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Report of the

Volta Delta

Status and trends

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Summary

This baseline assessment presented here was carried out by the Ghana Wing as well as secondary sources is a requirement for full membership of Delta Alliance and was commissioned by the Delta Alliance Secretariat in The Netherlands.

The Volta Delta is relatively small and rural compared to other deltas across the world but very unique due to its dynamic nature. Like most deltas it is a hot spot for biodiversity (migratory birds, sea turtle and sitatunga; an amphibious antelope) providing rich resources for sustenance of its communities and Ghana.. The results revealed that Volta Delta has a youthful population below 1 million people that is characterised by high levels of migration to other areas in Ghana and internationally. The major economic activities include agriculture, fisheries with an increasing services sector. Livestock farming, mat and basket weaving from reeds and mangrove farming for fuel wood, ensure diversified livelihoods options. Its abundant water resources (fresh, brackish and marine) and extensive sandy beaches, history arts and culture provide opportunities for eco-tourism, which are yet to be developed. Sea level rise, draught and flood are the main climate change effects. There has been increasing incidence of coastal flooding and erosion within the delta as a result of sea level rise with less variation in temperature. It has also been documented that Akosombo, Kpong and Bui dams upstream have implication for sediment flows with severe coastal erosion being experienced in the Volta Delta. Along the coast there is increasing expansion in small scale community irrigation facilities with increasing use of agro-chemicals. The major infrastructure along the coast include the sea defence structures to control rates of erosion and flooding of coastal communities and also expansion of the telecommunication, road network and transport infrastructure. The Volta delta has no delta specific policies and benefits from policies for water resources, riparian buffer and wetlands including traditional norms. The current actions of government to construct a harbour in Keta and oil and gas exploitation have implication for the future development of the Volta Delta. For a better understanding of the complex interrelationship among the various drivers of change in the delta, it is recommended that the following needs are considered:

- To further study the hydrology of the Volta delta in relation to groundwater extraction, impacts of sea level rise on the wetlands and the implications for salt water intrusion;
- Understanding the phenomena of subsidence in the Volta Delta is critical and the estimation of relative sea level rise;
- Land use and spatial planning is a prime action urgently needed to ensure sustainable development of the Volta Delta;
- Total economic valuation and cost benefit analysis is needed to enable the nature and path ways to sustainable development of the Volta Delta;
- There is also the need to investigate multiple livelihoods and livelihood diversification mechanisms by delta populations and connecting conservation to eco-tourism;
- The need for a proper participatory governance arrangement that ensure all critical stakeholders, including governmental agencies, and traditional authorities form part of the decision making and management of the Volta Delta resources including oil and gas exploitation.

Boxes, figures and tables

List of Abbreviations

CSO	Civil Society Organization
DDT	Dichloro diphenyl trichloroethane
DECCMA	Climate Change Migration and Adaptation
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
KSDP	Keta Sea Defence Project
KVIP	Kumasi Ventilated Improved Pit
NADMO	National Disaster Management Organization
NGO	Non-governmental Organization
PPP	Public-Private Partnership
UCC	University of C ape Coast
UG	University of Ghana
SLAM	Sea Level Rise Affecting Marshes
SNV	Netherlands Development Organization
UAVs	Unmanned Aerial Vehicles

Introduction: The Volta Delta, current and future state

Chapter 1

This chapter presents information for districts within the 5-metre contour of the Volta Delta. Socioeconomic and biophysical information is limited to Ningo-Prampram, Ada West, Ada East, South Tongu, Keta and Ketu South. All other districts within the boundaries of 5-metre contour but that are not wholly within the delta are excluded (Central Tongu, Akatsi South, Ketu North).

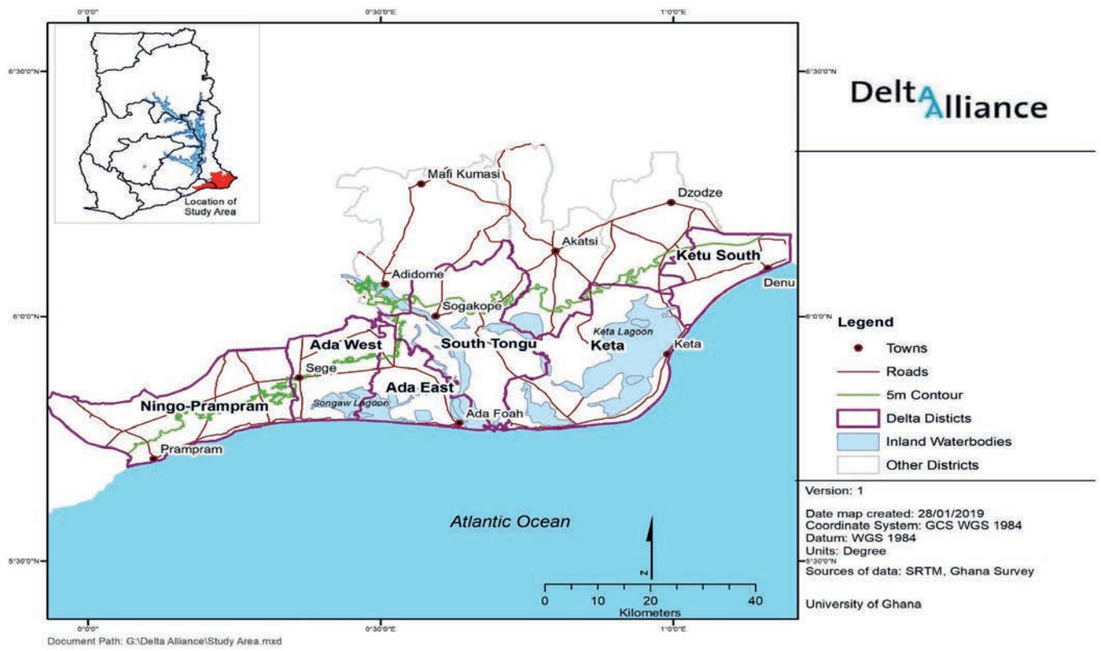

Figure 1, *Map of the Volta Delta*[1]

1 The immediate coastal delta districts are numbered 14-18. The south of Dangme West (14) is now Ningo-Prampram while Dangme East (15) has currently been divided into Ada West and Ada East.

1.1 Drivers of change

Summary of drivers of change

Anthropogenic and natural factors interact to drive change in the Volta Delta.

Demographic trends: The population of the Volta Delta is projected to be ca 600000 with a density of about 210 people per square kilometre and a population growth rate of about 1.6%, lower than the national average of 2.1%. The population is youthful with about two-fifth of its population under 15 years and a sex ratio of about 87 males per 100 females.

The delta is a migrant sending area to international destinations as well as within Ghana and even intra-delta. On the other hand, the sprawling cities of Accra and Tema extend into areas of the delta with both private sector and government housing projects in the delta.

Economic developments: The main livelihood activities of the working age population include agriculture, fisheries (marine & fresh water), and services such as commerce, infrastructural development, trade and transportation, indicating a structural transformation of economic livelihoods. While the services sector may represent the highest main economic activity, people in the service sector may engage in farming, fisheries and livestock keeping as supplementary livelihoods. The grasslands provide pasture for livestock farming and raw materials for mat and basket weaving; the mangroves provide fuelwood and the diversified land and water resources provide opportunities for eco-tourism, arts and crafts as common livelihood sources.

Climate change and variability: The Volta Delta lies within the south-eastern coastal savannah belt which is among the driest parts of Ghana. While temperatures have not varied much, precipitation patterns and volumes show more variability in the recent past. There has been increasing incidence of coastal flooding and erosion within the delta as a result of sea level rise (Appeaning Addo et al., 2018).

Subsidence and erosion: Although subsidence has not been measured in the delta, it is estimated to be between 1 and 2 millimetres (mm) per year based on other deltas around the world. Several Delta areas are dominated by high erosion rates reaching up to 4-8m/year leading to destruction of properties and key infrastructure as well as livelihoods along the coast.

Technological developments: Major technological improvements along the coast of the delta have been in the form of sea defence structures to control rates of erosion and flooding of coastal communities. Also, the construction of two dams (Akosombo and Kpong) upstream of the Volta river have restricted water and sediment flow as well as the population of freshwater fish, nutrients and other organisms into the lower Volta Basin where the delta lies. Sediment reduction has affected the evolution and possibly increased the level of subsidence. Other major technological developments include expansion of the telecommunication, road network and transport infrastructure. In the agricultural sector, there is increasing irrigation and mulching particularly in coastal communities in Keta and Ada East while fertiliser use is rapidly expanding.

Government policies and interventions: While there are no specific delta policies, the existing integrated water management policies, riparian and buffer zone policies as well as forest and mangrove protection policies apply to the delta's ecosystem protection. Traditional norms and values including taboos such as non-fishing/farming days, sacred water bodies and groves, continue to be relevant for natural resource management in the delta area.

Government interventions in the form of sea defence structures, resettlement schemes have helped reduce the impacts of coastal erosion and flooding among populations in the Volta Delta while nationwide interventions such as agricultural input subsidy programmes and livelihoods empowerment against poverty (LEAP) among others help alleviate economic vulnerabilities among populations in the Volta Delta. Plans to prospect for oil and construct a harbour in Keta also have implications for the state of the delta in future.

Research gaps

1. There is little understanding of the complex interrelationship among the various drivers of change in the delta.
2. An assessment of the impacts of sea level rise on the wetlands is required.
3. There is scanty information on groundwater extraction in the Volta Delta.
4. There is need for measurement of subsidence and estimation of relative sea level rise.
5. Socioeconomic and demographic characteristics in the delta need to be updated with regular and quality data.
6. There is also need to investigate multiple livelihoods and livelihood diversification mechanisms by delta populations.

Box 1: *Summary of drivers of Change and research gaps*

Socio-economics (population growth-migration, economic development and most relevant sectoral developments, e.g. for agriculture, fisheries, industry)

Evolution of key climate elements

With a population of about 600,000 in 2010 and a growth rate of about 1.6 % per annum the Volta delta population is projected to be over 1,100,000 by 2050. About 61% of the population resided in rural areas but with the current urbanisation trends nationally, the proportion of urban is expected to increase by 2050. The delta area has a sex ratio of 87 males per 100 females owing to the relatively higher out-migration rates among males. This is also associated with the higher rates of female household headship within the delta area compared with the rest of Ghana (DECCMA Project, 2018). Similarly, dependency ratio is high in the Volta Delta with about 84 dependent age population (aged under 15 and over 64 years) per working age population (aged 15-64 years) (Appeaning Addo et al., 2018). Generally, the Volta Delta area is a high migrant-sending area as the delta is largely rural. Fisher folks travel either seasonally or permanently along the West African coast and upstream the Volta River to engage in artisanal fisheries while Tema and Accra are also popular urban destinations for migrants from the delta area (Atiglo & Codjoe, 2015).

Economic development and industry

Economic activities are diverse but are predominantly primary or natural resource driven. Agriculture, fishing, livestock rearing, salt mining and arts and crafts (textile, ceramics, straw weaving etc.) are among the most important livelihood sources for households in the Volta Delta (Appeaning Addo et al., 2018). Agriculture, predominantly subsistence, is a very important and common part of livelihoods in the Volta Delta. The major crops cultivated in the delta include maize, rice, cassava, okra, water melon, tomato, shallots and other vegetables. Livestock and poultry mainly involves the keeping of goats, sheep, pigs, chicken and ducks in the house while some households, in very few areas, are engaged in cattle rearing. People engage in multiple economic activities both seasonally and perennially. In most households, people continue to engage in agricultural and other natural resource-dependent activities aside their main livelihood activities in the manufacturing and services sectors. Commercial activities have driven the transformation of main economic activities towards trade, transport, tourism and small to medium scale manufacturing activities. The gradual shift from natural resource-dependent livelihoods towards services sector indicates a structural transformation of economic livelihoods across the nation. Projections indicate that the manufacturing and services sectors are likely to overtake the agricultural sector as the leading economic activities (Osei-Wusu et al., 2016). Home to some designated RAMSAR sites, colonial relics, beautiful sandy beaches, migratory bird species, turtle breeding sites and traditional cultural practices, ecotourism is an emerging industry with the potential for further development and expansion. Before the construction of the Akosombo Dam in 1964, clam picking, fishing and farming were widespread and lucrative in the lower delta region (Tsikata, 2006). Construction of the Bui dam further upstream in 2013 has also affected economic activities downstream. Periodic opening of the Bagri dam in Burkina Faso also affect sources livelihoods through flooding. Future port developments and oil exploration have the potential to affect coastal processes in the delta.

Climate change (temperature, sea level rise, precipitation/discharge)

Located in the south-eastern corner of Ghana, the Volta Delta lies in the coastal savannah climatic zone which is mainly semi-arid and among the driest regions of Ghana. Temperature is rarely below 25°C and the mean annual temperature is between 27°C and 28°C (Andah et al., 2003). Temperatures are hottest between March and April while the driest period is around January. These values under climate change are projected to increase by up to 1.7°C by the end of the century (Kebede et al., 2018). Average annual rainfall is generally low ranging between 146mm and 750mm between years (Awadzi et al., 2008) while annual evaporation rates are relatively higher averaging about 1785mm per year (Yidana & Chegbeleh, 2013). The area is characterised by a double maximum rainfall pattern: the major season falls between March and July and the minor season between August and November (Yidana and Chegbeleh, 2013;

Appeaning Addo et al., 2018). However, precipitation patterns in recent years show more variability and deviation from this (Appeaning Addo et al., 2018). For the future scenarios, lower values of rainfall are expected to drop further by 25% while higher values will increase by as much as 40% (Kebede et al., 2018).

River discharge

Prior to the construction of the Akosombo Dam in 1964, the discharge from the Volta River varied from 1000m3/s in the dry season to as high as 6000m3/s in the rainy season (Anthony, 2015). The discharge reduced drastically with peaks less than 2300m3/s during dam releases (Logah et al., 2017). This reduction in flow affected sediment supply as well as agricultural activities that rely on the river bank flooding. The sediment reduction has possibly increased subsidence and affected the delta evolution. Future modelling indicates, however, that outflows from the lake will increase by 10% toward the end of the century (Jin et al., 2018)

Sea level Rise

Sea levels are rising at an estimated rate of about 3.1mm/year and expected to accelerate significantly as a result of the changing climate (Sagoe-Addy & Appeaning Addo, 2013; Evadzi et al., 2017). Sea level rise results in coastal inundation, erosion and saline intrusion which can consequently destroy coastal infrastructure and disrupt livelihoods. It has been established that, at the observed rate, sea level rise contributes about 31% of coastal erosion experienced along the coast of Ghana (Evadzi et al., 2017). Without any intervention, this is capable of inundating up to 20m of the delta coastal area by the year 2050 based on IPCC AR5 RCPs (Evadzi et al., 2017). Future scenarios estimate that sea level will rise by approximately 1.1m by the 2100 relative to the 2000 baseline (Kebede et al., 2018).

Subsidence (natural and human-induced)

Subsidence in the delta, though not measured, is estimated to be between 1 to 2 mm/year based on other deltas (Syvitski, 2008). This may be accelerated as there are plans advanced for oil and gas prospecting as well as increases in ground water abstraction in the delta region. This will contribute to local impacts of sea level rise (Ericson et al., 2006).

Erosion

Due to the geology along the delta coast which is characterised mainly by recent unconsolidated sand, clay and gravel, coupled with the high energy and sea level rise, the entire deltaic coastline is vulnerable to erosion (Kumapley, 1989). Reported rates vary from about 4-8m/year in Keta to about 6m/year in Totope-Ada (Appeaning Addo et al., 2018). The high rates of erosion over the past decades have resulted in the destruction of properties, loss of lives and livelihoods in areas along the coast, particularly in Keta, Fuveme and old Ningo (Figure 2). There are, however, areas along the coast that have experienced some accretion in recent years, particularly due to the effects of coastal engineering procedures (Dovie, 2017). Figure 2 shows the spatial pattern of erosion and accretion in the Delta.

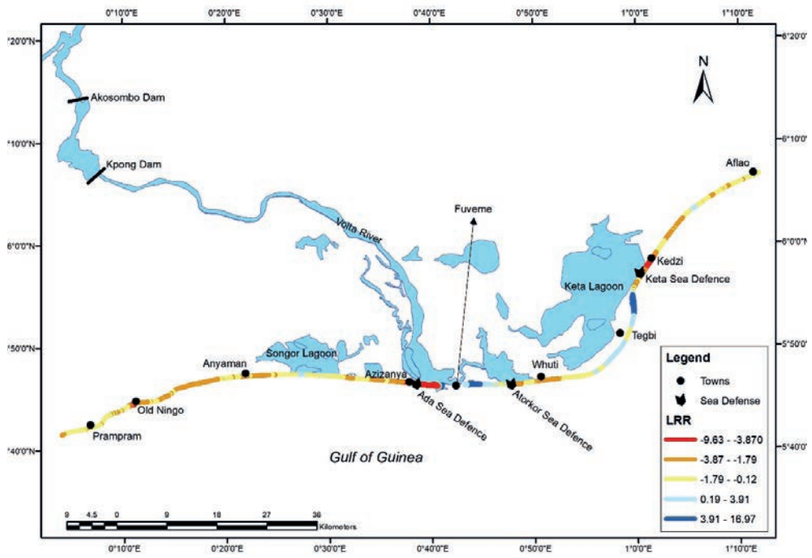

Figure 2: *Map Showing Erosion and Accretion Patterns and the Location of Dams and Sea Defence Sites.*

Technological/infrastructural developments

Technological advancement may not be currently having a major impact in the delta. Technological infrastructure development is quite limited in the Volta Delta. Although agriculture is widespread, it is predominantly rain-fed with irrigation limited to major towns and cities within the Delta. Some of the major industries found in the region include a cement manufacturing industry close to the border with Togo, mechanical salt extraction farm, a rice processing factoring. Due to the high risk of erosion and coastal flooding in the past, the government of Ghana has constructed sea defence walls along the coast of the delta area particularly at erosion hotspots in Keta, Akplorwotorkor and Ada.

The exploration of oil and gas in the Keta Basin and Volta basin area above the dam, and the proposed construction of a port in Keta (Appeaning Addo et al., 2018) are expected to lead to future impacts on the delta environment with regards to subsidence, erosion and flooding. These activities have the potential to attract investments to the Volta delta to stimulate economic growth and would need careful planning to ensure adaptive management of the delta. There is however, plans by Water Resources Commission to set up the Southern Volta River Basin Board; a multi-stakeholder governing body for decision making and to support the local governments to plan for sustainable management of the delta areas. There is also an on-going project preparation by the UN Habitat to Adaptation Fund to build community climate change resilience systems and improve livelihoods with special emphasis on land use planning and spatial planning.

1.2 Pressures – potential problems / Challenges – opportunities

Land and water use (Occupation layer)

Summary of pressures

Land and water use

Urban development both within and beyond the delta directly or indirectly exert pressure on land and water resources for domestic, agricultural and industrial use within the delta. For communities along the coast, land area is further threatened by coastal erosion. However, there are efforts by the central government towards sea defence and land reclamation technologies.

Sea level rise

Vulnerability to flooding and erosion The topography and geology of the delta makes it largely vulnerable to flooding and erosion. However, anthropogenic activities exacerbate the vulnerability of the delta system to flooding and erosion. Areas down-drift the defence structures have been affected by increased erosion and flooding due to the construction defence systems along the coast. Tidal floods continue to devastate properties and livelihoods in vulnerable areas not protected. Inland flooding occurs during the rainy season when rivers and lagoons overflow their banks.

Saltwater intrusion Sea level rise, high temperatures and minimal freshwater inflow increases the risk of saline intrusion in deltas.

Drought

There is a high risk level of agricultural drought in the delta as people are mainly engaged in rain-fed agriculture. The delta area is among the driest parts in Ghana.

Overfishing

The use of outlawed fishing gears including the use of lights, harmful chemicals and inappropriate fishing nets mesh sizes lead to overfishing in the delta. These can be linked to the rapid population growth and high demand for fish as well as the structural transformation of the delta economies. Although there are regulations against these activities, enforcement has been a major problem.

Mangrove destruction Growing populations imply growing demand and dependence on mangroves for fuelwood and construction material in the delta wetlands.

NGOs partner with local communities to replant mangroves in order to curb the rapid rates of mangrove destruction in the delta.

Research gaps

- Lack of high resolution hydrological, fishery, land cover/ uses, and erosion data makes the estimation of pressure on the delta area difficult.
- There is limited information on the quantification of ecosystem services in the delta.
- High resolution estimation of mangrove cover in the delta is necessary.

Box 2: *Summary of Pressures; Occupational layer and research gaps*

The predominant land use type in the delta is cropland, with mostly rain-fed agricultural practices (DECCMA Project, 2018). It covers about 39% of the land area, followed by wetlands (including rivers and lagoons) 32% and savanna grassland 14%, which is also used as pastureland (Figure 3). The built-up environment accounts for only 2% of the land use.

The urban expansion of Accra and Tema has created the need for more residential and industrial spatial developments which are gradually encroaching the delta area. Currently, private developers and the government have turned to developing areas in the delta such as Saglemi and Dawhenya (Ningo-Prampram District) for large-scale residential areas.

Another source of threat to the delta land is the extraction industry which seeks to exploit the fragile delta ecosystem for its resources including the potential for oil exploration and large scale salt mining. Sub-surface and groundwater, based irrigation systems have increasingly become common for crop farming, particularly in the Keta Basin (Namara et al., 2011) and the Ada basins. These mainly involve the development of permanent shallow wells where distribution is mainly done by hand or motor pump or the use of shallow tube-well systems (Namara et al., 2011). With further population growth and an incommensurate increase in treated/improved surface water systems, there is the likelihood of an increased pressure on underground water systems in the delta.

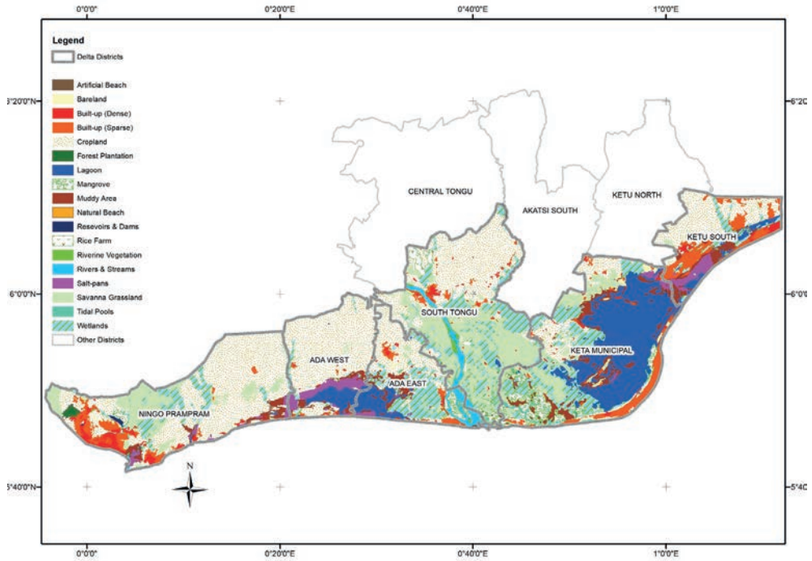

Figure 3: *Land cover map of the Volta Delta (Source: DECCMA Project, 2018)*

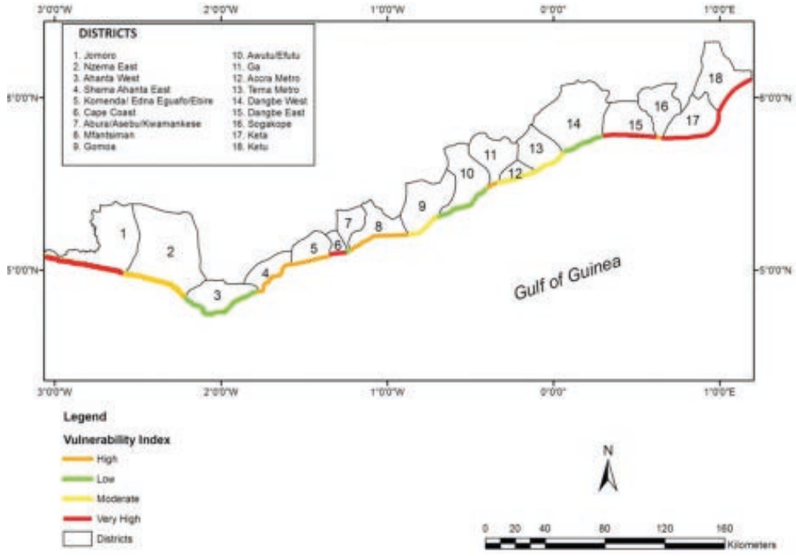

Figure 4: *Vulnerability index along the coast of Ghana using physical factors including erosion and sea level rise and population density (Boateng et al.,2017)[2].*

2 *The immediate coastal delta districts are numbered 14-18. The south of Dangme West (14) is now Ningo-Prampram while Dangme East (15) has currently been divided into Ada West and Ada East.*

Vulnerability to flooding and erosion

The Volta Delta is at risk from increased exposure to flooding and erosion as a result of rising sea levels (Tessler et al., 2015; Appeaning Addo et al., 2018b). Both flooding from the ocean and inland water is experienced in the area. However, tidal flooding is more common and continues to displace people. Furthermore, increasing erosion in the delta is leading to the destruction of coastal infrastructure including roads and houses, landing sites for fishermen as well as loss of recreational and farm lands. For example, in Fuveme (a coastal community near the estuary), tidal flooding has destroyed over 77 houses including the only school in the community and displaced over 300 people between 2005 and 2017 (Appeaning Addo et al., 2018b). These trends are projected to worsen putting more pressure on the already fragile system. Figure 4 shows that the vulnerability of the Volta delta shoreline is very high relative to adjacent shorelines in Ghana.

Salt water Intrusion

As the sea level continues to rise and high temperatures persist in the delta area, the risk of saline intrusion is high, particularly during the dry season where freshwater discharge from upstream or precipitation is low (Kortatsi et al., 2005; Yidana & Chegbeleh, 2013).

Figure 5: *Vegetable farming in Anloga area of the Volta Delta (experiencing sea water intrusion)*

Infrastructure (network layer)

Summary of pressures

Dam construction for hydropower generation: The Akosombo and Kpong Dams were built in 1965 and 1982 respectively to provide hydropower for the nation. This changed the hydrodynamics of the river affecting livelihoods and increasing erosion

Sea defence: Between 2005 and 2014 a number of sea defence structures have been constructed to protect about 26.2km of the delta coastline using mostly hard engineering approaches.

Irrigation and drainage: Hand dug wells are popularly used on the vegetable farms along the Keta Lagoon. Tube well and sprinkler irrigation systems are also increasingly being used by smallholder farms in the Delta.

Water supply and sanitation: The main source of water for drinking and household consumption is pipe-borne. However, wells and open water sources such as streams, ponds and dugouts are also common. The main toilet facilities include pit latrines and the Kumasi Ventilated Improved Pit (KVIP). Many households without toilet facilities resort to bush or beach or field for open defecation.

Roads and navigation channels: The road network within the delta spans about 1500km with feeder roads dominating (57%). The river is used for transporting goods and people to communities inaccessible by road. No railway is available in the delta

Research gaps

- Studies on alternative forms of sea defence in the delta to manage erosion
- Assessing the extent of irrigation farming in the Delta and its impact on ground water
- Assessing the use of the River as a means of transport

Box 3: *Summary Pressures; network layer*

The Volta Delta, current and future state

Chapter 1

Dam construction for hydropower generation

The Akosombo Dam was completed in 1965, forming the largest made-made lake in Africa and the world - the Volta Lake. Further downstream is the relatively smaller Kpong Dam which was completed in 1982 (Ofosu et al., 2017). The construction modified the hydrology of the River resulting in the reduced floodplain agriculture and increase in snail vectors for bilharzias. Before the construction of the dam sediment supply to the coast was estimated to be about 7.5million m3/ year but reduced drastically after the construction of the dam (Bollen et al., 2011). Consequently, there has been an increase in coastal erosion along the deltaic coast.

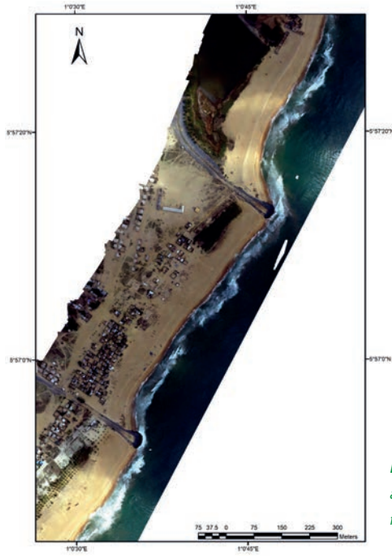

Figure 6: *Constructed groynes at Keta protecting the community from erosion*

Sea defence

In response to the chronic erosion along the deltaic coast a number of sea defence projects have been put in place. These include the Keta Sea Defence Project (KSDP) which was completed in 2005. The KSDP consisted of a revetment, six large headlands and beach fill covering about 7.5km of the coast. The project was followed by the Dzita-Atorkor and the Ada Sea defence projects in 2013 and 2015 respectively. The Dzita-Atorkor sea defence covered 2.7km with a revetment and a down-drift groyne field. The Ada Sea Defence project is the longest stretching about 16 km and consists mainly of groynes with some beach nourishment (Roest, 2018; Bolle et al., 2015 and Bollen et al., 2011).

Though these structures may be successful at reducing erosion locally, they are having negative impact on the 1down-drift coastline resulting in increased erosion (Angnuureng et al., 2013). Figure 3 shows a portion of the Keta sea defence groynes.

Irrigation and drainage

Irrigation farming in the delta is still under development with smallholder farms in major towns such as Keta and Ada using the tube well and other forms of irrigation. Due to the high water table, hand dug wells is a major source of irrigation along the coast. This is being replaced by mechanised irrigation systems such as tube well and sprinkler system by individual farms. Outside these settings, agriculture is predominantly rain fed. There is no reliable statistics on the number of irrigation farmers in the Delta.

Water supply and sanitation

The main source of water for drinking and household consumption is pipe-borne, however, wells and open water sources such as streams, ponds and dugouts are also common (Appeaning Addo et al., 2018). The main toilet facilities include pit latrines and the Kumasi Ventilated Improved Pit (KVIP). Many households without toilet facilities resort to bush or beach or field for open defecation.

Roads and waterways

The road network within the delta totals over 1500 km of roads with trunk roads accounting for about 23% (350 km). Feeder roads account for 57% (853 km) the remaining are mostly un-engineered and foot paths. There is no railway within the delta. The Volta River also provides a means of transport for the local people. It is used to transport for example mangroves and people (especially market across to communities along the River that are inaccessible by road.

1.3 Natural resources (base layer)1

Summary of pressures of natural resource layer

Summary of pressures

Mangroves: One of the largest population of mangrove along the coast of Ghana is located within the Volta Delta spanning over 8,900 hectares. This is however threatened by over exploitation due to urbanisation and fuelwood harvesting.

Protected Areas:Two major protected areas area are located in the delta: the Keta Lagoon complex and the Songor Lagoon Ramsar Sites covering over 150,000 ha of land. These areas are also threatened by overexploitation, coastal erosion and pollution.

Fish resources: The abundance of waterbodies in the delta promotes both inland and marine fishing in the Delta. There is great potentials for aquaculture development on the Volta River. Illegal fishing methods in the marine domain is affecting fish stocks negatively.

Research gaps

- Studies on population growth and mangrove dynamics as well as the
- Fish stock assessment in the Volta Delta
- Research on ecosystem services, livelihood and economy of the Volta delta

Box 4: *Summary of Pressure: Natural resource layer*

Mangroves

One of the largest populations of mangrove along the coast of Ghana is located within the Volta Delta. It covers an estimated area of approximately 8,900 hectares with the two dominant species being the red and black mangroves (Rhizophora and Avicennia respectively). The mangrove population is however threatened by overexploitation as a large proportion of households in the delta rely on wood as their main source of cooking fuel and livelihood (Appeaning Addo et al., 2018a). Furthermore, other land uses such as aquaculture and urbanization as well as loss of alternative livelihoods are also putting pressure on the ecosystem (Rubin et al., 1998). To curb this, some NGOs have partnered local communities with the delta (e.g. at Anyanui) to replant mangroves to sustain local livelihoods.

Protected Areas

The delta area includes 2 major protected areas namely the Keta Lagoon complex Ramsar site and the Songor Lagoon Ramsar site. According to the RAMSAR Secretariat, the Keta complex covers approximately 101,000 ha while the Songor covers approximately 51,700ha[3]. Both sites were designated on 14th February, 1992. These areas offer valuable ecosystem services such as safe nesting ground for threatened sea turtle species including olive ridley and leatherback, resident and migratory birds and support livelihoods of many people including fishing and mangrove harvesting. These protected areas are however threatened with over exploitation of resources, coastal erosion and pollution.

Fish resources

Fishing is mainly carried out on the Volta River, the Keta and Songor Lagoons and the marine area. Fish stock have been steadily declining in the lower Volta and the coastal waters of Ghana. The growing delta population as well as close urban populations connote an increased demand for fish in southern Ghana. Hence, artisanal fishermen have resorted to illegal fishing practices such as the use of outlawed fishing gears including the use of lights, harmful chemicals and explosives and undersized fishing nets mesh sizes. The Volta River has great potential for aquaculture and some residents along the river, particularly downstream of the dam, engage in tilapia farming which has a thriving market in urban areas in Ghana.

3 https://rsis.ramsar.org/ris-search/?f[0]=regionCountry_en_ss%3AGhana&pagetab=1

1.4 Governance (institutional/organizational aspects of delta management)

Summary of governance issues

Summary of governance issues

Cooperation between levels and sectors of government: Although there is no delta specific body to manage the delta, governance structures at the local level and national policies exist to manage various sectors of development such as water, land, natural resources, wildlife etc. There is no specific coordinated delta management or governance structure and implementation of government plans and policies are undertaken by individual municipal and district assemblies.

Also, while there is usually a congruence between district and national policies, these may be at variance with local or traditional adaptation goals and community needs.

Cooperation between government and private sector: Ghana has a national policy on Public Private Partnerships (PPP) which seeks to leverage government resources with private sector human and capital resources towards developmental projects and activities.

Stakeholder and citizen involvement: Governance processes and implementation largely excludes local communities and stakeholders. Even though communities may be organised under traditional authorities these constitute a separate hierarchical system from the central government structure.

Approaches for dealing with risks and uncertainties: The National Disaster Management Plan of 2010 guides the NADMO to effectively and scientifically manage disasters in Ghana.

Research gaps

- Asymmetry between community needs and district or national development plans.
- Research on building capacity for coordination between government and stakeholders or private sector or non-governmental organisations
- Research into integrated delta management

Box 5: *Summary of Governance issues and research gaps*

Cooperation between levels and sectors of government

The delta region falls within the jurisdiction of 6 administrative districts (Ketu South, Keta, South Tongu, Ada East, Ada West and Ningo-Prampram) and 2 administrative regions (Volta and Greater-Accra) working under the national government (see Figure 1). There is no delta specific body to manage the delta. Other management units that fall within the Delta are the Ramsar, Environmental Protection Agency, Wildlife division, Forestry Commission and the Volta River Authority. There are also a number of NGOs and private institutions and associations that operate in the delta area.

At the community level, there are community leaders, traditional councils and community watch dogs. While there is usually a congruence between district and national policies, these may be at variance with local or traditional adaptation goals and community needs (Dovie, 2017; Owusu-Daaku & Diko, 2017). Also, national policies fall short of harmonising sectors for implementing adaptation strategies or climate change mainstreaming into development plans. This leaves an implementation gap where individual sectors (water, agriculture, health, energy etc.) respond differently to the challenges associated with delta or system vulnerabilities (Dovie, 2017). The municipal and district assemblies in the delta area are each responsible for managing the areas that fall within their jurisdictions.

Cooperation between government and private sector

The government of Ghana has over the years emphasised the role of the private sector as the engine of economic growth. This is emphasised in the National Policy on Public Private Partnerships by the Ministry of Finance and Economic Planning (2011). The private sector has been involved in the delta management in various ways. This includes infrastructure construction, purchasing and supply of agricultural inputs, water management, etc. Incentives

have been provided by the government for private sector participants in agribusiness among others. The Ghana Coordinated Programme of Economic and Social Development Policies identifies the potential to leverage private sector resources and expertise to provide economic and social infrastructure. This includes exploitation of natural resources and the provision of infrastructural and developmental services in the delta. A key challenge for the private sector persists in the areas of access to financial services and risk management.

Stakeholder and citizen involvement

Civil society and other stakeholders can get involved in policy formulation at different levels of the decision making process. Land rights are mainly customary giving authority to traditional leaders but they do not have constitutional rights for enforcing traditional laws or customary norms. Traditional authorities have some influence on community organisation and opinion formulation. They may represent their communities in dealing with government agencies or authorities and non-governmental organisations. Formulation of the National Adaptation Plan and the Nationally Determined Contributions involved extensive stakeholder participation. That notwithstanding, there exists asymmetry between the national and district level policy goals and community needs leading to interventions that are inconsistent with the livelihood adaptation goals of local communities (Dovie, 2017; Owusu-Daaku & Diko, 2017). District and national intervention programmes usually involve top-down approaches which do not incorporate community perceptions and needs as opposed to externally determined needs (Owusu-Daaku & Diko, 2017).

Approaches for dealing with risks and uncertainties

The National Disaster Management Organisation (NADMO) is the government agency responsible for disaster management at the national and sub-national levels. Among the approaches used in tackling uncertainties are early warning systems, evacuation plans and distribution of relief items. Depending on the extent or magnitude of damage, NADMO has been differentially efficient in managing risks and uncertainties. In times of severe events other security services including the police service, fire service and the armed forces have collaborated with NADMO in disaster management. Again, community members may tend to disagree with the relief approaches used by the agencies towards managing uncertainties.

National policies and strategies aimed at environmental protection in the delta include the National Water Policy; the National Wetlands Policy; the Wildlife Conservation Policy; the Tourism Development Policy, Land Management Policy; National Environmental Policy and National Disaster Management Plan. Relevant international protocols for protecting the delta include the Volta Basin Declaration on improved management of the natural resources of the Volta Basin (2002); United Nations Convention on the Law of the Sea (1985); Convention for the Cooperation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region (1981) and the Ramsar Convention (1971).

Overview of stakeholders regarding delta management issues

Key Stakeholders	Brief description of responsibilities and tasks regarding delta management Issues	Related Networks/Co-operation Structure
Fishermen Association		
Centre for Scientific and Industrial Research (CSIR)	scientific and technological research and policy support for national development	Coordinates various departments for water, health, food, building etc. research
Universities & academic institutions such as the University of Ghana	scientific research, dissemination, and training	Research and train the next generation of scientists
Policy makers (National level)		
• Ministry of Water Resources, Works and Housing • Ministry of Lands and Natural Resources • Ministry of Information • Ministry of Environment, Science Technology and Innovation • Ministry of Local Government and Rural Development • Ministry of Food and Agriculture • Coastal Development Authority • National Development • Planning Commission • Ghana Meteorological Agency • Environmental Protection Agency • National Disaster Management Organisation • Forestry Commission • Wildlife Division • Fisheries Commission • Ghana Tourism Authority	Policy development, planning and implementation	Inter-ministerial committee
Policy makers (sub-national level)		
• Regional Coordinating Council • District Assemblies	regional and district level planning and implementation, develop budget for the region and district	• Decentralisation • Regional Coordinating Councils (Act 462 & Act 482) • Regional Ministers' Conference • District Planning Coordinating units
Policy makers (local level)		
• Assembly Members • Unit Committees	• Local development planning and implementation • Contribute to grass root development planning and implementation	
Community leadership		
• Traditional authority (chiefs, queen mothers etc.) • Opinion leaders (religious leaders, community groups/associations)	Preservation of cultural heritage and community representation	• Traditional Councils • House of Chiefs • They ensure adherence to traditional norms
Developers		
• Private sector • NGOs • Wildlife Association of Ghana, Friends of River and Water Bodies, CSOs • Development partners • Netherlands and European Development Organisation	Urban and rural development projects, local empowerment, environmental protection, information dissemination and community rights protection	• Partnership building • Policy influence

Table 1: *Overview of stakeholders regarding delta management issues*

Governance structures and networks of key stakeholders

District assemblies are autonomous of each other but are coordinated at the regional level. District budgets, planning and policy implementation are in line with the broader national economic development policies and require approval at the regional level. There is no body specifically mandated for delta management. Recently, the government has established a Coastal Development Authority to oversee and implement development programmes within the coastal belt but there is no specific delta management body.

Considering the peculiar socioeconomic and geophysical vulnerability of the Volta Delta, it is necessary to have a delta development authority to coordinate the administrative units within the delta and ensure sustainable delta development.

1.5 Main indicators for drivers, pressures and governance

DRIVERS	Main Indicators	
Demographic trends	• Delta population growth rate • Age-sex distribution • Dependency ratio • In-/out-migration trends • Rates of unemployment/ poverty	• Estimated at 1.6% • 87 males per 100 females • 84% • Migrant sending • 6.8%
Economic developments	• GDP per capita • GDP growth	• $1,641.50 (2017) • 8.5% (2017)
Technological developments	• % contribution to the Delta GDP by construction sector, transportation and communication (ITC), and services • sea defence projects	• Keta Sea Defence: 7.5km • Ada Sea Defence: 16km • Dzita Sea Defence: 2.7km
Climate change / variability	• Change in mean temperature • Change in precipitation	• 0.10C • No available data
Subsidence	• Tectonic subsidence • Human-induced subsidence	• 1 – 2 mm/yr • Not available
PRESSURES	**Main Indicators**	
Land and water use	• Population density • Proportion urban • Fresh water withdrawal as a proportion to available freshwater resources • Changes in land use • Water quality • Flood vulnerability • Drought vulnerability	• 210 per km2 • 33% • 2.79% • • Medium • Good • High • High
Network/Infrastructure	• Irrigation and drainage • Groynes • Revetments • Road network • Access to improved sanitation • Access to improved drinking water	• Present • Present • Present • Poor • 15% • Limited access
Natural resources	• Ecosystem sustainability • Mangroves	• Medium • 8,900 hectares
GOVERNANCE	**Main Indicators**	
Multi-level and multi-sectoral cooperation	• Existence of integrated plans (delta plan/ national adaptation plan) • Existence of inter-ministerial committees • Enforcement (joint/coordinated implementation of relevant laws, regulations & policy)	• No delta plan • National adaptation plan exists • Inter-ministerial committees exist for different sectoral agenda • Collaborations between NADMO and security services exist
Public private partnerships	Existence and scale of PPPs	Ministry of Finance
Stakeholder engagement	• Existence of legal public instruments and forum of stakeholder involvement in planning and decision-making • Existence of Civil Society-Based Organisations • Involvement of CSOs in planning and decision-making	• National Development Planning Commission • About 30 in number • They are involved in planning
Approaches for dealing with risks and uncertainties 1.6.1 1	• Existence of adaptation management, strategies etc • Existence of risk management, emergency, warning systems	• These strategies exist • Risk management and emergency systems in place

Table 2: *Main indicators for drivers, pressures and governance*

1.6 Scorecard

The scores presented are qualitative and indicative, based on the summary tables descriptions for each item above. Each item is scored on a 5-points scale, related to resilience and sustainability.

The following two development scenarios are recognised:

- Scenario 1, moderate perspective 2050: medium economic growth and related medium technological developments, combined with medium climate change and sea level rise (to be determined by experts)
- Scenario 2, extreme perspectives 2050: high economic growth and related high technological developments, combined with high climate change and sea level rise (to be determined by experts).

Delta	Land and water use (occupation layer)	Infrastructure (network layer)	Natural Resources (base layer)	Governance	Overall Resilience & Sustainability indicator
Current Situation 2015	+	0	0	-	0
Scenario 1 moderate 2050	0	0	-	-	0
Scenario 2 extreme 2050	-	+	-	0	0

Table 3: *Resilience/sustainability: ++(very good), + (good), 0(medium), - (low), -- (very low)*

Concluding remarks on scorecard:

The current pressure on land and water use (occupation layer), is considered good due to the relatively low population density. This pressure is projected to increase because of population growth in the future with people moving in from the densely populated cities of Accra, Tema and Lomé. Infrastructure (network layer) is scored low because there is limited access to portable drinking water, sanitation and poor road network. This is not expected to change under moderate scenario but will improve with high economic growth as the economy is improved with mechanised farming and aquaculture development. The delta natural resources (base layer) is rated medium because, the fish stock which is the back bone of the economy is currently on the decline (Appeaning Addo et al., 2018). Mangrove forest is declining. However, there is abundance of fresh water and arable land which is yet to be fully exploited. This resource base is projected to decline with increased pressure from population. Governance is expected to improve with decentralisation being promoted in the Country as well as improving technological and financial capacity. The contribution of Civil Society Organisations and NGOs is also expected to improve governance in the delta.

Overview of adaptive measures in the Volta Delta

The most important sectors that have been prioritized for adaptation in the Volta Delta are agriculture, water resources, and disaster risk reduction. Since the construction of the upstream Akosombo and Kpong dams, a number of projects and programmes have been implemented by governmental and non-governmental organisations to support communities in addressing the inundation of property and farms, salinization of groundwater, low agricultural productivity, coastal and riverine erosion, shortage of water and increased incidence of water and sanitation related diseases. These planned adaptation activities have mainly focused on implementing change with improved technologies, building capacity, providing alternative livelihoods for improving food security, minimizing the impacts of flooding on communities or individuals through disaster risk reduction and rural-urban development actions, improving ecological functions and services for providing sustainable access to natural resources, and improving access to water.

2.1 Examples of best practices

There are a number of manuals and other protocols being developed which are useful for guiding development in the delta. These include

- The Handbook for Coastal Processes and Management in Ghana (Wiafe et al, 2013)
- Illustrated manual for the Establishment and Management of Mangrove Plantations (SNV and Forestry Commission)
- Inauguration of closed fishing season along the coast of Ghana by the government of Ghana
- The coastal system of the Volta delta, Ghana: Strategies and opportunities for development (Roest, 2018).

2.2 Overview of (possible) adaptive measures

Name of Measure	Type of Measure 1. Technical 2. Ecological 3. Economic 4. Institutional	Brief Description	Strategy 1. Protect 2. Adapt 3. Relocate	Layer 1. Occupation 2. Network 3. Base
National Level Measures				
Sea Defence	1,2	Construction of revetments, groynes and beach nourishment to reduce coastal erosion and flooding	1, 2	3
Tube well Irrigation	1,2	Irrigation involving the lifting of water from shallow wells using pumps to be distributed through tubes/pipes	2	1
Improved water sources	1	Provision of improved water sources such as boreholes and pipes	1,2	1
Livelihood Empowerment Against Poverty (LEAP)	3,4	Social intervention programme to provide cash and health insurance to extremely poor households nationwide	2	1
Fertiliser Subsidy Programme	3,4	21% subsidy on all compound fertilisers and urea for smallholder farmers cultivating selected staples	1,2	1
Premix Fuel Subsidies	3,4	73% subsidy on premix fuel for marine artisanal fisheries	2	1
Resettlement scheme	1,4	Construction of houses to resettle populations displaced by tidal wave action along the delta coast	1,2,3	1
Local Level Measures				
Livelihood Diversification	1,2	Diversifying main livelihoods to more productive and climate-resistant income sources	2	1,2
Migration	3	Seasonal or permanent movements of livelihoods across spatial boundaries	2,3	1
Mangrove Regeneration/ Afforestation	1,2,3	Support from the Forestry Commission and NGO's to restore degraded mangroves and establish alternative woodlots of Acacia Mangium and Siamia, Albizia and Eucalyptus	1,2	3

Table 4: *Some examples of adaptive measures are selected for this assessment.*

2.3 Examples of maladaptation practices

Illegal fishing practices

Due to the declining fish catch, artisanal fishermen in Ghana have resorted to the use of illegal fishing practices which include the use of chemicals (DDT, carbide and powdered detergents), explosives, light fishing and unauthorised small mesh sizes. These practices do not only lead to further depletion of the limited fishery resources, but also contribute to the destruction of the nation's marine ecosystems. Though there are penalties and legal implications for engaging in such practices fishermen are motivated by the weak law enforcement and increasing demand amidst the depletion of fish stock (Afoakwah et al., 2018).

Excessive groundwater abstraction

Groundwater is an important source of freshwater for irrigation around the Keta Lagoon and domestic use in the delta area. However, abstraction of large volumes of groundwater has the potential to lower the water table and lead to saline water intrusion with negative implications for future crop cultivation (Kortatsi et al., 2005).

Overview of technical methods and tools to support delta management and development in the Volta Delta

Name of Tool	Brief Description	Institutions with local capacity	Available at
Remote Sensing Data Collection (including Use of Unmanned Aerial Vehicles (UAVs))	This is being used for mapping various delta features	University of Ghana	Department of Marine Science
Videogrammetry	Analyses of high resolution nearshore dynamics in the Delta using video cameras. One site established at Dzita in the Delta Region	Collaboration between University of Cape Coast (UCC) and University of Ghana (UG)	Centre for Coastal Management (UCC)
Delft3D	An integrated modelling suite (2D and 3D). For understanding flows, morphodynamics etc. Model being adapted for the Volta Delta	University of Ghana, Marine Science	Deltares (open Source) https://oss.deltares.nl/web/delft3d
SLAMM (Sea Level RIse Affecting Marshes)	Simulates Potential Impacts of long term sea level rise on wetlands and shorelines	University of Ghana, Marine Science	Warren Pinnacle Consulting Inc. (Open Source) http://warrenpinnacle.com/prof/SLAMM/index.html
Population Projection Methods	Estimating current and future population trends	University of Ghana	Regional Institute for Population Studies
Risk Assessment and Mapping	Assess risk levels in the delta using various indicators	University of Cape Coast and University of Ghana	

Table 5: *A summary of methods and tools for assessments, planning and decision making on the delta management and development issues is presented here. This list is not exhaustive but presents the most relevant ones based on this assessment.*

Knowledge exchange and development

Chapter 4

Lessons learned on delta management

In terms of human impact, the major culprit in the delta is the construction of the hydropower dam upstream, which has changed the hydrodynamics affecting morphodynamics and livelihoods. Population growth rate in the delta is slow as well as technological developments.

Currently, no delta specific plans exist for the Volta Delta, the closest are district level plans for various sectors within the delta which do not address the adaptive management of the delta.

Summary of Research gaps and related needs for knowledge exchange

Drivers of change Pressures – potential problems / Challenges - opportunities

- There is little understanding of the complex interrelationship among the various drivers of change in the delta due to inadequate integrated studies
- An assessment of the impacts of sea level rise on the wetlands is required.
- Lack of high-resolution hydrological, fishery, land cover and erosion data make the estimation of pressure on the delta area difficult.
- There is limited information on the quantification of ecosystem services in the delta.
- Assessment of economic potentials of the Volta is yet to be fully estimated and documented
- Research into climate change resilience farming in the delta

Gaps and needs

- The need for government to show a stronger interest in delta issues. There is scanty information on groundwater extraction in the Volta Delta.
- There is need for finer measurement of subsidence and estimation of relative sea level rise.
- Socioeconomic and demographic characteristics in the delta need to be updated with regular and quality data.
- There is also need to investigate multiple livelihoods and livelihood diversification mechanisms by delta populations.
- High-resolution estimation of mangrove cover in the delta is necessary.
- The need to create a centralised delta specific database cutting across all sectors and ministries.

Adaptive measures

- There is no proper documentation of adaptive measures being employed in the delta such as irrigation and aquaculture practices.
- Development of early warning systems is needed for the delta to reduce risk to hazards.
- Assess the potential of adopting soft engineering methods for coastal erosion management instead of the hard engineering approach being used

Technical methods and tools

- There is the need for development of hydrodynamic models for predicting erosion and accretion patterns. This also requires that appropriate capacities be developed in our Universities for modelling.
- There is also the need for tools such as wave rider buoys to collect long term oceanographic data
- The need to create a delta specific governance unit to effectively manage delta issues

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Chapter 5

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