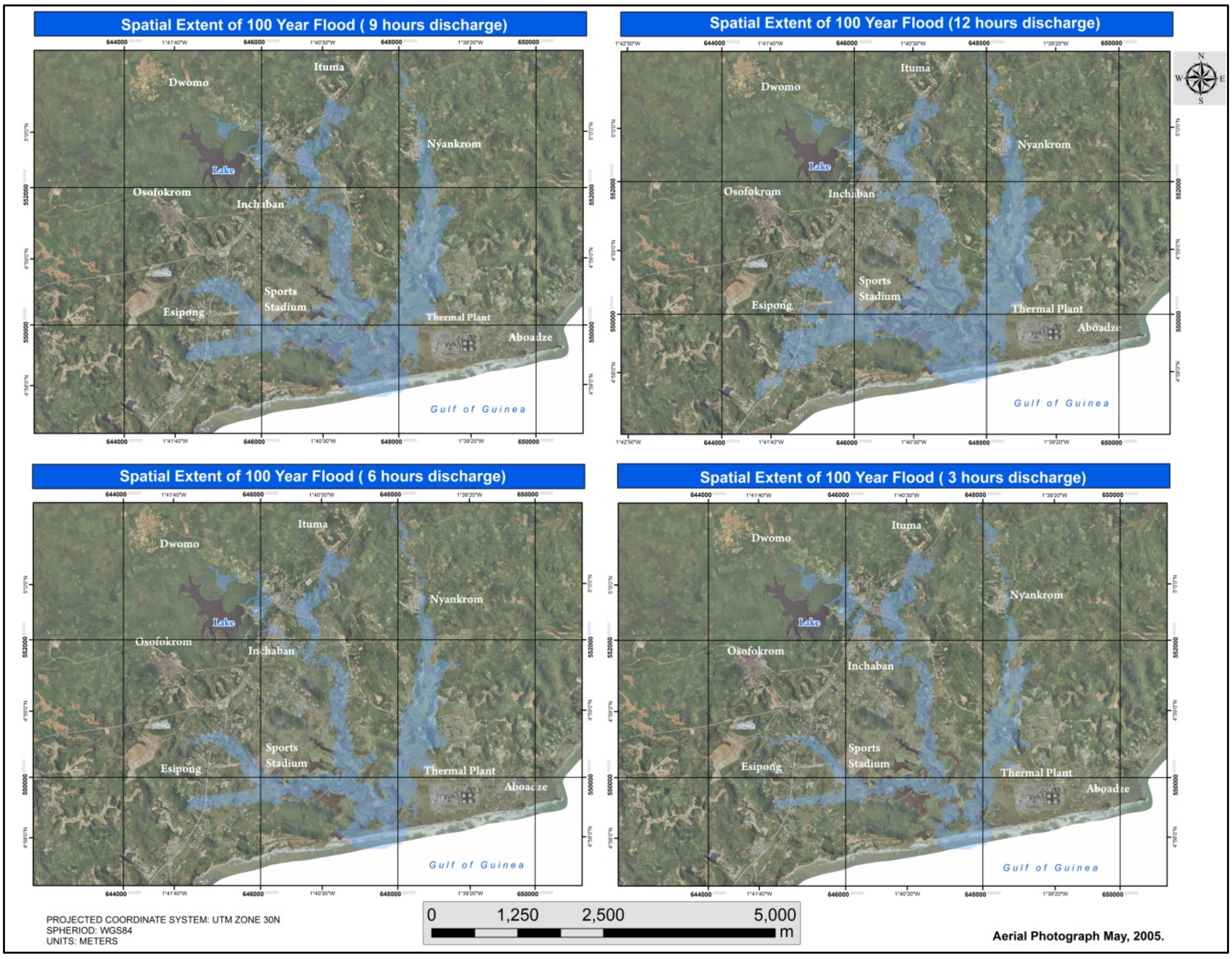


Figure 9 Inchaban Catchment 100 YEAR FLOOD

***Figure :* Spatial distribution of maximum extent of flooding for 2-, 5-, 10-, 25-, 50- and 100- year return period (Inchaban)**

With continuous rainfall event areas close to the main river channel and close to its estuary will experience flooding within the first 30 minutes. However, water level is expected to reach its peak flow at the 45 – 60 minutes from the beginning of simulation and remains constant until the end. The higher the return period the earlier this peak flow is reached.

Table 5: Potentially floodable areas in the Inchaban Catchment

5 Year Return period				
Land Use	Area (Km²) (3 Hrs)	Area (Km²) (6 Hrs)	Area (Km²) (9 Hrs)	Area (Km²) (12 Hrs)
Agriculture	0.632667	0.955145	1.054465	0.911737
Community service	0.007085	0.007364	0.007398	0.007153
Industries & Businesses	0.036183	0.072432	0.109854	0.184985
Residential	0.239861	0.498813	0.573910	0.558079
Natural Areas	0.721250	1.802549	2.157875	2.397154
Reservoir	0.000140	0.000140	0.000140	0.000140
25 Year Return period				
Land Use	Area (Km²)(3 Hrs)	Area (Km²) (6 Hrs)	Area (Km²) (9 Hrs)	Area (Km²) (12 Hrs)
Agriculture	0.957028	1.203882	1.3455	1.511498
Community service	0.007318	0.007623	0.00855	0.022323
Industries & Businesses	0.061034	0.122724	0.225891	0.22934
Residential	0.441597	0.610573	0.876269	1.420549
Natural Areas	1.280836	2.121163	2.765243	3.350153
Reservoir	0.000140	0.000140	0.000140	0.000140
50 Year Return period				
Land Use	Area (Km2) (3 Hrs)	Area (Km2) (6 Hrs)	Area (Km2) (9 Hrs)	Area (Km2) (12 Hrs)
Agriculture	1.003122	1.288445	1.400971	1.570866
Community service	0.007618	0.007733	0.009799	0.022932
Industries & Businesses	0.067076	0.123643	0.228555	0.232028
Residential	0.474288	0.709869	0.910510	1.454647
Natural Areas	1.394552	2.187735	2.789350	3.355938
Reservoir	0.000140	0.000140	0.000140	0.000140

Source: Field data 2011

Table 6: Potentially floodable areas in the Shama Catchment

5 Year Return period				
Land Use	Area (Km^2) (3 Hrs)	Area (Km^2) (6 Hrs)	Area (Km^2) (9 Hrs)	Area (Km^2) (12 Hrs)
Agriculture	0.278198	1.011012	1.398971	1.673873
Mining	0.006279	0.091808	0.115863	0.115863
Residential	0.158037	0.558393	0.791399	1.075663
Natural Area	1.314632	2.741032	3.605183	3.685512
Graveyards	0.007503	0.007503	0.007503	0.007503
5 Year Return period				
Land Use	Area (Km^2) (3 Hrs)	Area (Km^2) (6 Hrs)	Area (Km^2) (9 Hrs)	Area (Km^2) (12 Hrs)
Agriculture	0.680022	1.403459	1.713332	2.194571
Mining	0.008351	0.115863	0.115863	0.115863
Residential	0.496938	0.774616	1.075663	1.380706
Natural Area	2.197269	3.595727	3.690938	3.729814
Graveyard	0.007503	0.007503	0.007503	0.007503
50 Year Return period				
Land Use	Area (Km^2) (3 Hrs)	Area (Km^2) (6 Hrs)	Area (Km^2) (9 Hrs)	Area (Km^2) (12 Hrs)
Agriculture	1.026487	1.713096	2.194306	2.244283
Mining	0.015332	0.115863	0.115863	0.115863
Residential	0.537837	1.075663	1.380706	1.380706
Natural Area	2.246775	3.689072	3.729814	3.737417
Graveyard and Cemeteries	0.007503	0.007503	0.007503	0.007503

Source: Field data 2011

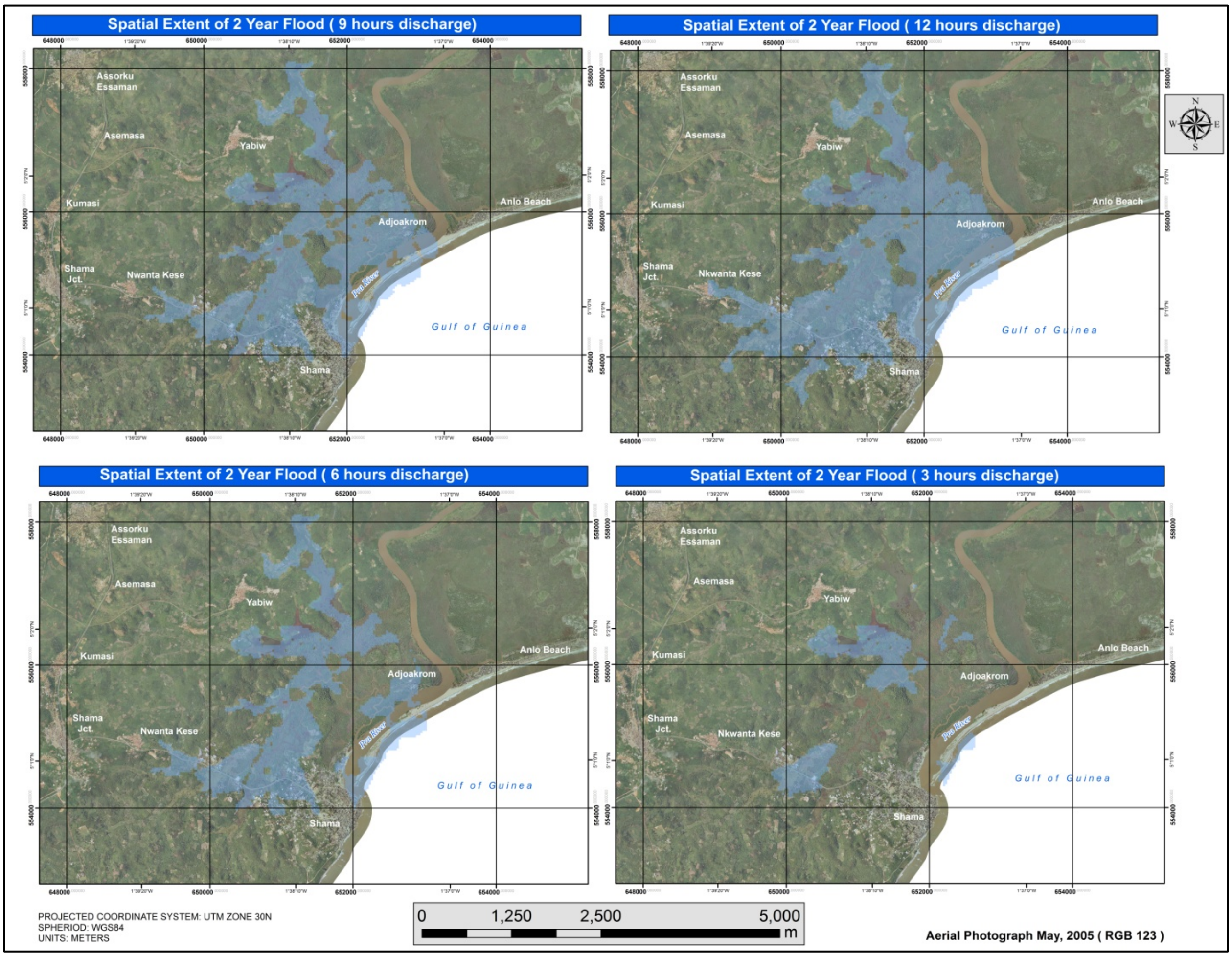


Figure 10 Anlo Beach Catchment 2 YEAR FLOOD

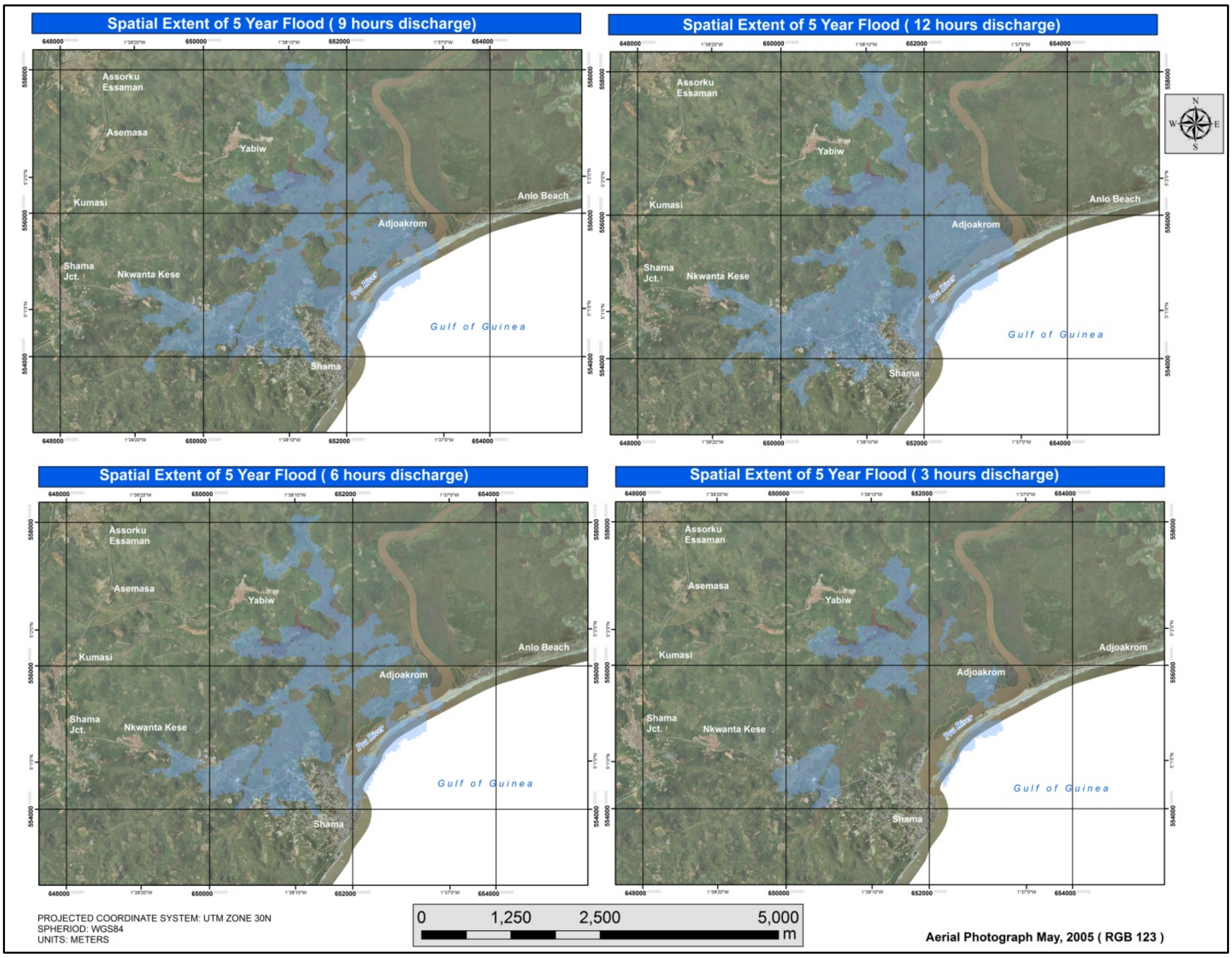


Figure 11 Anlo Beach Catchment 5 YEAR FLOOD

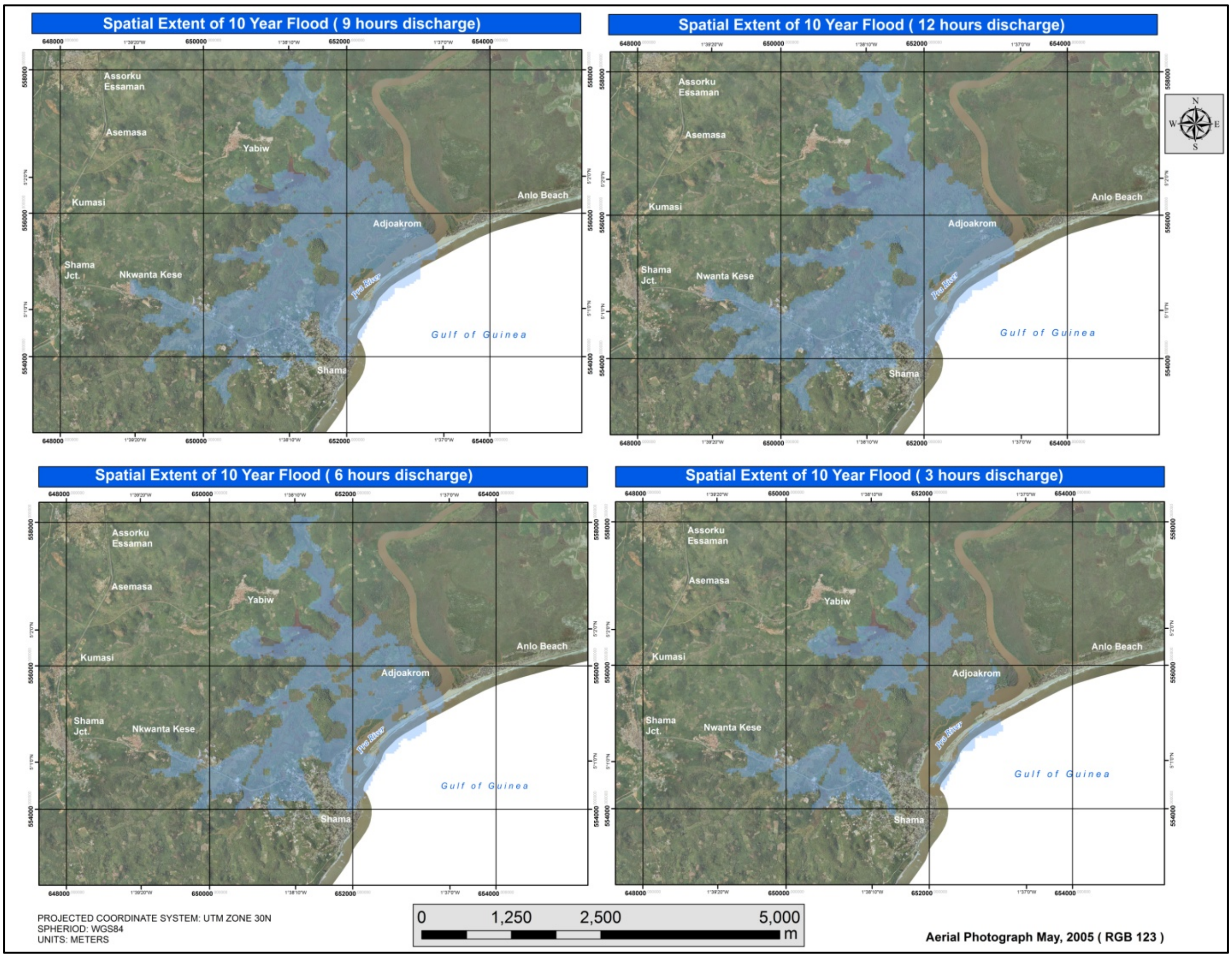


Figure 12 Anlo Beach Catchment 10 YEAR FLOOD

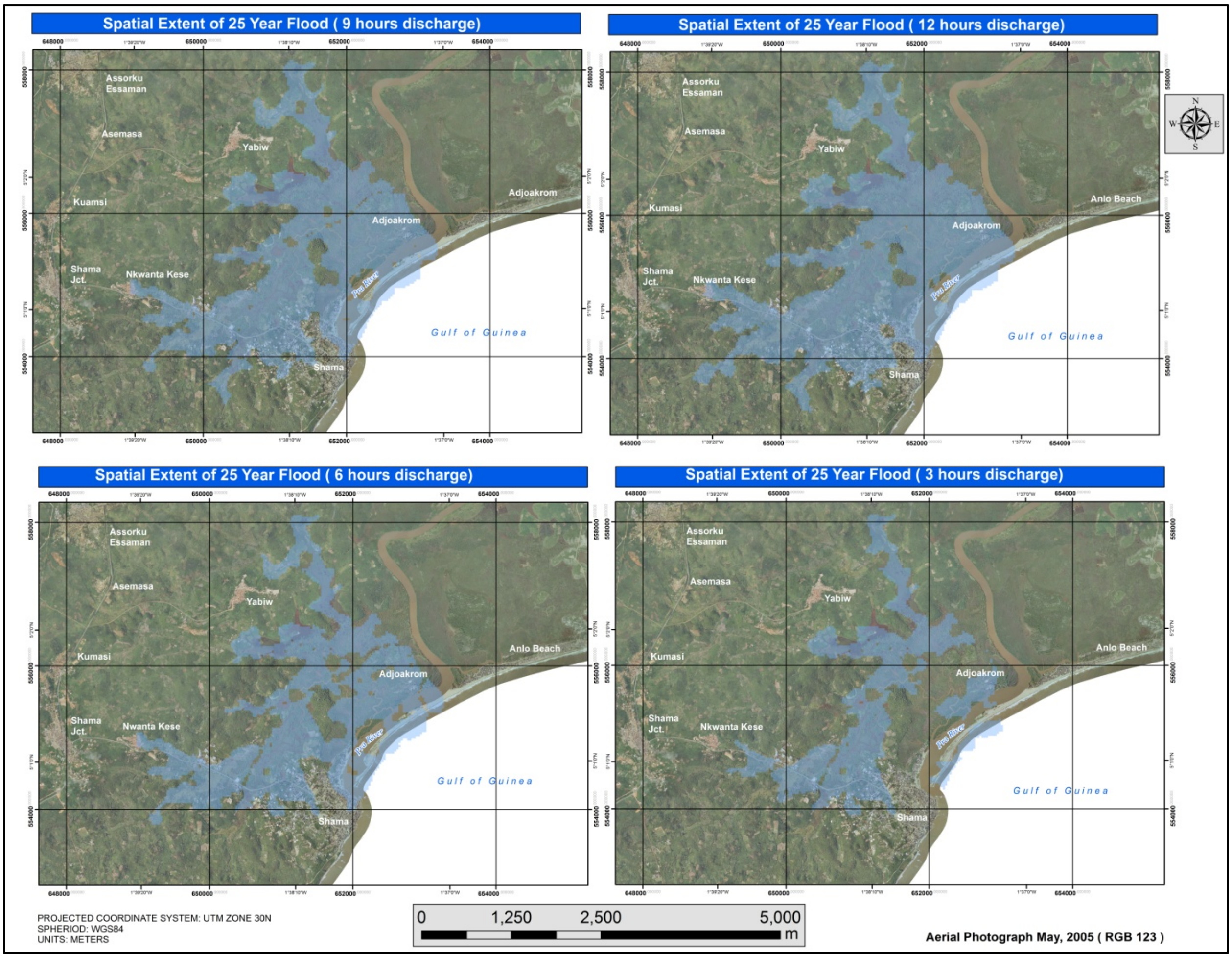


Figure 13 Anlo Beach Catchment 25 YEAR FLOOD

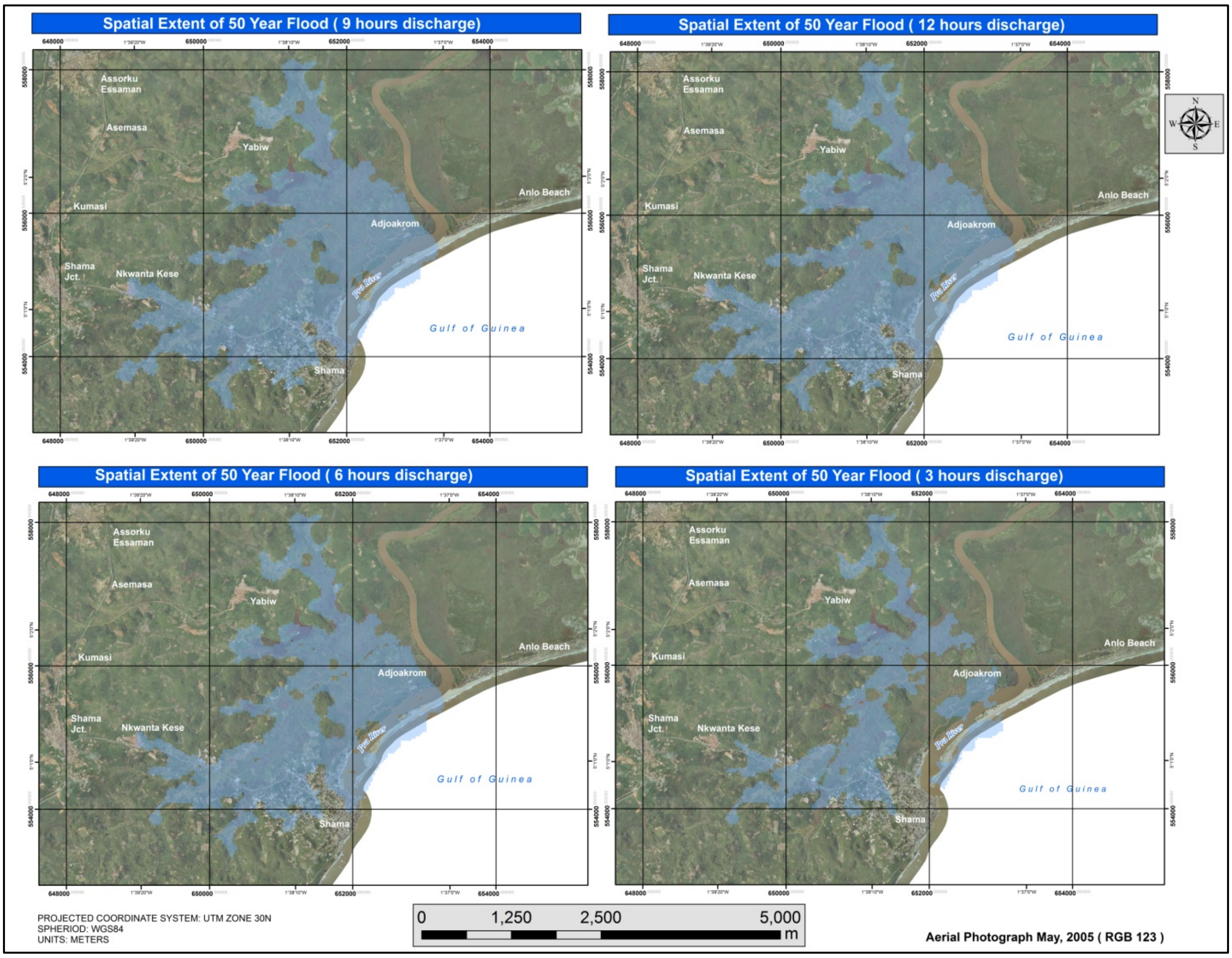


Figure 14 Anlo Beach Catchment 50 YEAR FLOOD

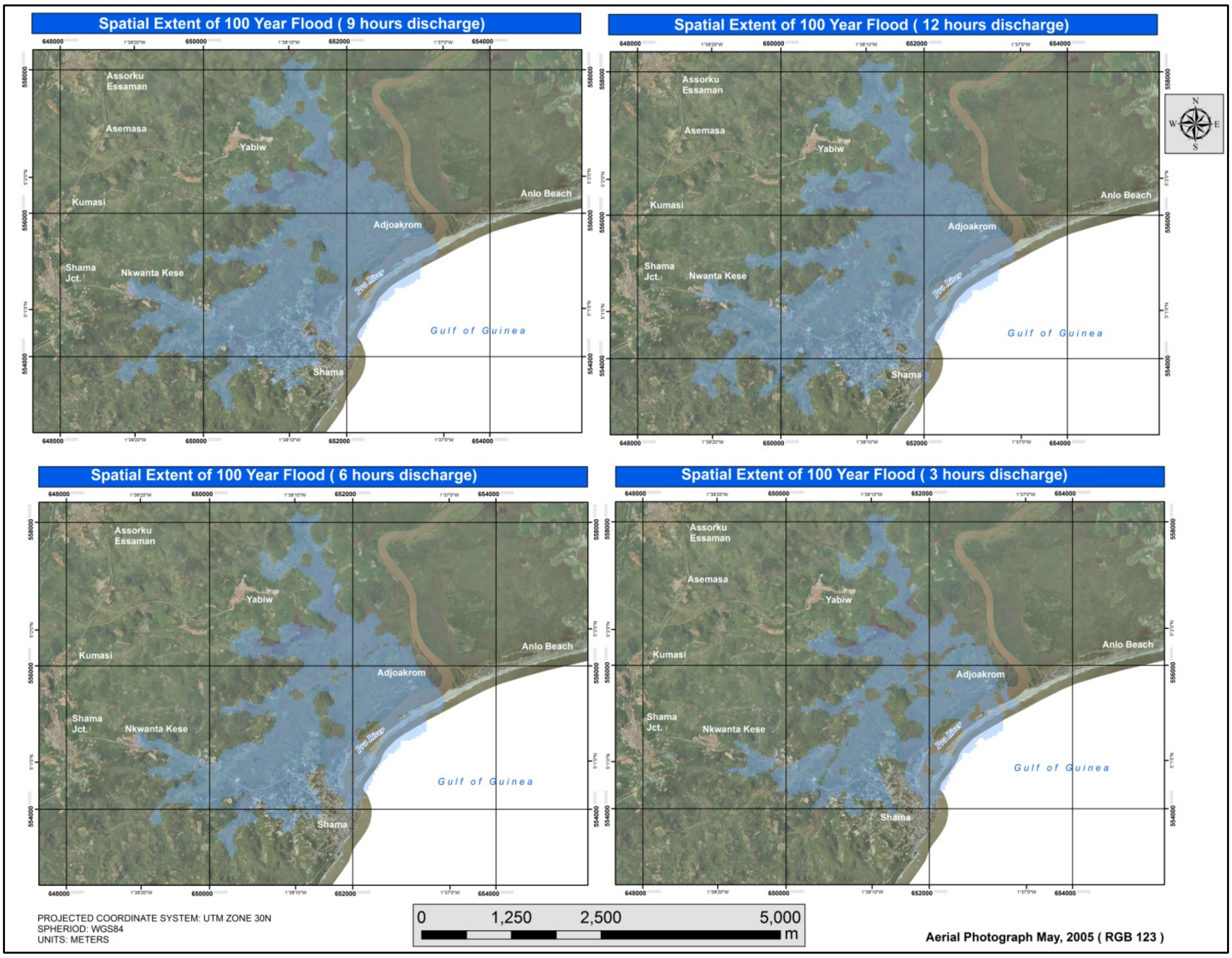


Figure 15 Anlo Beach Catchment 100 YEAR FLOOD

Figure : Spatial distribution of maximum extent of flooding for 2-, 5-, 10-, 25-, 50- and 100- year return period (Anlo Beach).

4.7 Flooding at Anlo-Beach

The Anlo beach settlement is partly located on the sand bar at the estuary of the Pra River. The topography of the area is low lying and below the 10 meter contour mark. Anlo beach and its environs do experience periodic flooding due to the interplay of factors including sea level rise due to wind speed caused by tropical depression over the Atlantic, sea level rise due to tidal differences, discharge from the Pra River, rainfall and the storage capacity of the wetland. Hydrological modeling was not done for this area due to the complexity of the landscape and lack of data. To get a clear picture on the extent of flooding, MICRODEM software was used as a simulation tool. This was to verify areas along the coast that will be inundated if there is an accumulation of water in case of sea level rise due to the effect of wind and tidal level.

Results from the MICRODEM simulation indicate that a meter rise in the sea level will have little effect on the coastal area. However, if the sea level rises above 1 meter, marginal part of the area will be inundated (Figure 16). From field observations, Anlo beach and its environs frequently get flooded due to the interplay of tidal level, high discharge level of the Pra River, and the low lying nature of the topography. Anlo beach floods when high discharge from the Pra River is not able to flow into the sea due to tidal levels. In periods of high river discharge and high tidal level the reduction in flow velocity generates a back water effect leading to the spread of water on the either side of the Pra River. From the observation and the simulation, areas such as Krobo, Adjoakrom, Anlo beach that are below the high water mark will be inundated (flooded).

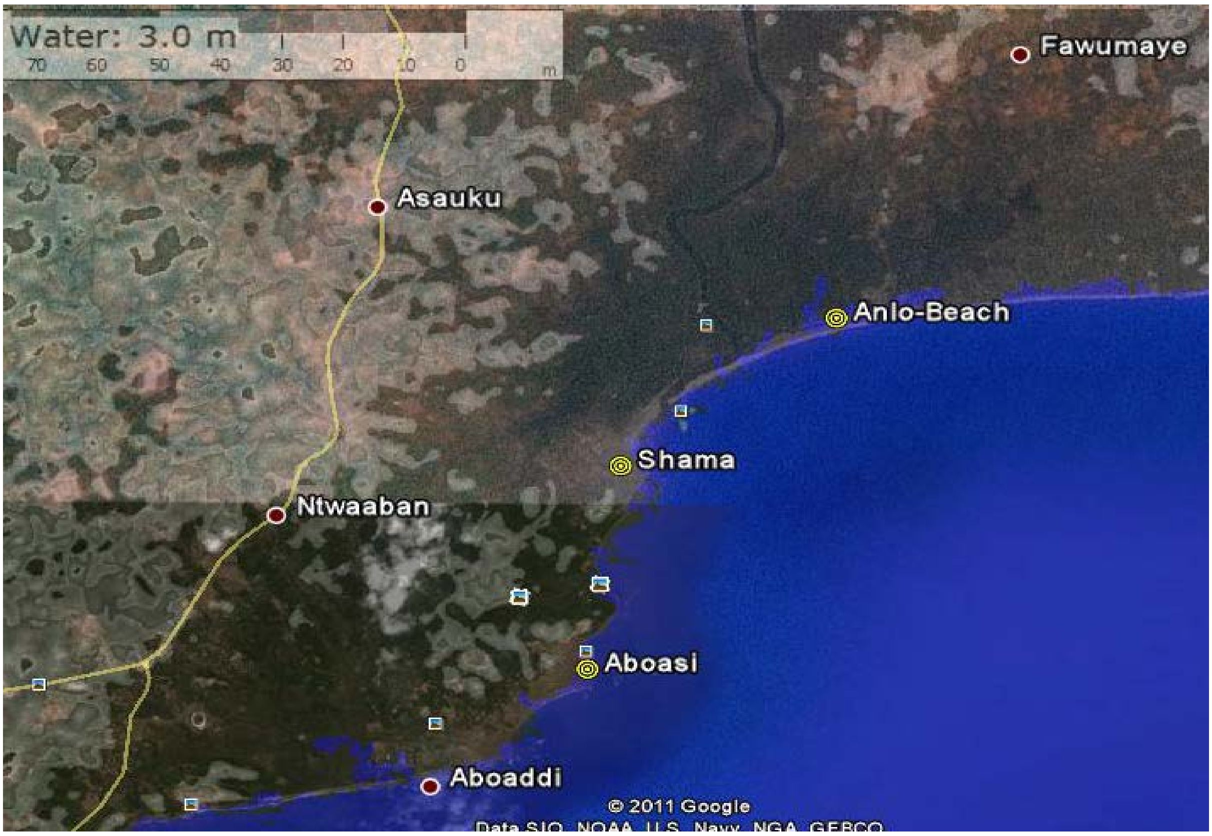


Figure 16: Areas to inundate if the sea level rises to a height of 3 meters (The simulation was done using MICRODEM).

4.8 FLOOD FLOW VELOCITY

Flow velocity is the speed at which floodwaters move and is measured in length per unit time (usually meters per second i.e. mps). Flow velocities during riverine floods can easily reach 5 to 10 mps and, in some situations, may even be greater. The velocity of riverine floodwaters in Inchaban and Shama catchment depends on a number of factors; one of the most important is the slope of the stream channel and floodplain. As expected, floodwaters move much faster along streams in steep highland areas than streams in flatter areas. On the average the slope in the Shama and Inchaban catchment are estimated to be around 0.5 percent (0.41^{o}). Even within the same floodplain, however, flow velocity can still vary. The velocity of floods flow depends largely on the roughness of the ground surface and will flow more swiftly over parking lots, roads, and other paved surfaces. However, it will flow more slowly over ground covered with large rocks, trees, dense vegetation, or other obstacles. Also, flow velocities in the floodplain will usually be higher nearer the stream channel than at the outermost fringes of the floodplain, where water may flow very slowly or not at all. In areas subject to coastal flooding, velocities depend largely on the speed of the wind.

Flow velocity is important for several reasons. Houses in these areas where floodwaters, move more than about 1.58 meters per second will experience varied degree of destruction. Flowing flood waters exerts pressure walls of a building than still water. Instead of hydrostatic pressure caused by the weight of the floodwater resting against the walls of the houses or structures, an additional pressure of moving water, referred to as “hydrodynamic pressure” is generated. As floodwaters flows around structures, it exerts a force against the structure in its path. Additionally, as it flows past structures, it creates friction that can tear or wear down wall. Also floodwater can creates a suction that pulls on walls. In some situations, the combination of these forces can destroy one or more walls, cause the home to shift on its foundation, or even sweep the home away.

Flowing water can also cause erosion and scour. Erosion refers to a general lowering of the ground surface over a wide area. Scour refers to a localized loss of soil, often around foundation of houses. Both erosion and scour can weaken the structure of a home by removing supporting soil and undermining the foundation. In general, the extent and depth of erosion and scour increase as the flow velocity and size of the home increase. The floods waters also carry with it objects and moves roughly at same speed as the water and have high abrasive powers.

4.9 Emergency Response, flood Warning Time and Flood Risk Zones

Flood warnings are effective tools that enable residents to take action to lessen the negative impacts of a coming flood. Flood warning help disaster management agencies and rescue teams to carry out their essential operations during flood events. The degree of effectiveness of flooding warnings can be assessed by the extent to which the warnings reached the at-risk community, the level of recipient satisfaction with the information and advice contained in them, the degree to which appropriate behavioural adjustments are made and the amount of losses avoided by those who are advised. Achieving effectiveness will depend on the cooperative involvement of stakeholders in the development of warning systems. The stakeholders include the agencies, which are responsible for the design and delivery of warning services, but they must also be seen as including the members of flood-prone communities.

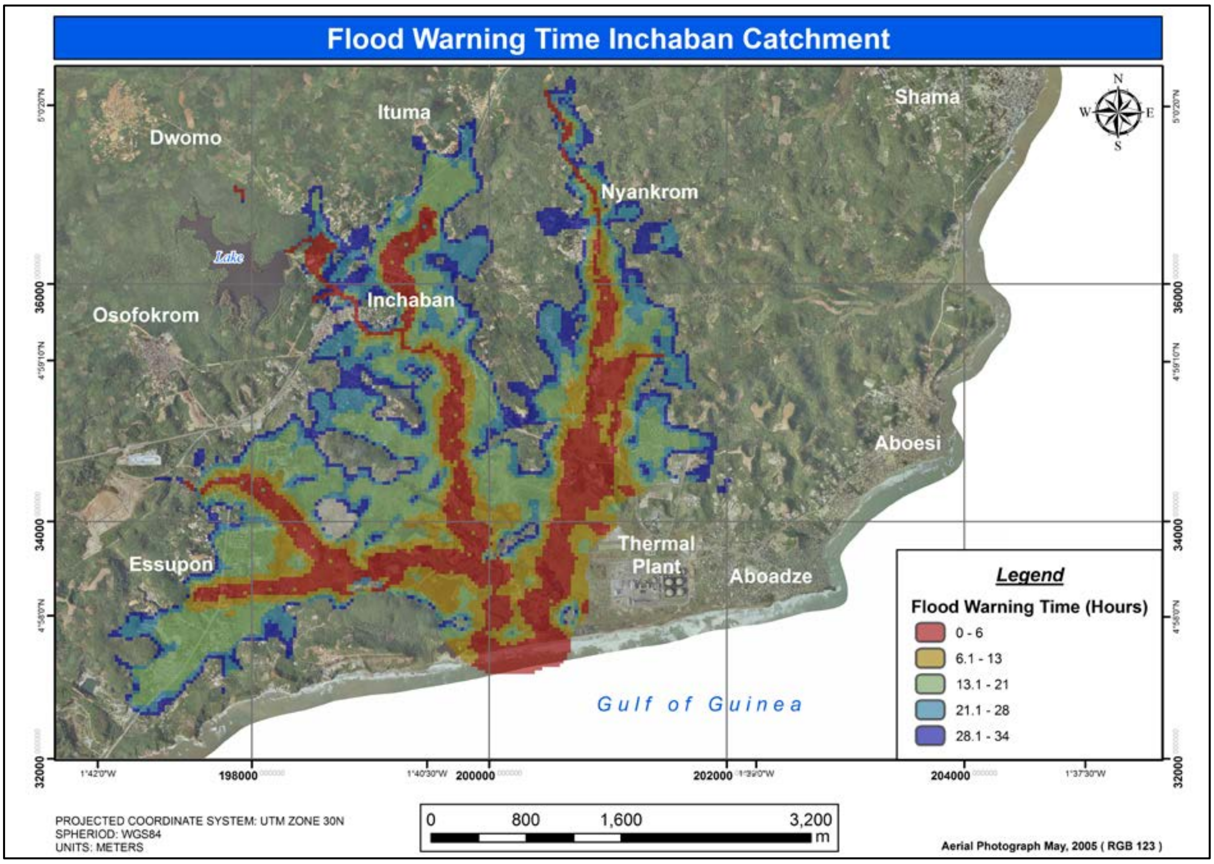


Figure 17: Flood warning times for the Inchaban catchment

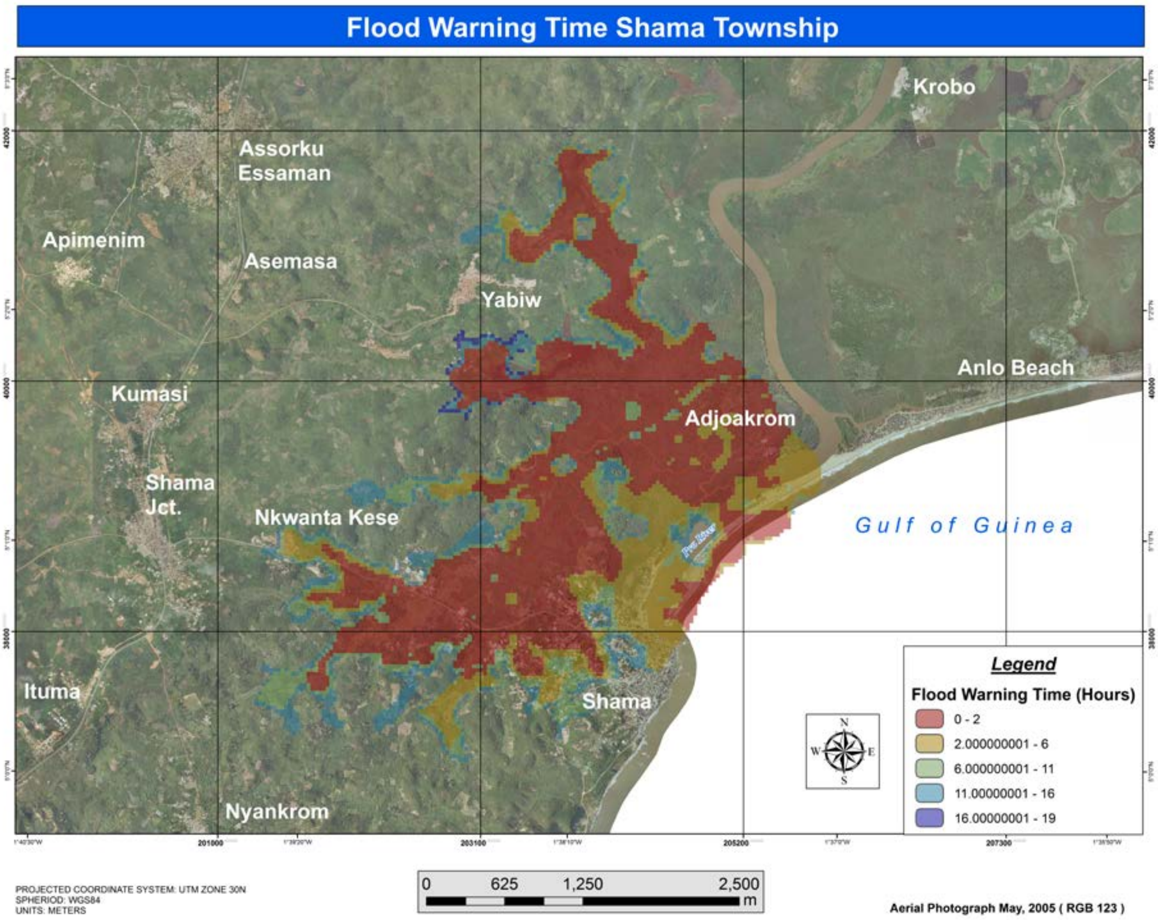


Figure 18: Flood warning times for the Shama catchment

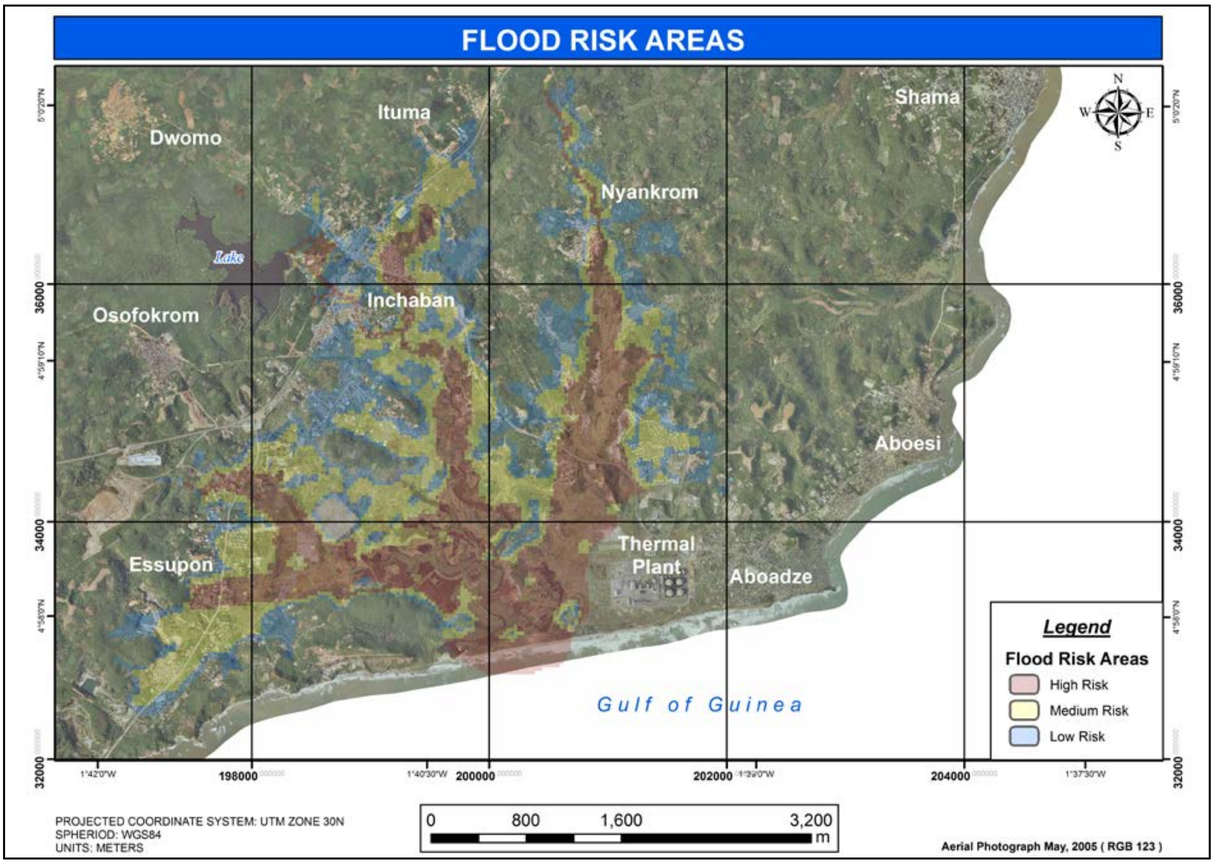


Figure 19: Flood Risk Map for the Inchaban catchment

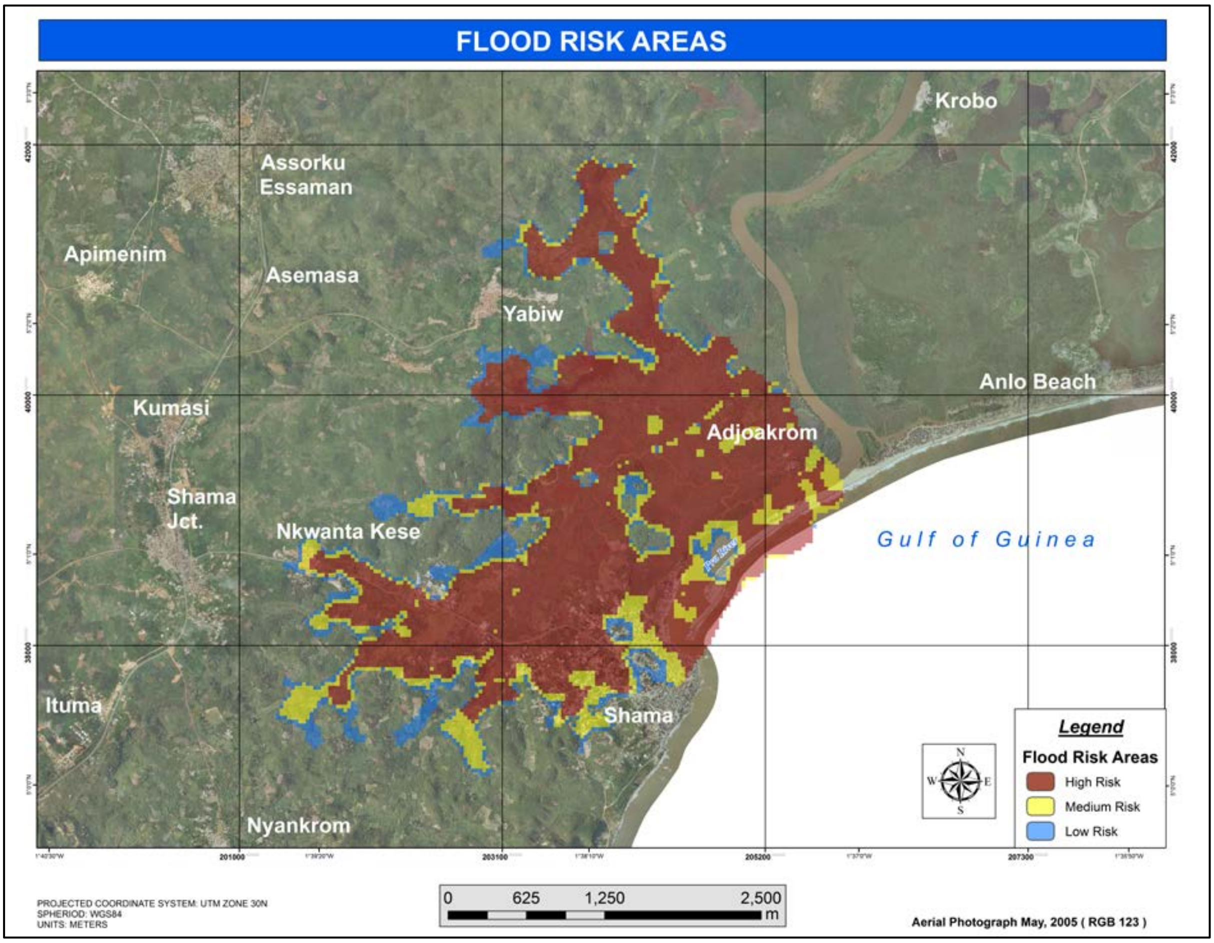


Figure 20: Flood Risk Map for the Shama catchment

4.10 Conclusions

Flood occurring in the Shama District has a direct effect on the life of the residents in the various communities that fall within the areas that are likely to be affected by the floods. Depending on the nature of flood, it is likely to put a lot of residents out of their home, cause destruction to houses, schools and health facilities. Agriculture and fishing activities will be heavily impacted. Greater part of fields will be inundated.

From the flood extent map, a number of houses and other infrastructures will be affected. For instance market stores including warehouses that fall within the flood extent map are likely to experience loss or contamination of stored food and agriculture inputs. This in turn will decrease the capacity of operators along the values chain, lower market functioning and availability of food commodities. Properties likely to be affected will experience different level of destruction.

Health: The health of people living in the communities will be affected and this is linked to health care services, safe water, hygiene and sanitation. Stagnant water is the most likely place for mosquitoes breeding. Malaria cases are likely to rise after days of flooding, if stagnant water is not drained. Most homes take their water source from hand dug well and underground storage tanks, these sources are unprotected and likely to be contaminated. Using water from contaminated wells or storage tanks can cause acute or chronic health effects.

Table 7: Summary of deliverable products for Task III

NO.	TYPE OF PRODUCT	QUANTITY	HARD COPY	SOFT COPY	REMARKS
1	Flood Extent (Shama) 2 YEARS 5 YEARS 10 YEARS 25 YEARS 50 YEARS 100 YEARS	1 1 1 1 1 1	YES YES YES YES YES YES	YES (JPEG & PDF) YES (JPEG & PDF) YES (JPEG & PDF) YES (JPEG & PDF) YES (JPEG & PDF) YES (JPEG & PDF)	
2	Flood Warning (Shama)	1	YES	YES (JPEG & PDF)	
3	Flood Risk (Shama)	1	YES	YES (JPEG & PDF)	

4	Flood Extent (Inchaban) 2 YEARS 5 YEARS 10 YEARS 25 YEARS 50 YEARS 100 YEARS	1 1 1 1 1 1	YES YES YES YES YES YES	YES (JPEG & PDF) YES (JPEG & PDF) YES (JPEG & PDF) YES (JPEG & PDF) YES (JPEG & PDF) YES (JPEG & PDF)	
5	Flood Warning (Inchaban)	1	YES	YES (JPEG & PDF)	
6	Flood Risk (Inchaban)	1	YES	YES (JPEG & PDF)	
7	Flood Extent (Anlo Beach)	1	YES	YES (JPEG & PDF)	
8	Database of Elements at Risk in Anlo & Shama				To be Compiled by FoN & SDA Using the Flood Extent maps

5 Task IV: SHORELINE FEATURE IDENTIFICATION AND CLASSIFICATION IN SHAMA DISTRICT

5.1 Background

The Shama District has experienced a number of human and natural changes to its coast. With the discovery of Oil and Gas and the potential for further developments such as tourism and climatic change impacting on the coast, it was important to identify and classify shoreline features and their significance. This is to provide preliminary information to guide local level management of the shoreline. The term coast is used to indicate the zone of contact between land and sea. The shore is the area between low water tides and the base of cliffs. The beaches consist of accumulations of sand, pebbles and cobbles upon the shore and the coastline itself is demarcated either by the cliff-line or by the line reached by the highest storm waves.

The investigation began with preliminary shoreline feature identification using aerial photographs. Shoreline features identified through visual interpretation were listed to form the basis for the actual field investigation.

During the fieldwork, the entire Shama coastline was traversed and relevant measurements of some features taken using GPS receivers (see Figures 21 and 22). In addition, digital photographs were also taken (See Plates 1-12). The list obtained from the photo interpretation assisted in the field observation, identification and mapping of relevant shoreline features. Based on these exercises, the shoreline classification was carried out.

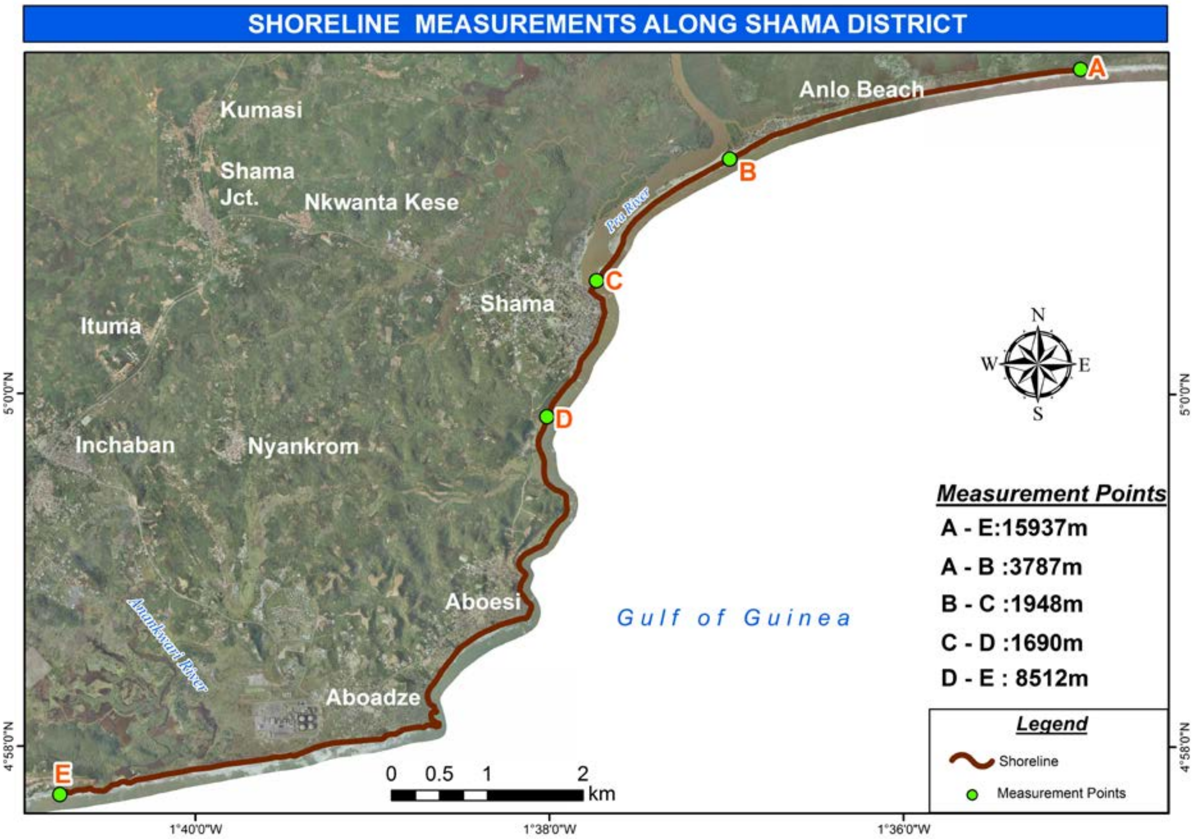


Figure 21: **Shoreline measurement along Shama District**

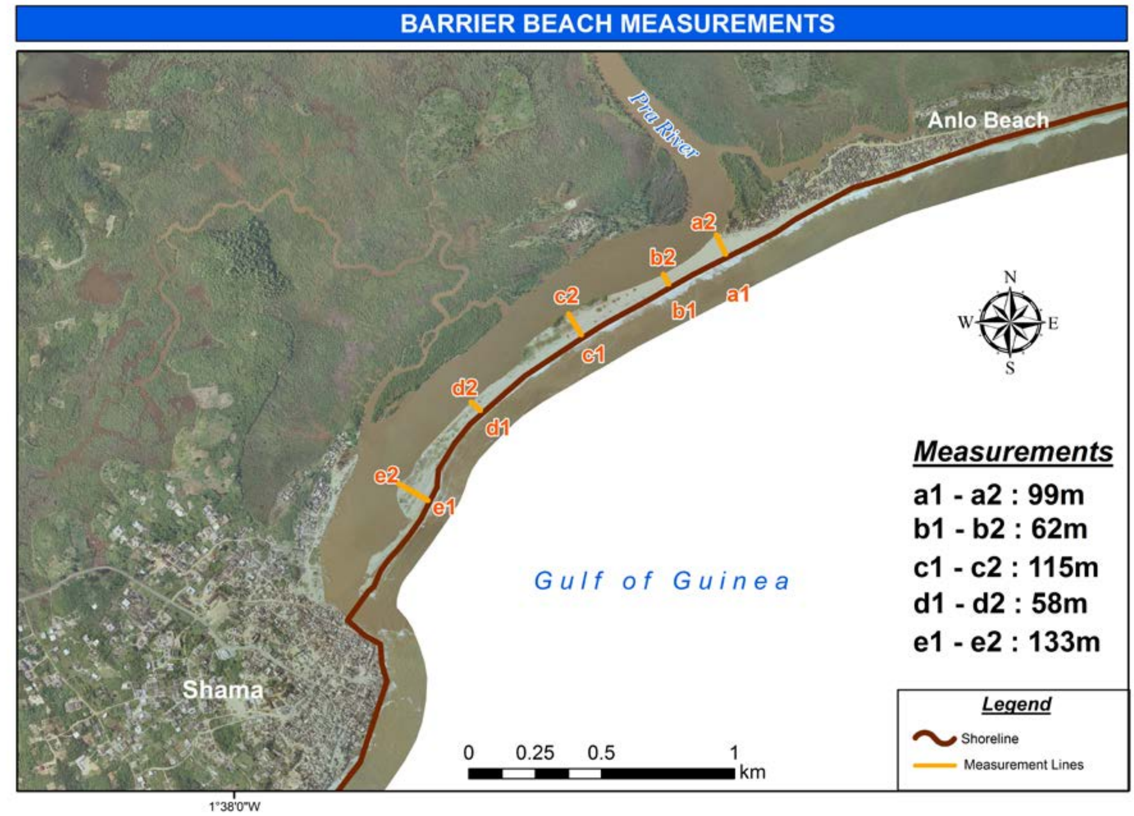


Figure 22: Barrier beach measurement in Anlo, Shama District

5.2 Results and specific deliverable products

Shoreline features identified during the exercise included both natural and manmade features as illustrated in Figure 23. Table 8 also summarizes the important shoreline features identified, their locations and significance.

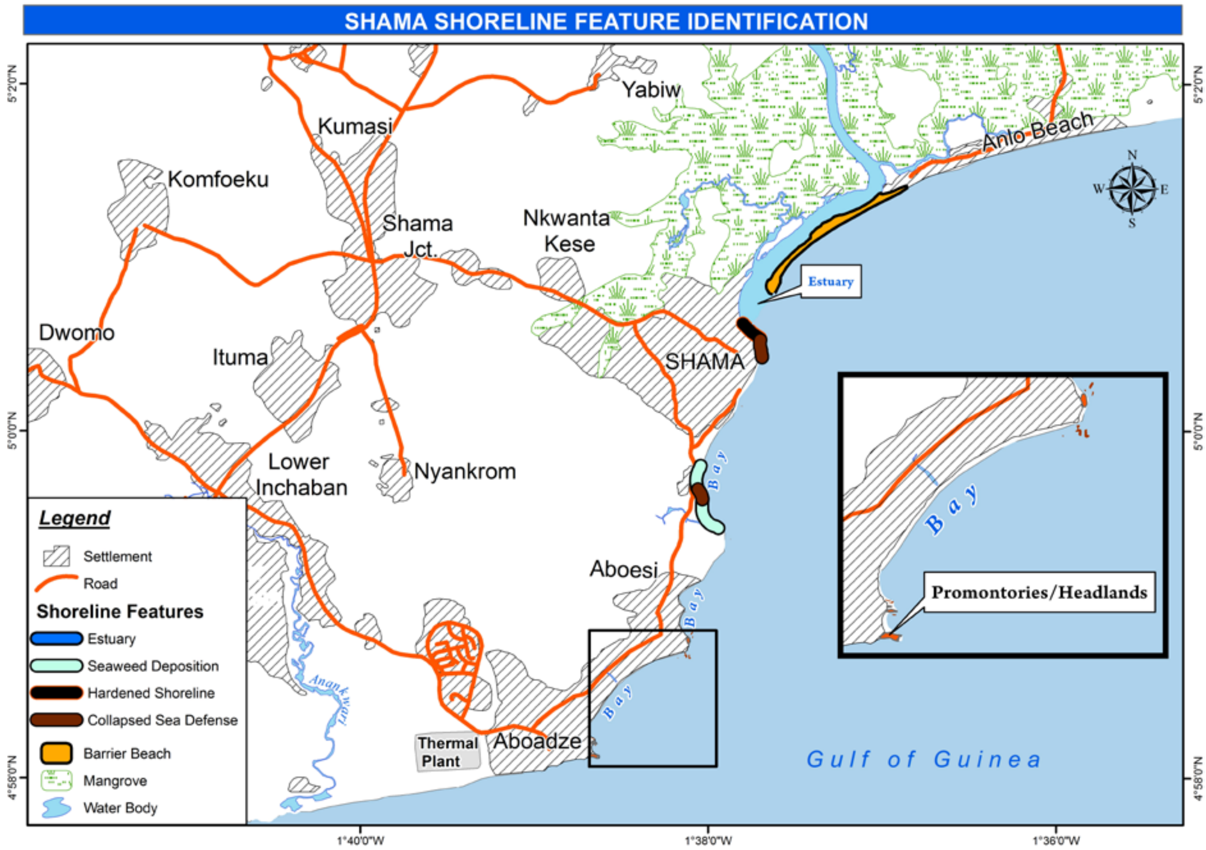


Figure 23: Shama Shoreline feature identification

Table 8: Shoreline features and their significance

No.	Shoreline Features	Location	Feature Significant	Photograph
1	Promontories	Aboadze, Aboesi	Light houses are built on them for sightseeing; Rocks are resistant to wave erosion and dissipate wave energy.	Plate 1
2	Barrier Beach	Anlo Beach	Serve as a check on coastal inundation/flooding; Dissipate wave energy and may be useful for human settlement	Plate 2
3	Rocky Cliff	Aboadze, Aboesi	Indicate the rate of rock resistance to wave erosion; May also prevent coastal floods; Houses can be built on them for sightseeing and adventure tourism	Plate 3
4	Estuary	Shama	Significant for development of delta; serve as habitat for some marine organism	Plate 4 i Plate 4 ii
5				
6				
7	Sea Defence	Shama	Serve as check on sea erosion; Prevents recession of land bordering the sea; Indicate the strength of waves and sea erosion and has to be monitored	Plate 7 i Plate 7 ii Plate 7 iii
8	Collapsed Sea Defence	Shama, Between Shama and Aboesi	Signifies the strength of sea wave and the extent of destructive nature of waves.	Plate 8 i Plate 8 ii
9	Bays/Coves	Shama, Aboadze, Aboesi	Habitat for turtle and other coastal creatures, it also shows that the rocks there are less resistant to wave erosion and could be a good spawning grounds for fishes	Plate 9
10	Mangrove	Anglo Beach	Serve as storm protection. Habitat for some organism such as crabs, reptiles; It is also a breeding, nursery and feeding ground for some aquatic	Plate 10 i Plate 10 ii

No.	Shoreline Features	Location	Feature Significant	Photograph
			organism. Temporal homes for some migratory birds; can be developed as recreational sites for tourists and tourist facilities such as hotels	
11	Built Up		Shows that the area is endowed with natural resources and opportunities (aesthetic, recreation, communition)	Plate 11
12	River	Anankwari, Shama, Anlo Beach	Serve as habitat for marine organism, for domestic and industrial uses; direction of the river shows the slope of the land or it gives information about the topology.	Plate 12
13	Rocky Island	Aboadze	Resistant Rock to wave erosion and dissipate wave energy	Plate 13

5.3 Shoreline classification

The shoreline was classified using four main beach features (see Figure 16)

i. **Fine sandy beaches:** These are mainly found east of estuaries where streams and rivers contribute fine materials to other particles being moved along by the long shore drift in an easterly direction. Fine sandy beaches exist in many areas, even behind rocky areas where strong waves at high tide are capable of selectively depositing such materials along the coast.

ii. **Coarse sand beaches:** These exist east of promontories where sea erosion is intensive and materials eroded from the cliff faces are deposited by the long shore drift of particles eastwards. These beaches are very narrow and not widespread.

iii. **Submerged rocks backed by fine sandy beaches**: These are also common and their formation may be related to the rough nature of the beach forcing coarse materials to be deposited whilst the finer particles are able to reach the coastline where they are deposited.

iv. **Rocky Coasts:** These are common in areas where promontories are found. Along the Shama District coast, the following rock outcrops were observed: granites, gneisses, granodiorites, metamorphosed schist of the lower Birrimian and Elmina sandstone. The latter outcrops are mainly at Aboesi and Aboadze. Each of these rocks responds differently to sea erosion. The Elmina sandstone displays spectacular features of erosion on the surface caused by potholing and constant sand-blasting. The other rocks are more resistant to sea erosion.

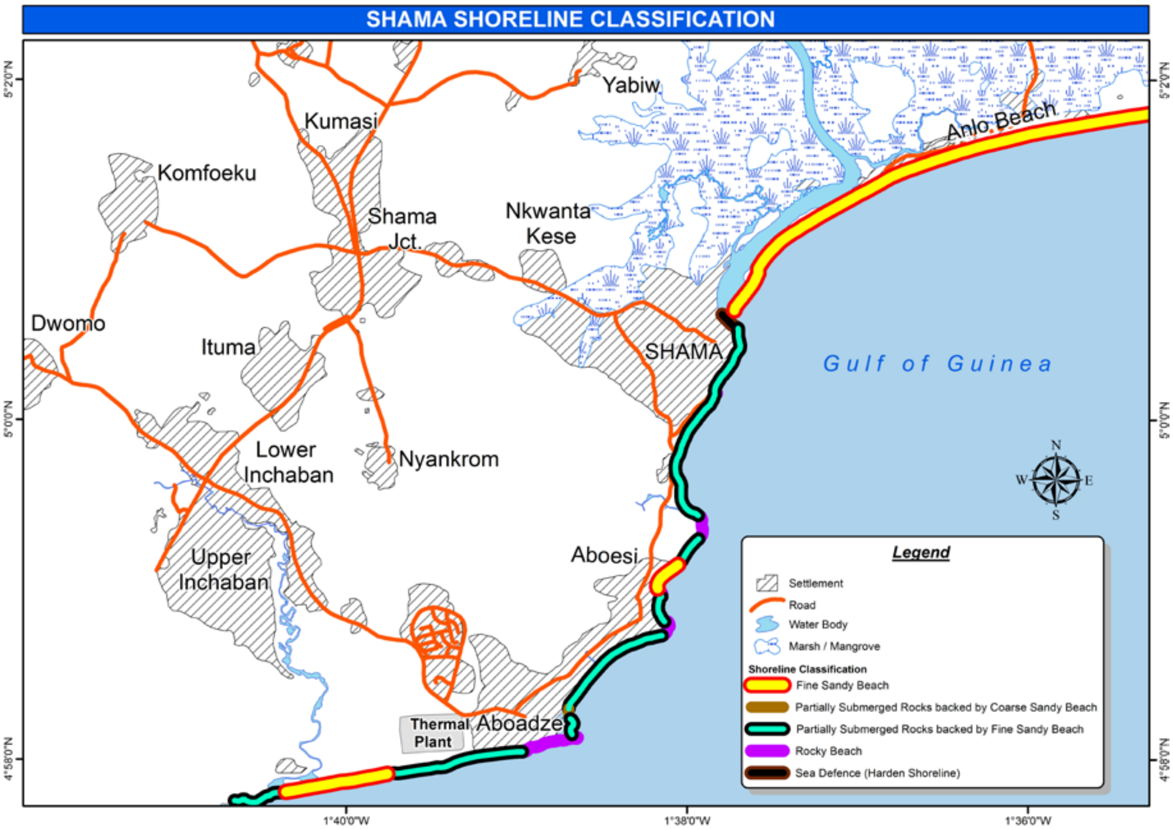


Figure 24: Shoreline classifications for Shama Area.

5.4 The Anlo Beach

This is the most prominent beach in the Shama District. It is more than 170m wide in its mid-section tapering longitudinally eastwards but curving at the Pra estuary. By the nature of its form, its formation may have originated offshore and gradually moved onshore towards the land blocking the former estuary of the Pra and pushing it westwards. It is evident that the Pra provided an enormous amount of sediment to the long shore drift of material in its formation. The meeting of the muddy waters of the Pra and the long-shore drift of beach material provided the materials that built the bar.

The Anglo beach is one of the most beautiful beaches in Ghana in terms of its length and width. It can be developed into a tourism facility using local architecture and involving the local community in its development. Mangroves are common in many places behind the estuaries; it is more widespread and well developed in the wetlands of the Pra floodplains behind the Anglo bar beach.

Table 9: Summary of specific deliverable products for Task IV

NO:	TYPE OF PRODUCT	QUANTITY	HARD COPY	SOFT COPY	REMARKS
1	Shoreline Feature Identification map	1	YES	JPEG & PDF	
2	Shoreline Classification map	1	YES	JPEG & PDF	
3	Map showing Shoreline Measurement	1	YES	JPEG & PDF	
4	Map showing barrier beach	1	YES	JPEG & PDF	

5.5 References

Ackom, Edward Kofi 2009 Flood Modelling and Simulation Using Hydrodynamic Model and GIS, A Case Study of Odaw River Basin in Accra, Ghana Master's Thesis 2009

Hague,C.,Wakely,P.,Crespin,J.and Hasko,C.(2006) Making Planning work: A guide to Approaches and Skills,Warwickshire:Intermidiate Technology Publications Ltd.

Hiraskar, A.K.(1993) Fundamentals of Town Planning,Delhi:Dhantpat Rai & Sons.

Nyarko, B.K. Application of a Rational Model in GIS For Flood Risk Assessment in Accra in Journal of Spatial Hydrology, Vol. 2, No 1, Spring 2002

UNESCO (1971) Flood Studies: An international guide for collection and processing of data, UNESCO, France.

UNESCO (1978) Researches in Urban hydrology: A contribution to International Hydrological Program UNESCO Vol. 2: 13-20.

US Soil Conservation Service (1964) Hydrology: Section 4 SCS national Engineering Handbook, Washington D.C. US Soil Conservation Service.

Viessman, W. Jr. and Lewis, G.L. (1996) **Introduction to Hydrology,** Happer Collins College Publishers, New York.

WL | Delft Hydraulics (2006): SOBEK Online Help

APPENDIX 1: LIST OF PLATES

Plate 1: Promontories

Plate 2: Anlo Barrier Beach

Plate 3: Aboadze Rocky Cliff

Plate 4i: Pra Estuary

Plate 4ii: Aminano Estuary

Plate 7 i: Shama Sea Defence Wall

Plate 7 ii: Shama Sea Defence Wall

Plate 7 iii: Shama Sea Defence Wall

Plate 8 i: Shama Collapsed Sea Defence Wall

Plate 8 ii: Shama Collapsed Sea Defence Wall

Plate 9: Aboesi Bay

Plate 10i: Anlo Beach Mangrove

Plate 10ii: Mangrove at Aminano Estuary

Plate 11: Built-Up area close to Shama Beach

Plate 12: Aminano River

Plate 13: Rocky Island at Aboadze

Plate 14i: Rock Outcrop at Aboadze

Plate 14ii: Rock Outcrop between Shama and Aboadze

Plate 14iii: Rocky Coast

Plate 15i: Effects of Erosion at Krobo


Plate 15ii: Effects of Sea Erosion at Aboesi

Plate 15iii: Effects of Sea Erosion at Shama Beach

Plate 15iv: Effects of Sea Erosion at Shama Beach (uprooted coconut tree)

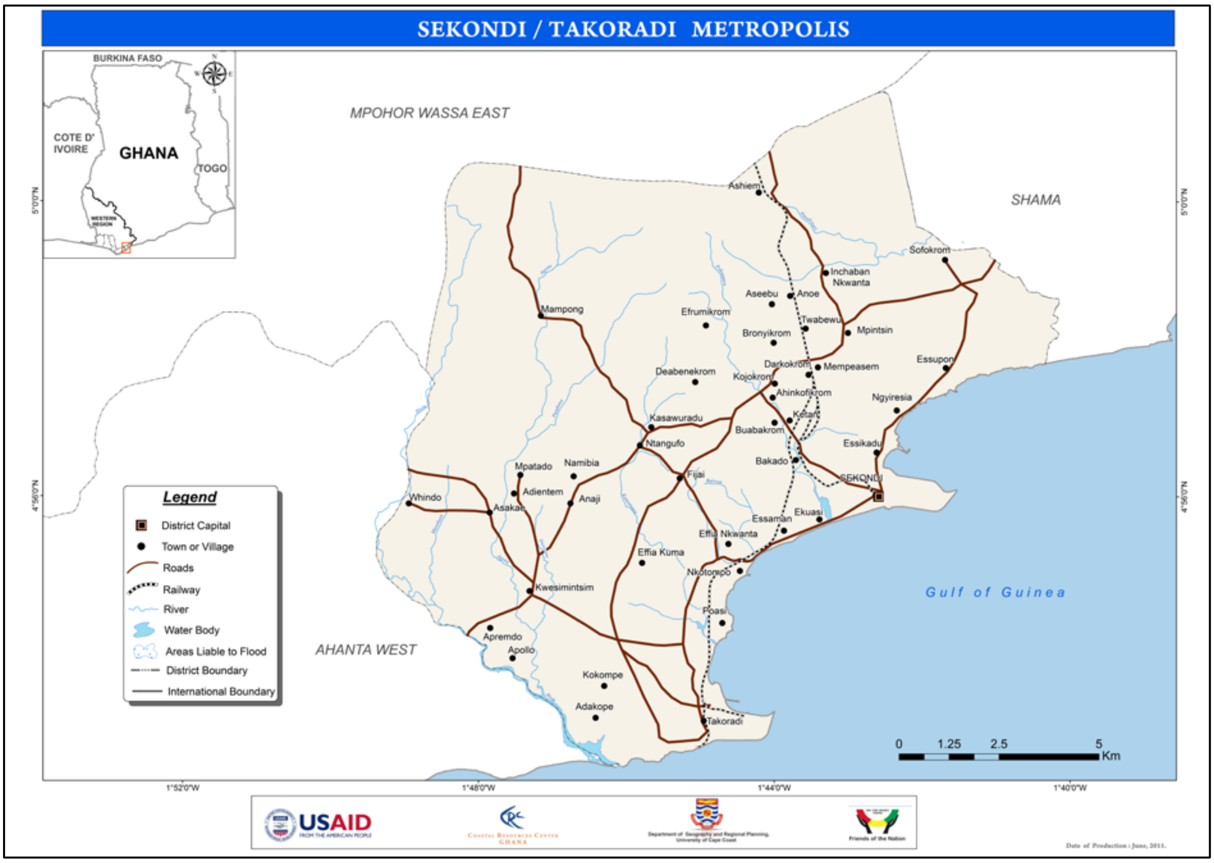
Plate 16i: Sea Weeds mixed with solid waste at Shama

Plate 16i: Rock Outcrop at Aboadze (men defecating section)

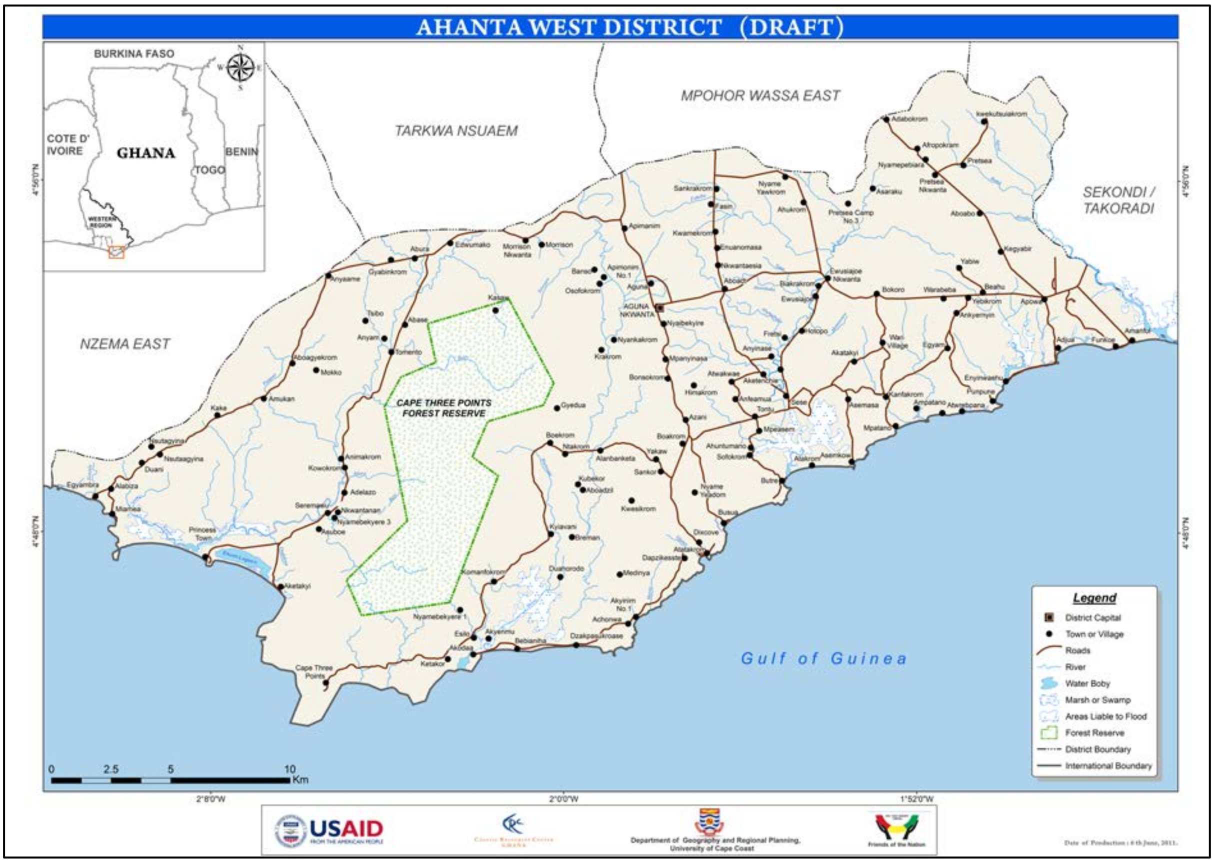
Plate 16ii: Rock Outcrop at Aboadze (women defecating section)

Plate 16iii: Rock Outcrop at Aboadze (accumulating waste)

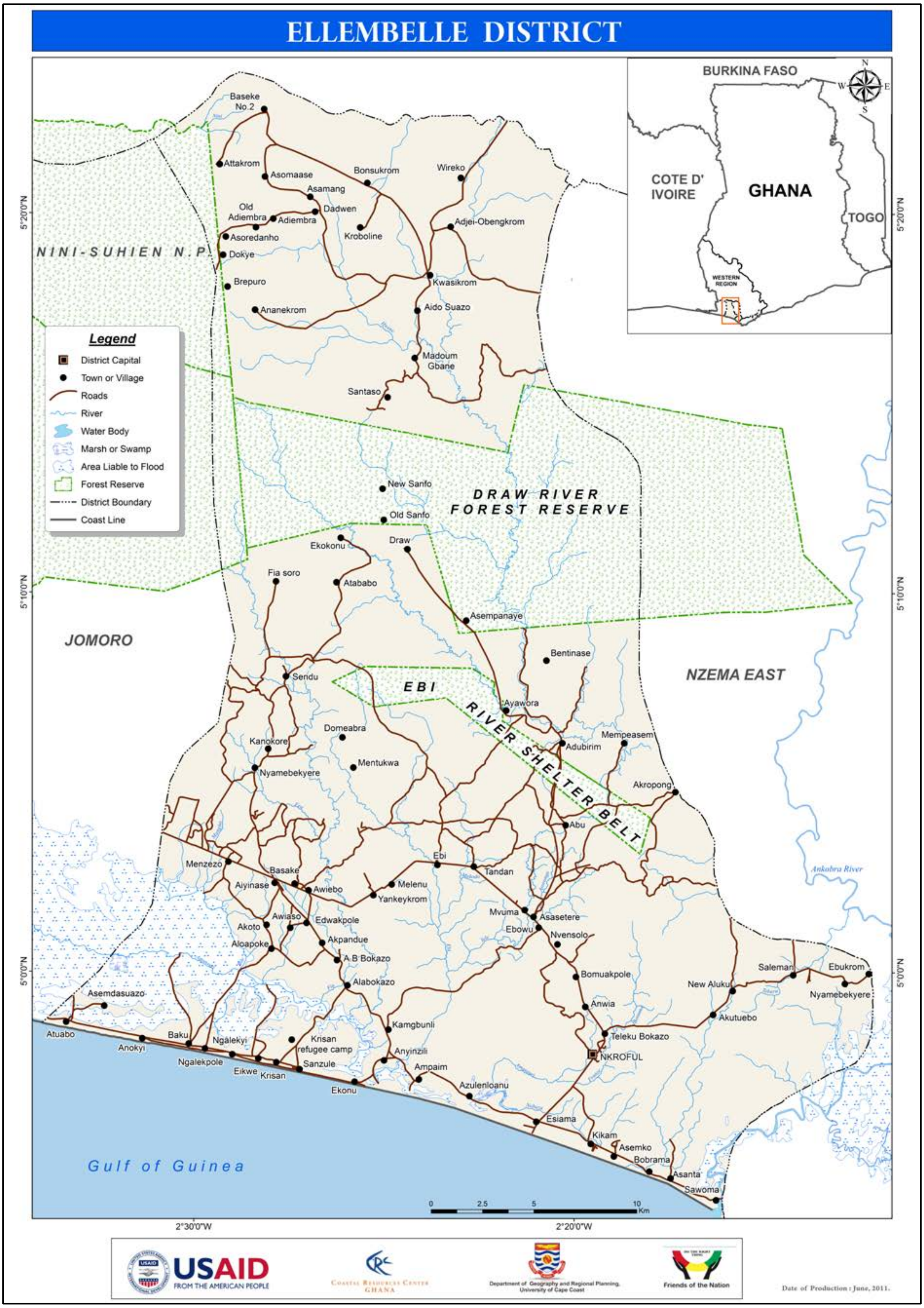
General Reference Maps



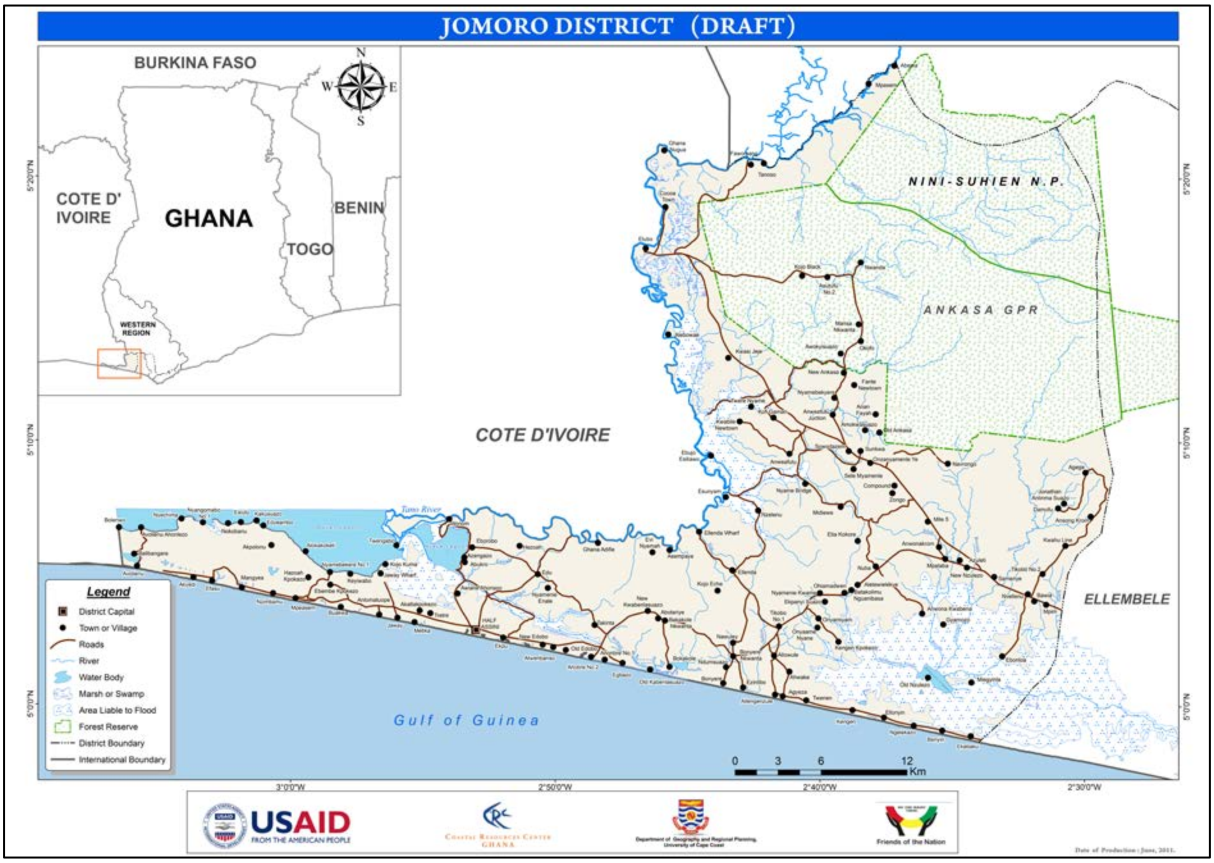
Map i: Sekondi / Takoradi Metropolis



Map ii: Ahanta West District

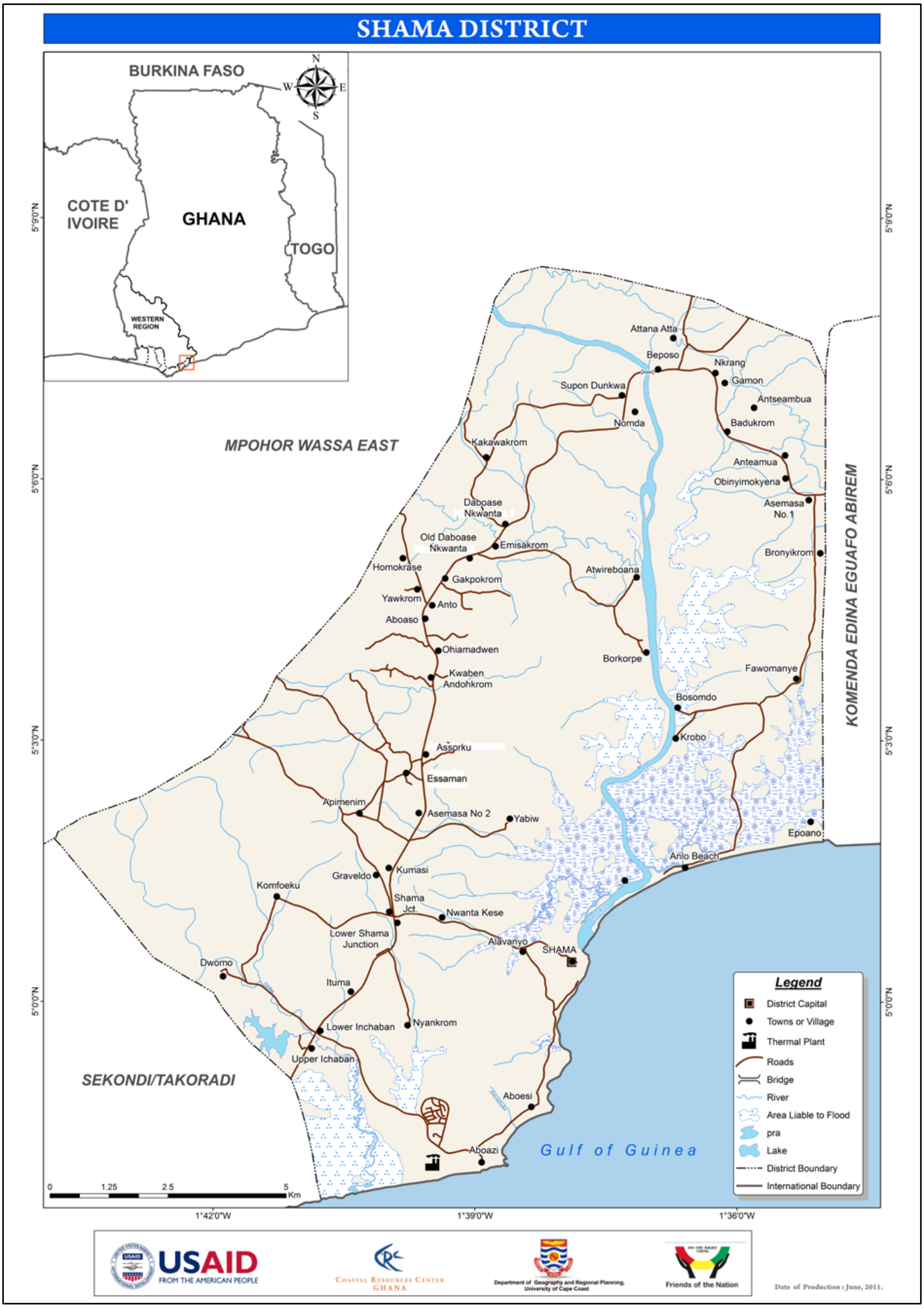


Map iii: Ellembele District



Map iv: Jomoro District

Map v: Nzema East Municipal



Map v: Shama District