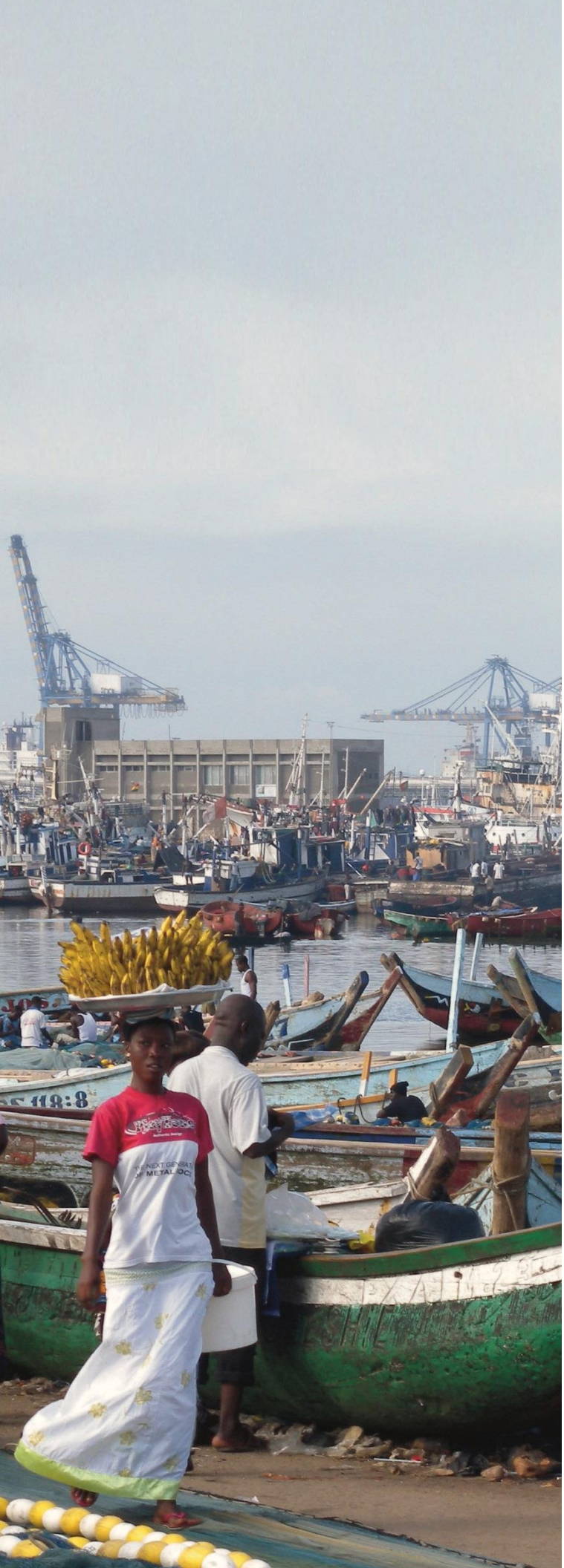

Universität Trier

Anna Larissa Celia Tyroller

Changing Socio-Ecological Dynamics in an African Peri-Urban Wetland

The Case of the Fisheries in the Densu Delta Ramsar Site

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Authors' contact

Anna Larissa Celia Tyroller
l.tyroller@googlemail.com

Abstract

The rate and range of ongoing changes in social and ecological systems and particularly the global environmental degradation illustrates the need of holistic and sustainable approaches for the governance of natural resources to ensure their well-functioning for future generations (Rockström et al. 2009). The narrative of common pool resources system such as SES of small-scale fisheries, reports world-wide of stock collapse, environmental degradation and overexploitation (Cinner et al. 2013). In order to understand the complexity of system interactions in those resource systems, the consideration of local scale specific phenomena is of great relevance (Ostrom 2007b). The focus of this thesis consequently is the social-ecological system of a small scale fishery in a heavily urbanised coastal wetland on the fringes of Ghana´s capital Accra. With the theoretical foundation of the social-ecological system (SES) theory (Folke et al. 2004; Berkes et al. 2003; G. S. Cumming 2011) and the social-ecological system framework (SESF) by Ostrom (2007a) and McGinnis & Ostrom (2014) as analytical tool, the study examines the role of the fishers as focal actor group and the governance system based on traditional ecological knowledge (TEK) (Berkes et al. 2003). While the common narrative of system collapse is partly confirmed for the focal system, also contradicting findings about the diversity of the actor group, their sustainable and responsible exploitation of the deltas resources have been found, that rather illustrate the fishers as potential cooperation partners for the development of sustainable governance strategies (see Hollup 2000) than simply as burden to the system. However, the results also show that in order to achieve sustainable outcomes in the focal SES, so far unsuccessful top-down governance efforts have to work cooperatively with the fishers to challenge the multiple threats to the system from external perturbation and internal changes, in the long run.

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1 Introduction

> *"I think the next [21st] century will be the century of complexity. We have already discovered the basic laws that govern matter and understand all the normal situations. We don't know how the laws fit together, and what happens under extreme conditions. But I expect we will find a complete unified theory sometime this century. There is no limit to the complexity that we can build using those basic laws."* [Stephen W. Hawkings, 2000 cited in Sengupta, 2006. Preface]

As this quote of the theoretical physicist Stephan Hawkings illustrates, the world's dynamics that are challenging humans are becoming more and more complex. Hawkings predicts that humanity will soon find a complete unified theory where science from multiple disciplines increasingly works together on interdisciplinary and transdisciplinary concepts and theories to understand and explain complex dynamics on different scales. The growing scientific body on social-ecological system theory (see Folke 2006; G S Cumming 2011; Berkes et al. 2003) emphasises the need of such holistic discipline and scale-crossing research to understand the complexity of interactions between humans and nature (Berkes et al. 2003). Particularly in the field of natural resource exploitation where humans and nature interact directly with each other, those approaches are of relevance. Since the human population is growing in a never present rate and exploits natural resources in a never present range, the development of sustainable governance systems constitute a major challenge to ensure the well-functioning of the global ecosystems. To ensure their capacity to support human societies and all living organisms also in future sustainability is absolutely necessary for the functioning of natural resource systems (Folke 2006). Whether science will find a holistic strategy for the complex SES of the Earth will remain thrilling.

"Without doubt, the increasing complexity of the world's socio-economic reality has immediate relevance for sustainable development and there is now a pressing need for the exploration of approaches that have been explicitly conceived to address complexity in the organisational and societal domain" (Espinosa & Walker 2011. p. 5). The authors stress further that the *current "political and economic systems are driven by short-term gains, regardless of long-term consequences"* and that the worldwide problems of environmental degradation, dramatic consequences of climatic changes, biodiversity loss, economic and social inequalities just to name a few emerging challenges that are *"the result of our inability to deal with the exploding complexity of our social and ecological interactions at the local, regional and world levels"* (Espinosa & Walker 2011. p. 3). The shift from irresponsible resource exploitation to a more sustainable way of harvesting the earth`s resources consequently needs sustainable resource governance strategies (Espinosa & Walker 2011).

The common-pool resource systems of small-scale fisheries worldwide represent systems under heavy threats through multiple changing social and ecological dynamics (Kittinger et al. 2013). Local to global pressures from growing populations, market development, climatic changes and urbanisation, according to Jentoft & Chuenpagdee (2015) are particularly putting traditional small-scale fisheries at risk of losing their cultural identity. However, their governance systems are often characterized by shortcomings and the lack of implementation and system conservation. In order to approach the goal of developing sustainable governance systems that preserve the ecological and the social components of these systems, a holistic understanding of the diversity and complexity of these SESs is necessary to be achieved (Jentoft & Chuenpagdee 2015). As Basurto et al. (2013) show, the specific local conditions in

dynamics and outcomes of interactions in these systems can vary extremely even if the settings are relatively similar. Also Ostrom (2007b) emphasizes that these local specific dynamics and interactions of components of the resource systems are of great importance to understand the system as a whole and hence to develop governance implications.

The analysis of systems on local scale is therefore mandatory to get a holistic picture of SES small scale fishery systems. As an analytical tool, the social-ecological system framework (SESF) by Ostrom (2007) and (McGinnis & Ostrom 2014) provides the needed structure for collected data, fosters the identification of variables and components of importance and enables the comparison of outcomes of the research with other studies that use the same framework. Located in the coastal zone of West Africa, where changing socio-ecological dynamics are impacting heavily on small scale fishery systems (Smith et al. 2009; Willoughby et al. 2001), the Densu delta Ramsar site was chosen as local scale case study. The (peri-) urban wetland fishery system and its actors and governance system are at the focus of this work. Even the diversified actor group inhabits great potential for the development of sustainable governance strategies, the fishers themselves are often ignored in governance concerns (Hollup 2000). The overall research interest is consequently on the complexity of the dynamics in the focal SES. And more particular on the role of the fishers in the focal SES and the existence of governance system based on traditional ecological knowledge (TEK) while facing changing socio-economical and environmental dynamics.

Guide through the Thesis:

In chapter 2 the thesis first gives theoretical background on the development and content of science on social-ecological systems and their links to sustainability governance of small-scale fishery systems and related traditional ecological knowledge. Chapter 3 introduces the reader to coastal wetland fishery systems with a focus on Ghana. It further examines changing socio-economic and ecological dynamics in the coastal zone of West Africa and their impact on coastal wetland fisheries particularly in urbanised areas. Finally top-down and TEK-based governance approaches of natural resources are introduced, as well as their efforts towards more sustainability in coastal wetland fisheries in Ghana. After presenting research gaps in the relevant fields, the main research question and derivative hypothesis are presented. In chapter 4 the SESF by Ostrom (2007a and McGinnis & Ostrom 2014) is explained, its suitability for the thesis-emphasized and supplementary critics (Cleaver & Koning 2015; Hinkel et al. 2014; Agrawal 2014) are presented that help to extend the framework where necessary. The chapter rounds up the overall research questions and the postulated hypothesis. Chapter 5 explains the qualitative-methodological approach of the research project and leads over to chapter 6, where the results of the empirical work phase in Ghana are presented. In Chapter 7 the results are discussed in relation to the role of the fisheries and the examined governance systems and final conclusions are drawn in chapter 8.

2 Theoretical Framing of Social-Ecological Systems and Sustainability

The following chapter provides the theoretical foundation for the research project. The chapter first describes the conceptual foundation of the Social Ecological System (SES) theory by explaining insights as far as it is necessary for the following chapters. It aims to embed the research objective in a broader scientific context and to further draw the link to sustainable governance of natural resources as well as to traditional ecological knowledge and resource practices.

2.1 Social-Ecological System Dynamics

Facing more and more challenges that have to be solved on the interface of human and natural interactions, humans appear to increasingly understand the need of a more holistic concept to understand the complex mechanism behind those challenges. Already at the beginning of the last century, scientists from different fields started to develop holistic approaches of understanding the Earth`s dynamics from a system perspective. The research fields like system theory, cybernetics, complexity science and system ecology which are further explained in table 1, created the conceptual foundation for those integrated studies on the interface of human and natural systems (Glaser et al. 2008). Deriving from these concepts with stronger technical, physical or ecological focus, a growing body of scientific research started to concentrate on a more comprehensive, system thinking understanding of interactions between human society and natural environment (Espinosa & Walker 2011; Mitchel 2009; Cumming 2011; Glaser 2008). Since the 1970s, an increasing number of disciplinary studies explicitly includes interdisciplinary aspects in their concepts such as environmental ethics, political ecology, common property and traditional ecological knowledge (Berkes et al. 2003).

In this context, the Social Ecological System theory (SES theory) has also been developed, including both ecological as well as social aspects such as equity or human wellbeing (Cumming 2011). Social and natural science work closely together on a system-thinking basis, considering the ecological and social system as two subsystems of equal importance within one complex SES (Glaser et al. 2008). The term *ecological system* (or ecosystem) here is used along with Berkes & Folke (1998) as the natural abiotic environment and the self-regulating community of biotic organisms that interact with it. The ecosystem stretches over an explicit spatial extension that can range from the size of a bacterial system to the Earth´s ecosystem as a whole, depending on the scale of the system we look at. The timescales of processes and interactions between its living organisms and the non-living environment are characterized by rhythms or cycles which can range from seconds to thousands of years (Westley in Gunderson & Holling 2002). And further the term *social system* is defined here as *"any group of people who interact long enough to create a shared set of understandings, norms, or routines to integrate action, and established patterns of dominance and resource allocation*" (Westley in Gunderson & Holling 2002. p. 107). As the ecological system, it has a dynamic character where all components can be even affected by small changes. Its size depends on the functional or spatial boundaries reaching from the group of family members (functional) to the inhabitants of a continent (spatial). As for the ecosystem, the dimensions of time and space are important system features for processes and structures (Westley in Gunderson & Holling 2002).

TABLE 1 CONCEPTUAL AND THEORETICAL FOUNDATION OF THE SES THEORY

Theory	Concept description
System theory	System theory puts an emphasis on the interrelations of system components. The theory *"is concerned with the exploration of wholes and wholeness. It emphasizes connectedness, context and feedback, a key concept that refers to the result of any behaviour that may reinforce (positive feedback) or modify (negative feedback) subsequent behaviour"* (Berkes et al. 2003. p. 15).
Cybernetics	The key concept of cybernetics is the dynamics of feedback loops that couple the systems' levels. "[It is] *concerned with the structure of systems and their regulation, controllability and self-organizing capacities*" (Glaser et al. 2008. p. 77).
Complexity theory	The complexity theory "*examines non-linear, dynamic systems with a large number of system connections, whose history is not of steady development but of discontinuity. In these systems, stable states can suddenly appear – and disappear again. [...] It analyses emergence – the appearance of unexpected phenomena. The system here is more than the sum of its parts*" (Glaser et al. 2008. p. 77.)
System ecology	System ecology is concerned about *"the study of whole ecosystems and includes measurements of overall performance as well as a study of the details of systems design by which the overall behaviour is produced from separate parts and mechanisms"* (Odum 1994)

The division in nature and humans in SES science is seen largely "*artificial and arbitrary [since] social and ecological systems are in fact linked*" (Berkes et al. 2003. p. 3). Humans – like all living organisms – have always influenced and modified their surrounding environment and various ecosystems that appear unaffected by anthropogenic activities in the first place, can be in fact identified as human-shaped. According to Vitousek 1997, not only obviously human-shaped landscapes like agricultural fields or urban areas, but more or less all natural systems on earth are dominated by humans. The range and rate of this modification has extremely increased with human population growth, its growing consumption, expanding settlements and industries, as well as its technical innovations of the last centuries (Vitousek 1997; Crutzen 2002). At the same time humans are living beings like all other organisms and therefore part of nature. They impact earth in a more dominant way than other species, however they are natural themselves. Hence their impact on the natural environment can be considered natural as well. Taking this as foundation, it seems impossible to understand nature without humans and humans without nature, but also seems challenging to distinguish the two systems (Becker 2012). Differentiating the two subsystems is symbolic for a deep conceptual division of nature and humans which was and is however still present in science as well as in (western) societal thinking (Becker 2012).

Nevertheless the name SES implicates two subsystems and even the delineation might be blurry (Becker 2012; Halliday & Glaser 2011), Becker (2012) sees it essential to draw those boundaries to a certain extent for analytical reflection. Otherwise interaction between them, which is in the centre of SES research, would be unthinkable. The focus of SES theory on these complex interactions between social

and ecological systems emphasises the co-evolution of humans and nature that strongly influence each other. And the integrated character of the concept does not take - in contrast to single discipline approaches - either humans or nature as a box that has to be somehow fitted in eco-centric or anthropocentric frames (Berkes & Folke 1998). It instead works as a bridging concept between the two subsystems seeing the SES as one dynamic system consisting of various (social and ecological) components that interact on multiple spatial and temporal scales (Westley et al. in Gunderson & Holling 2002).

The SES theory, as well as its underlying concepts (see table 1) further highlight the importance of the dynamical character of a SES (Cumming 2011; Glaser et al. 2008), which is essential to this thesis. This dynamic character is explained by system components that "*interact in ways that cause the system to adjust or "adapt" in response to changes in conditions. This is a simple consequence of interactions and feedbacks*" (Grove 2009). The complexity here - in the sense of dynamic and nonlinear processes – reflects the behaviour rather than the number or arrangement of its components (Cumming 2011; Espinosa & Walker 2011). Being adaptive means that a SES is able to adapt to a changing environment through self-organization, describing the process by which a system is able to restructure when exposed to external disturbance or internal growth or decrease (G. S. Cumming 2011; Espinosa & Walker 2011). Systems are able to adapt to changes up to a certain level of changes in conditions (threshold) (see Scheffer et al. 2001). Due to globalization, the drivers of changes that for example local fisheries have to face are increasingly out of reach for the resource users themselves, thus learning to adapt is essential for their survival (Kittinger et al. 2013).

Since the interplay of persistence and change is central to SES's dynamics, change is not seen as something negative per se. Berkes et al. (2003. p. 3) *"consider change and the impact of change as universal givens. The social–ecological system is impacted by change and deals with it as a function of its capacity to adapt to change and shape it."* The variety of possible social, ecological or organizational changes can be gradual or episodic and extend from local to global scale. There can be changes which might have destructive but also constructive impacts on the system, leading to transformation (that can cascade upscales and affect multiple components and levels) or being absorbed through adaptation (Gunderson & Holling 2002; Holling 2001). While economic, cultural or socio-political changes such as urbanisation, market dynamics, but also new nature conservation laws can be clearly identified as anthropogenic changes, it is more challenging to distinguish whether ecological changes such as climate change are anthropogenic or naturally caused (Berkes et al. 2003). In any case, living in the Anthropocene, most of the highly influencing environmental changes such as land cover conversion, habitat and biodiversity degradation, water and air pollution are directly resulting from human resource exploitation and other activities on earth. Those changes again cause climatic changes, which therefore can be seen as indirectly anthropogenically caused (Vitousek 1997; Berkes et al. 2003). Understanding these changes, the driving forces as well as the system structure and its reaction to change lies in the centre of SES research (Berkes et al. 2003), where therefore a SES here is defined along with Cumming (2014. p. 4) as

> ***"an integrated system of people and nature in which feedbacks occur between human and biophysical system elements".***

By *"integrat[ing] and evolv[ing] the functional understanding of SES, and [...] us[ing] that knowledge to find practical and effective sustainability solutions for real-world challenges"* SES science gives essential foundations for the transdisciplinary and interdisciplinary development of sustainable strategies and their implementation (Partelow 2015b. p.1). SES thinking has been applied to many other disciplines such as

economics, political science and ecosystem analyses. The necessary interdisciplinary approach to understand complex adaptive social-ecological systems and to develop sustainable strategies to face increasing environmental challenges, can therefore build on the experience of different disciplines (Norberg & Cumming 2008). The SES theory consolidates related concepts like *resilience*, *robustness*, *adaptation* and *vulnerability* that focus on reactions and system evolution when facing perturbation and stress and are explained in more detail in table 2. The SES theory spans over these concepts but further is *"concerned with a wider range of SES dynamics and attributes than any one of these terms implies*" (Cumming 2011p. 8). The constantly increasing number of publications from various disciplines is enhancing the theory and its application to real-world phenomena, largely in the context of sustainability and natural resource governance (such as Berkes & Folke 1998; Berkes et al. 2003; Cumming 2011; Gunderson & Holling 2002; Norberg & Cumming 2008; Ostrom 2009; McGinnis & Ostrom 2014; Walker et al. 2004).

TABLE 2 DEFINITION OF RELEVANT SES RELATED CONCEPTS AND TERMS, WHICH ALL HAVE THE CAPACITY OF SES TO REACT TO DISTURBANCE AND CHANGE AS COMMON THEME OF INTEREST

Terms & concepts	Definition
Resilience	is "*the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks*" (Walker et al. 2004.n.p.)
Robustness	*"is defined as a system's ability to remain functioning under disturbances. This implies that information is needed on how the system responds to different degrees of disturbance"* (Mens et al. 2011. p. 1122).
Vulnerability	*"is the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt*" (Adger 2006. p. 268).
Adaptability/ Adaptation	is *"the capacity of actors in a system to influence resilience. In a SES, this amounts to the capacity of humans to manage resilience."* Walker et al. (2004. p. 574) "*In the context of human dimensions of global change* [adaptability] *refers to a process, action or outcome in a system (household, community, group, sector, region, country) in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity*" (Smit & Wandel 2006. p. 282). From a natural science perspective it refers to the ability of organisms to survive.
Sustainability	is "*the use of environment and resources to meet the needs of the present without compromising the ability of future generations to meet their own needs. [...] [S]ustainability [is further considered] as a process, rather than an end product, a dynamic process that requires adaptive capacity for societies to deal with change*" (Berkes et al. 2003. p. 2).

2.3 Links to Sustainable Governance of Natural Resources

Understanding the interactions of SES components as well as the dynamics of system internal and external changes is crucial for sustainable governance of natural resources, hence SES theory is often applied in these fields (Cumming 2011; Berkes&Folke 1998). The analyses of social-ecological common pool resource systems by Ostrom and her colleagues (see Ostrom 2007; Ostrom 2009; Basurto et al. 2013; Low et al. 2002; McGinnis & Ostrom 2014) largely relates to challenges and opportunities for their sustainable governance. With the analytical tool of the social ecological system framework (SEF) (see chapter 4) they particularly highlight the role of governance structures and needed conditions for well-functioning institutions on different scales. Ostrom thus defines the governance system as one of the subsystems (such as the resource system and governance system) and variables (such as the resource units and actors) that together form a complex interacting SES (McGinnis & Ostrom 2014). The interplay of system interactions, formed institutions and feedbacks of externals (social, economic and political settings and related ecosystems) on the system result in the degree of sustainable outcomes of the SES (Ostrom 2009; Ostrom 2007).

Embracing the dynamical learning character of sustainable governance structures, Holling (2001. p. 399) defines sustainability as "the *capacity to create, test, and maintain adaptive capability* [of a system]". Espinose & Walker (2011. p. 16) further define it *"from this holistic understanding, [as] a property of a socio-ecological system that results from the dynamic, long-term preservation of the system's identity amid permanent change. Sustainable development is a process of directional change by which the system co-evolves [...] through recurrent interactions."* Thereby they emphasize along with Ostrom (2007) a needed process rather than the final character of solutions to sustainable governance. The interplay of persistence and change should accordingly be part of the governance system as well as the capacity to adapt to changes. This relatively new approach that sees change more likely than stability is breaking with the traditional view of sustainability in the context of growth equilibrium and stability (Berkes et al. 2003).

These system-inherent cross-scale and non-linear dynamics and interactions of SES variables and multi-stable state behaviour in ecosystem dynamics make it however challenging to practically implement governance strategies in resource systems (Gunderson in Berkes et al. 2003). Understanding SES's dynamics and scales (spatial as well as temporal) as well as the properties of a system and therefore the *capacity to deal with change and disturbance – its capacity to sustainability* – is crucial in this field. Deriving from the complex system approach, it includes multiple upper-level dimensions as well as specific local contexts (Ostrom 2007b; Berkes et al. 2003). Sustainable resource use and governance hence means to adapt to changes and support the system in its ability to co-evolve with its environment on all scales (Espinosa & Walker 2011). It is no longer seen in the light of yield maximization but rather in the sense of maintaining ecological resilience and supporting social flexibility in order to be able to cope and adapt to changes through creative innovations (Gunderson & Holling in Holling & Gunderson 2002). This includes for example the shift of gears or target species or the innovation of new techniques in local fisheries in order to adapt to stock decline or changing market demand (Kittinger et al. 2013).

> Governance here refers to "*the interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global) that are set up to steer societies towards preventing, mitigating, and adapting to global and local environmental change" (*Biermann et al. 2009. p. 3).

Consequently, the emphasis is on the importance of adaptive governance approaches that integrate local resource users and other relevant actors and constantly adapt the policies to changing conditions of the system (Gunderson in Berkes et al. 2003). Policies here are as *"the rules, norms, behaviour, and infrastructure of management action"* (Ostrom 1990 cited in Gunderson in Berkes et al. 2003). Gunderson (in Berkes et al. 2003) argues that there should be a shift from optimum policies towards a more flexible adaptive one. This adaptive governance approach (theoretically) meets these requirements in emphasizing a constant process of social and institutional learning. In an iterative process of learning, applying and evaluating, governance practices are ideally reviewed and modified through changes and adaptation processes in SES (Berkes et al. 2003). Still, the concept faces problems in implementation and remains not practiced enough, even though there is a constantly growing body of studies about the adaptive and sustainable resource governance (Allen & Garmestani 2015).

Conventional approaches to resource and ecosystem management failed largely due to so called one-fit-all solutions of centralized institutions (Berkes et al. 2003). Underlying these approaches, it is largely the goal to control resource systems, make them more efficient, profitable and predictable. Local specific context, history and dynamics, which are crucial to the understanding of SE resource systems, are hardly integrated and the system remains susceptible to crisis (Ostrom et al. 2007; Berkes et al. 2003). When actors (e.g. resource users) and governance of a system are flexible and adaptive, crises can be buffered and behaviours adapt to new situations, without a major change in policy (Ostrom 1990 cited in Gunderson in Berkes et al. 2003). The maintenance of the system's resilience and adaptive capacity offers an important possibility for failures without a collapse of the system and opens the opportunity to learn from mistakes and modify the governance concepts (Gunderson in Berkes et al. 2003). When changes occur where consequences are unpredictable or new to the system (e.g. the introduction of invasive species or changing climate pattern cycle) and particularly where there is no local knowledge available, the system can easily fall into a crisis.

While ecological crises are linked to the ecological properties of the system, the social responses are connected to the adaptability and flexibility of institutions, here *"the set of norms, rules that people use to organize activities"* (Ostrom 1990 cited in Berkes 2003). They are social constructs formed by formal (e.g. laws constitutions) and informal (norms of behaviour, conventions, morals) restrictions as well as through their enforcement (Berkes & Folke 1998). Especially the development of institutions in common pool resource systems, where exclusion is difficult and the use of the resource by one individual reduces the level of resource available for other users (Berkes & Folke 1998), is a urgent issue and broadly discussed predominantly in matters of their sustainability (Ostrom 2007b). Common pool resources such as fisheries are largely overexploited or stocks even collapsed due to missing institutions or enforcement (Cinner et al. 2013). According to Cinner et al (2013), there are yet many examples especially amongst small-scale fisher groups with local traditional knowledge that developed institutions to successfully manage common pool resources. Various variables were identified, influencing the possible sustainable system outcome, such as presence of governance, productivity improving investments, mobility of resources, presence of shared norms and number of users (see Ostrom 2007). These variables can extremely vary from location to location; and it is stressed by several authors that one of the most important features of governance systems is the recognition of those local specific or system specific contexts (Ostrom 2009; Olsson 2003).

Institutions are formed by groups of individuals to organize activities within the system (with outcomes that possibly also affect other groups). Similar to other subsystems, they are hierarchically nested on different scales, so they form on local up to regional and even global institutions, where each level has its own properties and is connected with others through feedbacks and interaction (Berkes et al. 2003). Innovation and learning processes are faster on smaller scales where smaller groups of individuals are involved and information is passed on more rapidly, hence institutions work more efficiently on local scale resource systems (Ostrom 1992 cited in Berkes & Folke 1998). In those local resource systems (often) with a long history and tradition of resource use and governance structures, these institutions are of significant importance. According to Danvidson-Hunt (in Berkes et al. 2003), it is more likely that local-level common property institutions challenge risks and crises since they are more flexible and adaptive to changes through innovations and learning.

2.4 Governance Based on Traditional Ecological Knowledge (TEK)

In local resource systems such institutions are formed by transmitting knowledge and practices from generation to generation and constantly adapting strategies to changing conditions of the local system. According to Low et al. (in Berkes et al. 2003), there are various examples of traditional governance systems of natural resources that work in sustainable ways but apply different resource use practices and are organized in different ways. These resource users (e.g. harvesting fish, wildlife or forest products) gain knowledge through their own observation and practice. Local knowledge on fish species, their reproduction, stock condition and reaction to changes is used for example for the modification of regulations and the prohibition of certain gears which are considered to be harmful (such as light fishing, small mesh sizes or dragnets) (Berkes & Seixas 2005). Traditional systems are guided by this location-based knowledge and have large potential for sustainable governance of resources. Nevertheless there are still huge gaps in knowledge about their functionality and development (Berkes et al. 2003).

Local, traditional or indigenous knowledge is defined here as "*ecological understanding, built, not by experts, but by people*[1] *who live and use the resources of a place*" (Berkes et al. 2003. p. 12). Whereby local knowledge can be scientific and practical knowledge generated in a local environment and includes modern as well as traditional knowledge. Indigenous knowledge points at its foundation in a unique culture or society, held by indigenous people. Here along with Berkes et al. (2003), the term *traditional ecological knowledge (TEK)* is used. TEK is considered as knowledge, practice and belief about the relation of living organisms with their environment. The knowledge of species and environmental phenomena develops over generations and is handed on as cultural knowledge that constantly modifies practices in resource use through adaptation processes (Berkes & Folke 1998; Berkes et al. 2000; Berkes et al. 2003).

Consequently, the knowledge of those traditional governance systems can help science and governments to develop sustainable and more adaptive strategies, since it generates in a continuous local-based adaptation of the social respondent to changes (Berkes et al. 2003). Based on trial-and-error evolution (including observation, understanding of the ecological system, used practices and transformation processes in response to ecological and social crises), this knowledge is of particular interest in local systems. It derives from context-based reactions that are often not included in scientific approaches

[1] They could also be seen as non-scientific or governmental experts

but important to consider (Gunderson & Holling 2002; Berkes & Folke 1998). Drawing back to Holling´s (2001. p. 399) definition of sustainability that lies in "the *capacity to create, test, and maintain adaptive capability* [of a system]", local resource governance can be very helpful in directly interacting with the system, in creating new strategies after changing conditions, testing them and maintaining them, if they are considered as functional.

There is a large variety of practices how TEK is applied to resource systems in multiple cultures and locations. The practices of resource use as well as the relation of humans and nature are strongly connected to the cultural setting. Sets of rules, rituals, and taboos guide the exploitation of resources in form of off seasons, prohibition of hunting certain species, taboo areas (often around key ecosystem zones such as springs, riversides, mangrove stands) or taboo days which foster stock recreation, biodiversity enhancement and habitat protection (Hens 2006). The knowledge is transmitted by teaching, oral storytelling and the performance of rituals for gods and nature spirits that show the interdependency of human and nature (Berkes & Folke in Gunderson & Holling 2002).

These governance systems based on TEK differ extremely from `western` conservation ideas and resource use practices. Living directly with and in their natural surrounding and further depending directly on the well-functioning of the ecosystems, primary resource users in small traditional SES largely have a closer relationship to their environment which is often complexly linked with their religions and beliefs (Gómez-Baggethun et al. 2013). TEK-based systems are not ecologically wise or adaptive per se. They are constantly redefined by societies and co-evolve with the system open to "modern" influences and are therefore also challenged by overexploitation, or by the use of harmful techniques. However, they provide a variety of (traditionally/locally) sustainable approaches that can complement conventional resource management (management systems based on western science and top-down managers) and be combined with scientific knowledge to design more adaptive strategies (Berkes et al. 2000; Gunderson & Holling 2002).

Summing up, local specific context is crucial to the understanding of SESs and hence essential for the development of sustainability governance strategies of natural resources. Their dynamic character, multiple components and complex interactions shape and determine the reaction to changes. A change of system conditions through internal growth or external perturbation has to be accepted as a system-inherent dynamic process and hence be adapted to sustainable governance strategies in order to make them also adaptive and thus resilient to changes. The specific local context encompassing local ecosystem conditions and processes as well as social institutions and arrangements have to be considered to fully understand SESs. With the actor group of the Densu delta fishers and their traditional governance strategies in the focus of this research, all these SES features have to be considered to approach a full understanding. To comprehend the dynamics of the local Densu delta fishery system, the external processes affecting the system also have to be considered. The traditional fisheries in Ghana, the conditions of wetlands and possible perturbation and change from outside as well as from inside the focal SESs are looked upon in the following.

3 Literature Background on Governance and Threats of Coastal Wetlands Fisheries in Ghana

The fisheries, in particular the small-scale fisheries represent worldwide examples of common pool resources that ensure food security and livelihood of millions (Kittinger et al. 2013). Yet they also exemplify social-ecological resource systems that are challenged by multiple local threats and global pressures (Jentoft & Chuenpagdee 2015; Kittinger et al. 2013) and hence form content of multiple studies concerning possible sustainable governance strategies (e.g. Ostrom 2007b; Kittinger et al. 2013; Basurto et al. 2013). Changes in environmental conditions, socio-economic as well as political and cultural settings can have strong influences on local resource systems and their sustainability (Jentoft & Chuenpagdee 2015). While the common narrative on fisheries, particularly in developing countries is one of stock collapse, lack in governance and loss of livelihood for marginalized poor people, there are yet many examples of successful fisheries governance with sustainable outcomes (Cinner et al. 2013). As Basurto (2005 and Basurto et al. 2013) shows local conditions within the system, as well as external settings, matter strongly to the sustainable governance performance of small-scale fisheries systems. Even close by resource systems can vary extremely in their sustainability depending on the local socio-ecological conditions and the governance structures.

For the analyses of the SES of the Densu delta fisheries consequently the conditions of SES of coastal wetland fisheries in Ghana, as well as on cross-scale influencing socio-economic and ecological dynamics are important to consider. In order to foster the understanding of the empirical work, the state of the art on Ghana´s fishery and its governance in coastal wetlands as well as on perturbing pressures is further presented here. Thereby research gaps are addressed, showing the importance of research about the focal resource system and associated interrelation with changing dynamics. Finally the working hypotheses are drawn.

3.1 Coastal Wetland Fisheries in Ghana

Ghana is known as a strong fishing nation since centuries and its fishers dominated the industry of many West African countries for centuries (Mensah et al. 2006; Marquette et al. 2002). Providing 60% of Ghanaian´s animal protein intake, fish in general is with a per capita consumption of about 22kg/year and a 4.2% (in 2011) contribution to the country´s GDP, of great importance for Ghana´s economy and food security (Atta-Mills et al. 2004; Niang et al. 2014; Directorate of Fisheries 2004; Nunoo & Asiedu 2013). 1.5-2 million Ghanaians depend directly on the fishing industry and its related sub-sectors and hundreds of fishing communities along the coast and the inland waterbodies receive the main share of their income from the fisheries that shape the cultural map of the country (Atta-Mills et al. 2004; Mensah et al. 2006).

While the marine sub-sector with a dominant role of the artisanal production (60-80% of all marine catches) (Marquette et al. 2002) constitutes with 85 % of all catches the major production contributor (Nunoo & Asiedu 2013; Mensah et al. 2006), Ghana´s international reputation as a fishing country is rooted in the traditional lagoon, river and estuary fishery (Mensah et al. 2006). Even the marine sector has a dominant role in the total domestic production (Mensah et al. 2006; Atta-Mills et al. 2004; WARFP

2010; Fisheries 2004), the aquatic resources of the coastal wetlands (such as estuaries, lagoons and rivers) were exploited many centuries before the marine fishery even started in the 18th century (see Appendix 10.1) (Akyeampong 2007; Marquette et al. 2002; Mensah et al. 2006).

Since the country´s domestic production of 440,000 t/yr (in 2011) (ATFALCO 2012; WARFP 2010) accounting for 20% of all West African catches, cannot meet its high consumption of 600,000 t/yr per annum, Ghana remains an import country and the development of its fishery production is of high interest for the country´s economy and food security (Atta-Mills et al. 2004; Welcomme 2011). According to Mensah et al. (2006), the marine catches have already reached their maximum in the early 1990s, while the overall inland production has been increasing for decades. Yet, the catch level of Lake Volta, which is with 85%-90% of all inland catches considered as the main contributor of the sector, has also reached its maximum production decades ago and records decreasing numbers ever since (46.8 kg/ha in 1976 to 32.6 kg/ha in 1998) (Mensah et al. 2006; WARFP 2010). According to official statistics, the only increasing production is reported for commercial aqua-cultural production, where mainly small-scale production increased from 400 tons in 1995 to 6000 tons in 2001 and explains the overall reported increasing trend of the inland fisheries (Mensah et al. 2006; Fisheries 2004).

The inland fishery sector encompasses multiple waterbodies inside the country and particularly along the coast. About 10% of Ghana´s land surface are wetlands (Okyere et al. 2011) and along its 550 km long coast multiple rivers (such as the Ankobra, Pra, Densu, Volta) that enter the Gulf of Guinea feed about 90 -100 open and closed lagoon systems and estuaries[2] that cover an estimated total area of 36,596 ha representing 0.15% of the country´s total land suface (Gordon 2006). According to the Ramsar Convention on wetlands of international importance (an intergovernmental treaty for wetland conservation and wise use of their resources) "*wetlands include a wide variety of habitats such as marshes, peatlands, floodplains, rivers and lakes, and coastal areas such as saltmarshes, mangroves, and seagrass beds, but also coral reefs and other marine areas no deeper than six metres at low tide, as well as human-made wetlands such as waste-water treatment ponds and reservoirs*" (Ramsar Convention Secretariat 2007). Located on the interface of land and ocean, their diversity in biomes and ecological processes relates to changing salinity, temperature, water depths, topography, hydrological and sedimentation dynamics interacting with both the marine and the terrestrial environment (Diop et al. 2014). Within the large variety of coastal ecosystems and habitats, deltas, lagoons and estuary largely with mangrove swamps and forests are the most dominant coastal wetland formation (Darwall et al. 2011; Diop et al. 2014).

While the coastal marine environment here is very diversified and strongly characterized by seasonal nutrient rich upwelling responsible for the species rich fish stocks, the fauna and flora diversity of these fluvio-marine and brackish waterbodies is regionally uniform and has low seasonal variations (Wolanski, McLusky, Diop, et al. 2011). Yet, they are known for their biological productiveness and play a crucial role as nursing and feeding grounds for a variety of marine and fluvial fish and shellfish species (Goussard & Ducrocq In: Diop & Cyr 2014). This high productivity, ranging amongst the most productive ecosystems of the globe, entails their importance for human societies and economies and is manifested in their traditional exploitation since centuries (Goussard & Ducrocq In: Diop & Cyr 2014). As presented in table 3, the coastal wetlands deliver on the one hand important foods and materials, ensure the regulation and self-maintenance of the ecological system and further represent important cultural aspects for the perfor-

[2] In the following the term "coastal wetland" compromises in general coastal brackish and freshwater lagoon, delta and estuary systems.

mance of religious practices on the other hand. Thus, they are highly important for livelihood and culture of the communities that depend on their well-functioning and further for the country's economy, food security and cultural heritage (Diop & Cyr 2014; Dudgeon et al. In: Darwall et al. 2011; Bojang, 2009; Schuyt 2005; Jennerjahn & Mitchell 2013; Entsua-Mensah et al. 2000).

TABLE 3 ECOLOGICAL SERVICES OF WETLANDS. MODIFIED FROM GOUSSARD AND DUCROCQ (IN: DIOP & CYR 2014. P. 18) AND LEPAGE (IN: LEPAGE 2011. P. 7)

Ecological services of coastal wetlands

Self-maintenance through structure and processes	Wildlife habitat, biodiversity, maintaining the flow of energy and nutritional cycles, primary productivity, reproduction, nitrogen removal
Provisioning with goods	Fisheries and aquaculture (artisanal and commercial) and wildlife meat products, agricultural and other food products, firewood (energy), crafts, building materials, medical plants, genetic, water, salt production, grazing ground
Regulating functions	Climatic regulation (e.g. carbon sequestration), sediment trapping, protection against coastal erosion and extreme marine weather events, treatment and recycling of liquid waste water, flood prevention, runoff storage, stabilization of mobile dunes
Cultural uses	Recreation, aesthetics and leisure activities (landscape appeal and environmental quality), research and education, cultural and religious heritage (sacred sites, customs, traditional ways of life, artistic expression)

3.2 IMPACT OF CHANGING SOCIO-ECONOMIC AND ENVIRONMENTAL DYNAMICS ON COASTAL WETLAND FISHERIES IN GHANA

Located on the interface of land and ocean, the social-ecological fishery systems in coastal wetlands are on the focal point of impacts through anthropogenic as well as environmental dynamics from the terrestrial-fluvial and also from the marine side. These SESs are therefore particularly characterized by the interplay of change and persistence and affected by changes from both environments (Jennerjahn & Mitchell 2013; Diop et al. 2014). In the last decades environmental and socio-economic changes revealed that at unprecedented rates and ranges in the coastal zone of West Africa result particularly in a vast aggravation of pressures on the SES of coastal wetlands (Diop et al. 2014; Wolanski, McLusky & Williams 2011; Smith et al. 2009).

Even there is a lack of historical observational data for temperature and precipitation, hence trends are characterized by huge uncertainty, Niang et al. (2014) identify tropical West Africa as hotspot of climatic changes. Rising temperatures, rain pattern changes, sea level rise (in Ghana currently 2 mm/yr) (Addo 2013), coastal erosion and extreme events like floods increasingly challenge West Africa's coastal aquatic ecosystems and the interrelated social systems, such as the fishers (Jennerjahn & Mitchell 2013; Smith et al. 2009; Diop & Cyr 2014; Niang et al. 2014). Future trends show a medium to

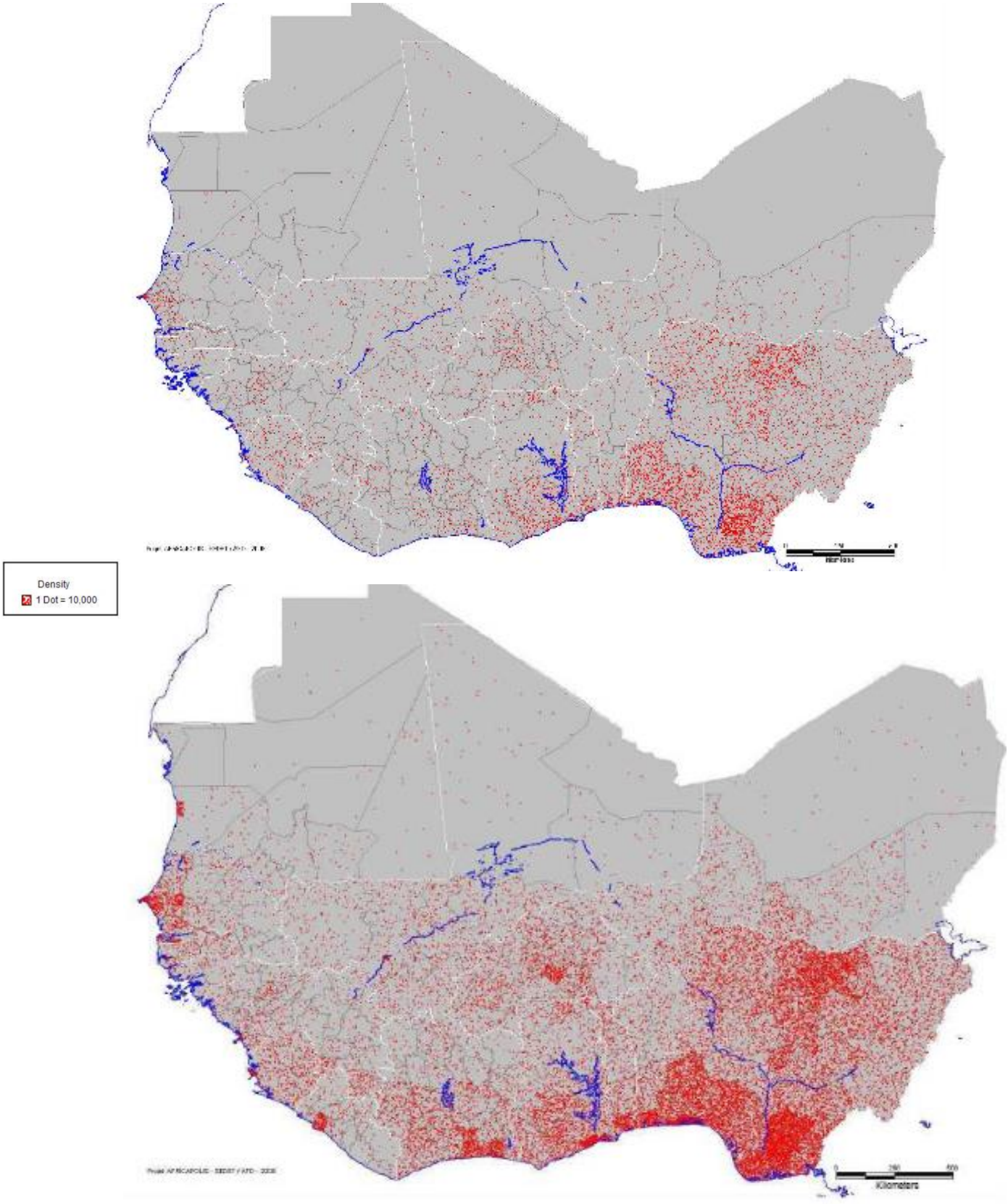
high potential for risks through biome shifts, water resource degradation and sea level rise (Niang et al. 2014). Particularly low lying wetland systems are at risk of sea water intrusion that alters the ecosystem and spoils potable water (Tanner et al. 2014; Niang et al. 2014). Flooding due to storm surges and inland floods submerges these areas and consequently alters coastal wetland habitats and biodiversity as well as socio-economic activities such as fishing (Addo & Adeyemi 2013; Aheto & Mensah 2011; Tanner et al. 2014).

In many cases it is very challenging, if not impossible, to clearly distinguish anthropogenic and purely naturally caused environmental changes, yet the Report of the Intergovernmental Panel on Climate Change concludes that the impact of climatic and natural changes is by far outmatched by the range and rate that anthropogenic activities compromise Africa's coastal wetland systems (Niang et al. 2014). Socio-economic and demographic changes with expanding settlements and agricultural areas, increasing food demand and waste quantities pile on the pressure on the natural environment of coastal wetlands and consequently also affect human societies (in terms of food security, health risks, source of livelihood, access to potable water etc.) (Niang et al. 2014; Darwall et al. 2011; Lee et al. 2006).

> *"The current human footprint on these* [West African] *coastal areas appears to be dominated by the concentration of population and economic stakes related to the (i) urbanisation and its forerunners (communication routes, alleviation from isolation, electrification, recent changes in artisanal fishing strategies, etc.); and (ii) rapid development of tourism and residential areas, often on the periphery of urban areas. [...] The acceleration of the often anarchic and spontaneous use of coastal land is all the more pronounced as land ownership control often remains unclear, given that such areas were still rural a short time ago, where legal pluralism prevails in terms of land ownership (customary law and modern law)."* (Goussard & Ducrocq In: Diop & Cyr 2014. p. 10)

Goussard and Ducrocq clearly stress that urbanisation and its related processes such as land use change, increasing resource use and environmental pollution combined with a lack of city planning and complicated land tenure systems are claimed to be the main drivers of change in the West African coastal social-ecological wetland systems (see also Smith et al. 2009; Wolanski et al. 2011). Even Africa is globally the least urbanised continent, the concentration of urban centres along its western coastal zone, as well as their fast growth, is outstanding as it is pictured in figure 1 (Songsore 2009; Bruns & Frick 2013; Denis & Moriconi-Ebrard 2009). West Africa is the continent´s second fastest urbanising sub-region where more than a quarter of the continents population lives within the first 100 km of the coast (Niang et al. 2014). Illustrating global trends of urbanisation, the share of urban dwellers in West Africa is projected to rise from 44.9 per cent in 2011 to 65.7 per cent by 2050 (UN-Habitat 2014).

FIGURE 1 POPULATION DENSITY IN WEST AFRICA IN 1960 (UP) AND 2010 (DOWN); SOURCE: (DENIS & MORICONI-EBRARD 2009. P. 9 AND 11)



In Ghana, urbanisation mainly concentrates on the coastal Accra-Tema as capital and primate in politics and economics with fast growing suburban areas (Yankson & Bertrand 2003; Adank et al. 2011). A highly land consuming horizontal spread of cities is characteristic for West African urbanisation and also delineates Accra's growth (Goussard & Ducrocq in: Diop & Cyr 2014; Yankson & Bertrand 2003). Coastal wetlands especially those in or close to urban agglomerations, are highly affected by physical modification through uncontrolled spread of built-up areas, tourist facilities and industries that disturb sensitive birds and other wildlife species (Willoughby et al. 2001; Dankwa et al. 2004; Darkwa & Smardon 2010; Aheto & Mensah 2011). Natural habitats are getting fragmented and destroyed, hydrologic flows are modified and bio-physical and chemical water parameters change. Several wetland locations such as the Densu Delta and the Sakumo lagoon close to Accra and Tema (see Willoughby et al. 2001) the Fosu lagoon close to Cape Coast (see Darkwa & Smardon 2010), the Whin river estuary and the Butuah lagoon close to Takoradi centre (see Aheto & Mensah 2011) are already highly affected.

Not only the environmental conditions are altered by urbanisation but also the social and cultural changes impact on the fisheries. Immigration from other regions, high natural urban-population growth combined with better health facilities are the major growth accelerants in Ghana´s urban agglomerations (Yankson & Bertrand 2003). According to various authors, the different ethnical backgrounds of new inhabitants have strong influence on the community structure of coastal wetland fishers. The changing community patterns are identified to range amongst the major catalyst of the breakdown of traditional conservation systems and consequently changes in fishery governance systems (see Dankwa et al. 2004; Ntiamoa-Baidu & Gordon 1991; Ntiamoa-Baidu 1991; Entsua-Mensah et al. 2000). Further influences of Christianity and Western education that arise with urbanisation are leading to an increasing disrespect of local traditions and finally also to ignorance of conservation practices in the coastal inland fisheries (Ntiamoa-Baidu 1991; Ntiamoa-Baidu & Gordon 1991; Entsua-Mensah et al. 2000).

As stressed in previous chapters, the wetland provides valuable resources for local communities, hence the demand on these resources is correlated with increasing numbers of inhabitants in the coastal agglomerations (Willoughby et al. 2001). According to Willoughby et al. (2001) the combining factors of immigration, breakdown of traditions and the increasing number of resource users lead to overexploitation of Ghana´s coastal wetlands. As visualized in figure 2, the rising fishing pressure (numbers of fishers) after an initial rise in yields (catch), in the long run depletes the fish stocks. Besides environmental degradation, increasing numbers of fishers and irresponsible fishing methods have been identified as main reason for declining fish stocks and fish sizes for decades (see Darkwa & Smardon 2010; Entsua-Mensah et al. 2000; Addo et al. 2014). Various studies state that the resource users (the fishers) are rather a threat to the coastal ecosystems in overexploiting inland fish stocks and spawn of marine species by intensive activities throughout the year and by using illegal fishing methods (see Dankwa et al. 2004; Okyere et al. 2011; Ntiamoa-Baidu 1991; Baffour-awuah 2014b).

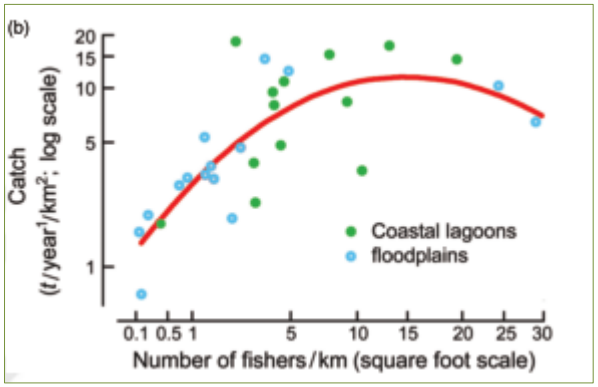


FIGURE 2 RELATIONSHIP OF YIELD AND FISHING INTENSITY IN 13 TROPICAL COASTAL LAGOONS AND 15 RIVER FLOODPLAINS (BAILEY 1988 CITED IN PAULY & YÁÑEZ-ARANCIBIA 2012. P. 471)

TABLE 4 LIQUID WASTE DISPOSAL IN ACCRA (GSS 2002 IN ADANK ET AL. 201. P. 601)

	GAMA
Sewerage system	15.3%
Gutter	41.1%
Street / outside	18.3%
Compound	24.8%
Other	0.6%

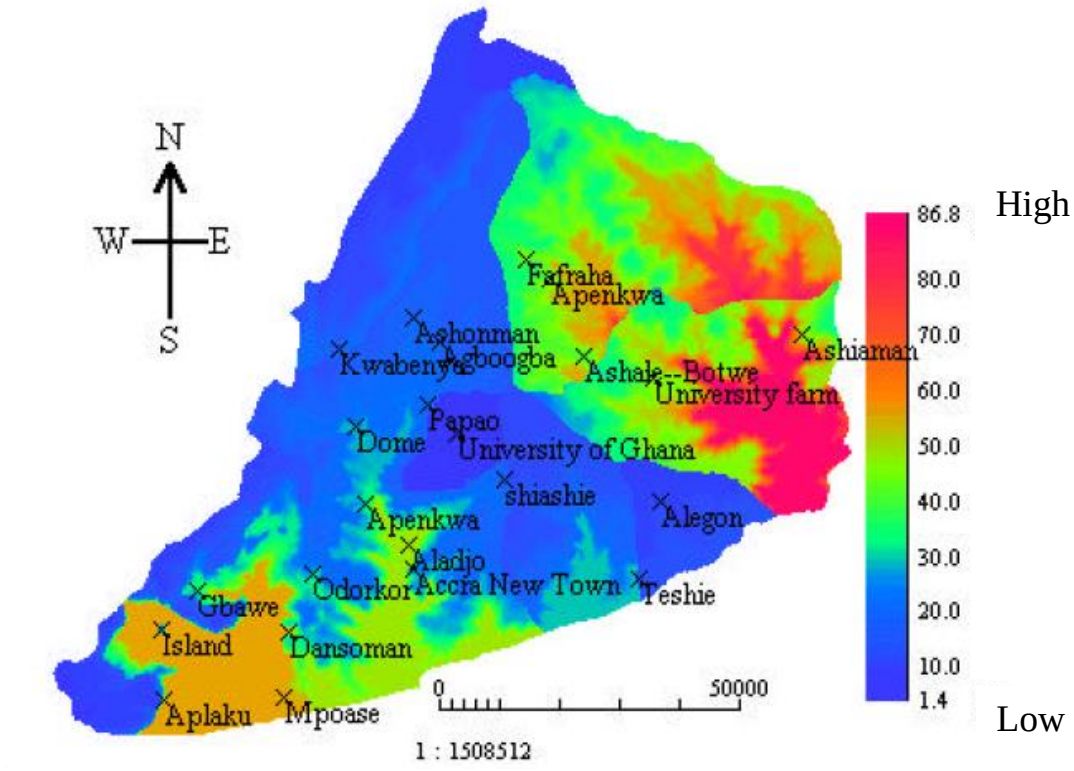
According to Barrios et al. (2006), the massive rural-urban migration movements further impact sustainable development in cities and consequently the sustainability of urban resource systems. Population growth and a changing consumption pattern come along with increasing amounts of waste that are for the most part ending up in the cities' waterbodies. Inadequate solid waste collection systems, especially in poor urban communities of Accra, such as Nima and informal settlements like Old Fadama, then lead to blocked drainages and the development of illegal dumping sites (Adank et al. 2011; Songsore 2009; Monney et al. 2013). Beyond that, fast urbanisation is largely associated with the emergence of unplanned, unstructured communities that are often characterized by environmental threats like water contamination, inadequate water supply, insufficient sanitation and a lack of waste disposal supply and drainage systems (Songsore 2009; Adank 2011; Weeks 2013). As seen in table 4, 41.1% of GAMA`s liquid waste drains unfiltered through gutters, rivers and lagoons, whereas only 15.3% enter the sewerage system, whereof a huge part is finally anyhow pumped into the ocean (Adank et al. 2011). Draining through urban and peri-urban waterbodies, the liquid and solid waste puts massive stress on the aquatic and surrounding ecosystem as well as on its primary resource users like the fishers. Water and aquatic species get contaminated through sewage intrusion, landfill leakage, waste from drainage systems and further through agricultural run-off (Willoughby et al. 2001; Baffour-awuah 2014a; Osei 2010)

These massive waste accumulations (in combination with other anthropogenic impacts on the hydrological systems) further aggravate natural processes like seasonal flooding in and around urban wetlands and consequently lead to high flood risks in these areas (see figure 3). During annual peak water flows, deficient drainage systems blocked with huge amounts of solid waste are a key factor for the catastrophic dimension of flood events that especially have an impact on riparian communities (Adank et al. 2011; Frimpong 2014; Gyekye 2013; Frimpong 2014). Furthermore, anthropogenic changes of hydrological processes in form of river bed engineering, soil sealing and up-stream deforestation are enhancing inundations (Frimpong 2014). Since more and more communities are built close to river beds in Accra and often encroach into natural floodplains and waterways, the number of houses exposed to flood risk in increasing, hence the damage per flood event is rising (Gyekye 2013; Frimpong 2014; Adank et al. 2011). As seen in figure 3, particularly areas in GAMA close to large lagoon and delta systems like the Sakumo lagoon and the Densu Delta are extremely vulnerable to flooding, which also has great impact on the resource systems (Adank et al. 2011).

Not only natural processes such as flooding are exacerbated by anthropogenic settlement and infrastructure extension, but also natural coastal erosion (Addo 2013). The unstable texture of the sandy beaches, sandstone sediments and highly fragmented rocks of Ghana`s coast are already sensitive to wave energy, strong littoral currents and rising sea levels (Goussard & Ducrocq In: Diop & Cyr 2014). Human impact through upstream river damming for hydro-power generation and water reservoirs for example at the Volta (Akosombo dam) and the Densu river (Weija dam), sand mining, river bed engineering, mangrove degradation and upstream land use changes have aggravated the situation in many locations (see Goussard & Ducrocq and Diop et al. In: Diop & Cyr, 2014; Mensah et al. 2006;

Vörösmarty et al. 2005; Smith et al. 2009; Frimpong 2014). At critical points erosion rates of 2-4 m per annum were recorded along Ghana´s coast, pertaining foremost fisher communities that are located close to wetlands and the seashore. In the fishing communities Gleefe and Bortianor, close to the Densu delta for instance, coastal erosion destroys settlements, infrastructure and canoe landing sides (Mensah et al. 2006; Addo 2013).

FIGURE 3 FLOOD RISK AREAS IN ACCRA. SOURCE: NYARKO. 2002. P.10



3.3 GOVERNANCE OF COASTAL WETLANDS RESOURCES

As a result of the severe threats to local resource systems and the collapse of fish stocks in various regions, not only science is increasingly promoting more adaptive governance approaches for natural resource systems, but also many developing countries have shifted the governance of wetlands from the central to local governments and regional authorities in recent years (Béné et al. 2009). According to Béné et al (2009), this shift to decentralised forms of governance, largely undertaken with the support of international organisations, has been done with hope to progress in sustainability, empowerment of marginalized groups of the society and public accountability. Through this process, governance variables of local SES such as leadership, community coherence and the capabilities local institutions became more prominent (Béné et al. 2009), however the outcomes in many cases did not meet the initial goals. New accountabilities on local scales were often superimposed on customary governance systems that

are based on local contexts and established over generations and an emerging pluralism of governance systems (Benjamin 2008).

Recognizing the value of the coastal wetlands for livelihood support, economy and nature conservation and addressing their increasing degradation (Ntiamoa-Baidu & Gordon 1991), also in Ghana new governance approaches were established in the 1990s. With support of the Word Bank, the Ghana Coastal Wetlands Management Project (GCWMP) was initiated and five lagoon systems were officially designated as Ramsar sites (wetlands of international importance) (Entsua-Mensah et al. 2000). The Keta, Songor, Muni-Pomadze and Sakumo Lagoon, as well as the Densu delta were thenceforward managed under the authority of the Wildlife Division (WLD) of the Forestry Commission of Ghana with regard to the Ramsar Convention on Wetlands (Ramsar, Iran, 1971) (for further readings Ramsar Convention Secretariat 2007). While the overall responsibility and the administration of all social, economic and environmental programmes related to wetlands stays with the central government, the local communities and assemblies together with the WLD and NGOs are responsible for the direct management and the "wise use" of wetland resources.

The mission of the Ramsar Convention and hence the concept for the designated sites is *"the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world"* (Ramsar Convention Secretariat 2007). The National Wetland Strategy emphasises the objectives of strengthening an effective "[the] full and effective participation and the collective actions of stakeholders, including indigenous peoples and local communities, for the existence of sustainable, comprehensive and wise use of wetlands" (Ramsar Convention 2016. p. 6). According to the Strategy paper, the *"decentralisation of government administration provides a unique opportunity for District Assemblies to enact by-laws to support relevant traditional practices useful for wetlands management programmes"*. Meaning that traditional authorities, believes system and practices for wetlands conservation and resource use are explicitly supported by the government, including the goal of legally backing them (Ministry of Lands and Forestry Ghana 1999).

According to Gbogbo (2007), the Ramsar site concept in Ghana principally aims to diminish the pressure through environmental degradation and encroachment, regulating the fisheries, maintain bird watching facilities and generally patrol the area to ensure law enforcement (Willoughby et al. 2001). Human communities are neither excluded to live within the sites, nor to harvest their resources, but are obliged to ensure the ecological integrity of the coastal wetlands, so only sustainable small-scale interventions that conform with the wise use concept are permitted to continue the provision of livelihood for the surrounding communities (Willoughby et al. 2001).

Unfortunately, as shown in the previous chapter, the concept does not stand the pressures of urbanisation and increasing recourse demand, leading degradation and rising fishing pressure. Hence, most management plans for coastal wetland identify the fishers as a burden to both the marine (Akyeampong 2007) and the brackish and freshwater fish stocks (Dankwa et al. 2004; Okyere et al. 2011; Ntiamoa-Baidu & Gordon 1991; Entsua-Mensah et al. 2000). Besides the reduction of pressures from "outside", an especially stricter fishery law enforcement on mesh size, gears and off seasons, diversifying of fishers income and the promotion of traditional conservation practices are considered by various studies as urgently needed interventions to reduce pressure on the wetlands (see Dankwa et al. 2004; Okyere et al. 2011; Ntiamoa-Baidu & Gordon 1991; Willoughby et al. 2001).

Stricter law enforcement includes the formal determination of the fisheries which is based on the Fisheries Act, 2002 (Act 625), amended by the Fisheries (Amendment) Act, 2014, Act 880. The Fisheries and Aquaculture Policy (2008) and the Fisheries Regulations 2010 give effect to the Act and are responsible for restrictions and regulations. These laws, acts and regulations coordinate the control of fishing gears, techniques and licenses. They further regulate the number of fishers per unit and the prohibition of fishing activities in certain areas. The Directorate of Fisheries is the executive arm of the Fisheries Commission, which operates under the Ministry of Fisheries and Aquaculture Development (MOFAD 2016). This also counts for the coastal wetlands but according to Gbogbo (2007), despite the five designated Ramsar sites, Ghana´s wetlands are largely unmanaged and therefore highly exposed to overexploitation and other pressures.

The following statement by Pauly and Yáñez-Arancibia (2012. p. 391), shows clearly how governance is seen from a perspective of yield maximisation, which is still the underlying approach of most conventional fishery management, largely also applied in Ghana: *"[F]isheries, at least in modern times, tend to quickly become overfished unless they are well managed, the result of an overwhelming harvesting capability applied to finite resources that belong to no one before they are caught (common property) and which everyone has the right to exploit (open access). Fisheries management, therefore, generally involves putting restrictions on (i) access to the resources, (ii) number of gears, (iii) type of gear deployed, (iv) timing of effort deployment, or (v) some combination of these."*

As shown above, the governmental management plans has emphasized for decades the integration of traditional strategies, however the role of artisanal fisheries and their traditional conservation strategies for long were neglected and largely still are. When governmental and international agencies finally paid attention to those traditional approaches, the fisheries were tried to fit into capital-intensive projects or rural development plans (Mensah et al. 2006). After these interventions failed, integrated approaches, which are mainly need and assets-based, were applied with the integration of all facets of livelihood (e.g. education, health, water, sanitation) of fishers communities. According to Mensah et al. (2006), this approach obviously needs the knowledge and perspective of the local fishers and fish workers, but still is missing in the governance implementation. He further states that research about the complex interactions of these SES is needed to meet the urgent shift to sustainable governance.

3.4 Traditional Governance of the Fisheries

As indicated above, Ghana´s traditional fishery systems are associated with various beliefs, taboos and traditional management practices that have been maintained for centuries and constitute the important role of the fisheries in cultural and religious practices (Dankwa et al. 2004; Darkwa & Smardon 2010; Ntiamoa-Baidu 1991; Ntiamoa-Baidu & Gordon 1991; Entsua-Mensah et al. 2000; Koranteng et al. 2000). Various traditional resource use practices and management strategies are combining ecosystem conservation, culture and religion, emphasizing a deep relation between nature and humans (Akyeampong 2007). These institutions that determine the practices of the fishers, their nature relation and cooperation within the community form from generation to generation. Akyeampong (2005) argues that Ghana´s fishery tradition is more than just work, but rather is a crucial part of Ghana`s cultural heritage passing significant TEK intergenerational. Hence he argues, that the creation of alternative livelihoods for fishers would not meet the goal of sustainable governance, since the social and cultural heritage would be ignored (Hens 2006; Akyeampong 2007).

Instruments that were and still are used for the maintenance of traditional rules and regulations within the fisheries include for example taboos, respected spirits and common beliefs (see table 5). Here, the interaction of social and ecological systems is not only defined by the use of resources, but further includes religious bounds with ecosystem components. Certain species or habitats were traditionally considered as sacred and preserved from hunting (Ntiamoa-Baidu 1991; Hens 2006). Those TEK-related taboos, spirits and beliefs in Ghana (see table 6) can vary from lagoon to lagoon, however the instruments and established institutions resemble each other. The review of literature on the assessments of seven lagoons (including all 5 Ramsar sites) by Ntiamoa-Baidu & Gordon (1991); Entsua-Mensah et al. (2000); Ntiamoa-Baidu (1991); Koranteng et al. (2000); Darkwa & Smardon (2010) and Dankwa et al. (2004) revealed that most lagoons in Ghana are still managed according to some or multiple traditional resource management practices (see table 6). However the authors state the breakdown of traditional structures for most fishery systems, particularly in urbanised areas such as the Densu delta, the only system where no traditional regulations were found.

TABLE 5 INSTRUMENTS AND SYSTEMS UNDERLYING TEK ACTIONS THAT ARE BIODIVERSITY RELATED. SOURCE: HENS 2006. P. 25

Instrument/system	*Examples*
Taboo and prohibition	clearing vegetation along riverside days and periods where fishing or hunting is prohibited
Respect traditional spirits	sacred groves trees that should only be felt after accomplishment of rituals
Common belief	cultivate land in such a way that it can rest afterwards during a period that is long enough for the recuperation of the fertility of the soil
Land tenure	land owned as common, communal, clan or extended - family property

TABLE 6 SUMMARY OF REVIEW ON TRADITIONAL GOVERNED RESOURCE SYSTEMS IN 7 COASTAL LAGOONS IN GHANA

Lagoon/Delta	Traditional conservation practices and beliefs	Function	Effectiveness and adherence
Sakumo Lagoon (Ntiamoa-Baidu & Gordon 1991; Entsua-Mensah et al. 2000)	**Ntiamoa-Baidu and Gordon (1991):** Taboo on Black ; Prohibition of mesh size use below 25mm and taboo of fishing on Friday from daybreak to noon (for lagoon fetish); Closed season Oct/Nov and end March to April (depending on the status of the fish stock). **Entsua-Mensah et al. (2000):** fishing taboo on Friday and four- month off season; dragnets, mesh-size below 25mm and canoes are prohibited.	Species and stock protection	Rules and taboos are disregarded and the traditional system breaks down due to: Christianity, western education and influence, community change through migration
Djange Lagoon (Ntiamoa-Baidu 1991)	Prohibition of: Monday fishing; collection or removal of specific mollusc species; use of poles or sticks; crossing of the lagoon with vehicle; entering the	Fish stock and species protection	The taboos are not backed by a law. The elders say that traditions

	lagoon with footwear or gold earrings; women entering during menstruation; frying of lagoon fish; use of dragnets; Closed season lasts for three weeks after the lagoon opens to the sea	testify respect to lagoon god	where increasingly ignored. The taboo mollusc is spread all over the lagoon
Muni Lagoon **(Koranteng et al. 2000; Entsua-Mensah et al. 2000)**	**Koranteng et al. (2000):** Only indigenous people are allowed to fish; Wednesday is prohibited; women in their menstrual period are not allowed to cross the lagoon; dragnet is prohibited **Entsua-Mensah et al. (2000):** Wednesday taboo; dragnet and mesh-size below 25mm and the use of canoes is prohibited; only indigenous people are allowed to fish; women are prohibited to cross the lagoon when menstruating	Enhance conservation of the fishery resources and limit fishing pressure	According to Koranteng et al. (2000), all are strictly obeyed except the dragnet rule. Entsua-Mensah (2000) in contrast states loss of tradition also for the Muni lagoons
Densu Delta **(Entsua-Mensah et al. 2000; Ntiamoa-Baidu & Gordon 1991)**	no restrictions in Densu Delta		Traditional regulations are lost due to urbanisation, migration of fishers and effects of western practices and Christianity
Songor and Keta Lagoon **(Dankwa et al. 2004; Entsua-Mensah et al. 2000)**	**Dankwa et al. (2004) :** Keta: no closed season; ban on certain days Songor: 1-week fishing ban before start of fishing season; Thursday is non-fishing day **Entsua-Mensah et al. (2000):** Keta: Sunday taboo and before annual festival Songor: one area is only allowed for fetish priest and close communities; no women crossing when menstruating	Harvest regulation and resource protection	In urban areas around Keta the closed seasons are not respected
Fosu Lagoon (Darkwa & Smardon 2010)	Prohibition of fishing on Fridays and during one week End August/Beginning Sept due to annual festival; Women are not allowed to cross the lagoon when having menstrual period Canoes and night fishing is prohibited	Prevention of overexploitation, respect of lagoon god	Traditional system has not been able to sustain, due to population growth and the increase in fish demand and fishers, which leads to overexploitation

The traditional organizational structure of inland fishing communities is barely assessed. The marine organizational structures by contrast are well-documented. The responsibilities in the marine fishery are hierarchical, strictly divided by gender and still similar to how it was established centuries ago (Entsua-Mensah et al. 2000; Marquette et al. 2002). The men are responsible for fishing from early age on (Mensah et al. 2006) and the women for distribution, marketing and processing (Akyeampong 2007). The communities are traditionally headed by the Chief and the Chief Fisherman and the queen of fish traders are responsible for all fishing concerns. They are followed by canoe and net owners (and their wives as trading heads) and finally by crew members. These institutions are crucial for conflict solving, ensure social order and unify the fishers in times of problems. These traditional structures are of particular importance for cooperative governance and in adapting strategies to changing dynamics, since the chief also serves as intermediary and therefore facilitator of communication between the governance structures and the fishers (Marquette et al. 2002).

3.5 Research Gaps, Research Question and Hypothesis

The literature review on the coastal wetland fishery in Ghana and changing dynamics revealed large data gaps in various important realms. There are even several studies on Ghana´s wetlands, they largely concentrate on specific, mainly bio-geophysical issues in one or two wetland locations and mainly relate to single empirical studies instead of long term assessments. Moreover, almost all publications on fish stock and species composition (see Dankwa et al. 2004; Okyere et al. 2011; Baffour-awuah 2014a; Addo et al. 2014; Afful et al. 2010), vulnerability to consequences of climatic changes (Addo 2013; Addo & Adeyemi 2013; Aheto & Mensah 2011; Codjoe & Issah 2015; Gyekye 2011), water bird population (Gbogbo 2007; Ahulu et al. 2006) and wetland pollution (Osei 2010; Darko et al. 2013; Nixon et al. 2007) conclude with more or less urgent emphasis that the wetlands are under stress through diverse stressors and conservation and sustainable governance systems should be enhanced.

Ghana is importing huge amounts of fish to satisfy its consumption, the main fish resources have reached their production limits decades ago, scientists constitute a large gap of data on the highly potent coastal wetlands and traditional resource use practices that are stated to foster sustainability are about to disappear. However official figures on Ghana´s inland fish production are only based on Lake Volta and commercial aquaculture, whilst other wetland´s fishery stays aside (ATFALCO 2012; Mensah et al. 2006). Particularly figures for Ghana´s small-scale inland fish production exhibit large data gaps (Nunoo & Asiedu 2013; Smith et al. 2009; West African Regional Fisheries Programme 2010; Lawson & Robinson 1983; Entsua-Mensah et al. 2000; Asiedu et al. 2013), even though these resource systems play a crucial role for local to regional economies and culture (see Mensah et al. 2006; Gordon 2006; Dankwa et al. 2004; Aheto & Mensah 2011; Darkwa & Smardon 2010; Addo et al. 2014; Baffour-awuah 2014b; Koranteng et al. 200). The only annual estimated catch data on wetland fish resources that were found is almost 20 years old. Even the total annual yield of the lagoon systems are with 270 tons/yr in the Densu delta and 114 tons/yr in the Sakumo lagoon (Entsua-Mensah et al. 2000) relatively low compared to annual catch data of Lake Volta (75,590 tons in 2008) (WARFP 2010), the estimated potential yield/ha are remarkable with estimated 343 kg/ha for the Sakumo and 130 kg/ha for the Densu Delta (Koranteng et al.1998) compared to the long exceeded maximum yield of 46.8kg/ha for in 1976 in Lake Volta (Mensah et al. 2006).

Concerning analyses of the coastal wetland fisheries as a social-ecological system, the availability of data is also poor. While there are some quite holistic publications on the history of Ghana´s marine fisheries (see Marquette et al. 2002; Akyeampong 2005), the inland sector´s history is largely ignored. Detailed studies on the fishers, their traditions and governance structures, the organisation of their communities and the interaction with ecological and other social systems are limited to some reports, case and baseline studies, which predominantly were conducted in the 1990s and 2000s (Ntiamoa-Baidu 1991; Ntiamoa-Baidu & Gordon 1991; Oteng-Yeboah 1999; Willoughby et al. 2001; Dankwa et al. 2004). Holistic data on the communities and their organization is non-existent and particularly the governance system of natural resources, which is claimed to be essential to adaptive approaches of the top-down[3] governance are not consequently assessed (Entsua-Mensah et al. 2000; Nunoo & Asiedu 2013).

According to Akyeampong (2005), the whole fishery in Ghana is not yet well-understood and probably totally underestimated. Incomplete data sets through unregulated fisheries in the dominant artisanal subsector, short-term observations, missing geographical location of samplings or changing surveillance methods and differences in sector inclusion generate unreliable data and extremely challenge the development of management implications (Palma et al. 2012; Welcomme 2011). According to Nunoo and Asiedu (2013), there is an existing disinterest in small-scale and inland fisheries due to an assumed low economical potential. The few data on those SESs, that can be found, often reveal differences (in the number of lagoons, the yield and revenue for fishers, as well as on the application and consistency of traditional management practices) or relate to the same data sets. The loop of insufficient assessment, due to economical disinterest, leads again to the assumption of the wetlands' irrelevance for the economy and livelihood.

According to Akyeampong (2007)it is only recently in the context of sustainable development since environmental issues and food security are in the global society focus, that small-scale fisheries (including coastal wetland fisheries) are getting more attention. Even the important role of traditional resource management practices for the field of sustainable resource management is highlighted by several authors (Hens 2006; Akyeampong 2007; Ntiamoa-Baidu 1991; Willoughby et al. 2001), only a few studies focus on lagoon and estuary fishers and their TEK on wetland ecosystems and resources. Barely any study analyses the interaction of actors and the top-down governance system related to potential cooperation in the development of sustainable governance strategies in wetlands under severe pressure through urbanisation. This thesis therefore aims to contribute to this issue by exemplarily assessing the SES of the coastal fisheries in the (peri-)urban lagoon of the Densu delta Ramsar site; consequently the following research question was developed:

What is the role of the fishers and their traditional ecological knowledge and practices in the SES of the peri-urban wetland of the Densu Delta, facing changing socio-economic and environmental dynamics?

[3] Top-down governance here includes all governance and management systems (and individuals) that are involved in the Ramsar Site and fisheries management from outside the fisheries. This includes the governmental and non-governmental organizations and individuals working for these entities. Whereas *from within or traditional* describes governance systems that are based on the fishers themselves, such as taboos and believes regulating traditional resource management practices

It was further shown, that traditional resource management systems have been breaking down for decades and top-down governance structures, such as the "wise use" concept of the Ramsar Convention, are introduced to foster sustainable resource use and to conserve the wetlands. However, the literature review revealed that particularly urban wetlands, which are even designated Ramsar sites (e.g. Densu delta and Sakumo lagoon) are under huge pressure through urbanisation and its negative impacts not only on the whole SES and especially on the traditional governance system (Darkwa & Smardon 2010; Baffour-awuah 2014b; Baffour-awuah 2014a). In order to gain insights on these SES and attempting to contribute knowledge about Ghana´s coastal wetland fishery, their traditional resource management systems and the strategies on governmental as well as on resource user side to foster sustainability, it is hypothesised that:

Hypothesis I: The impacts of urbanisation and its related changing socio-ecological dynamics are the main pressures on the SES of the delta´s fisheries.

Hypothesis II: Due to changing socio-ecological dynamics, traditional governance systems related to sustainable resource use have disappeared from the Densu Delta fisheries.

Hypothesis III: The top-down governance approach of the "wise use" concept of the Ramsar Convention integrates traditional resource governance to work jointly to ensure sustainable fishery in the Densu delta.

4 Analytical Framing

In order to answer the research question and to verify or reject the hypothesis by capturing and analysing the complexity of the system, an analytical frame is necessary. Even though real world problems can hardly be fully captured in their complexity, frameworks can facilitate research in this ambition and help to identify the core components and interrelations within complex systems (G. S. Cumming 2011). According to Cumming (2011. 37), *"[t]he issues framework may revolve around theoretical or practical questions that science is intended to solve, but it is an important reference point in that it defines the questions, and hence the components and interactions within the system, that are of greatest interest."* In order to define the role of the fishers and their traditional practices within the SES of the Densu delta, as well as their interactions with other systems components, Ostrom`s Social-Ecological-System Framework (SESF) is chosen and is introduced in the following.

4.1 The Social-Ecological System Framework

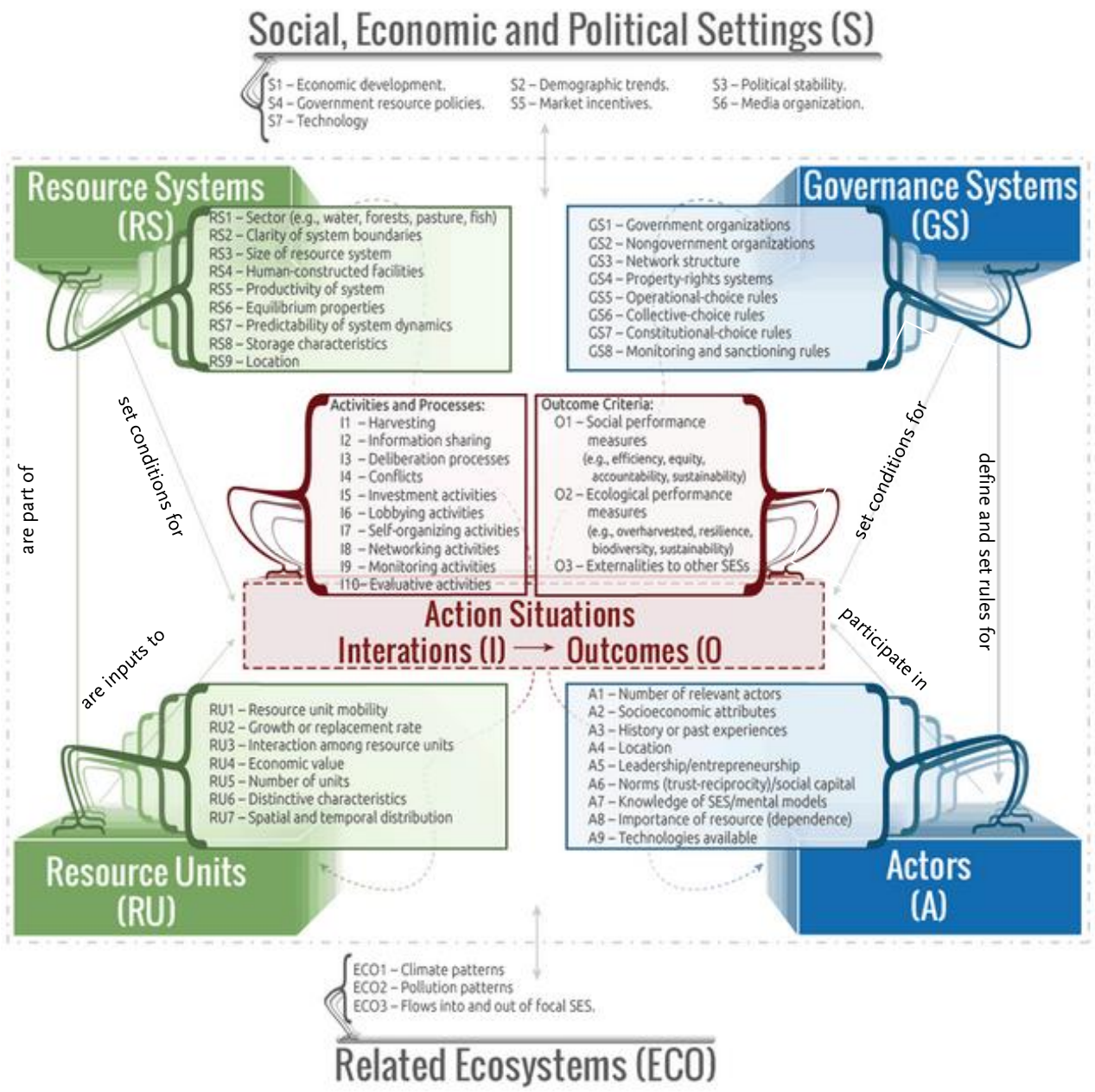
The SESF by Ellinor Ostrom (2007) is one of various frameworks that were developed in order *"to set a common language, to structure research on SES, and to provide guidance toward a more sustainable development of SES"* (Binder et al. 2013. p. 25). Since its publication in 2007, the SESF was constantly enhanced and here the extended version by McGinnis & Ostrom (2014) (see figure 4) serves as analytic framing. The SESF particularly examines institutions and interactions of SES with internal and external dynamics of common-pool natural resource systems (e.g. fishery) and processes of sustainability in SES (McGinnis & Ostrom 2014). Underlining the dynamic character of SES, Ostrom (2007) emphasizes the need of learning processes rather than final solutions to the sustainable governance of SESs. The framework therefore provides a classification system to structure the major variables of SESs that are important for natural resource management and the understanding of human group learning and behaviour in relation to the latter (McGinnis & Ostrom 2014).

Illustrated in figure 4, the framework "examine[s] the nested attributes of a resource system and the resource units generated by that system that jointly affect the incentives of users [actors] within a set of rules crafted by local, distal, or nested governance systems to affect interactions and outcomes over time" (Ostrom 2007a. p. 15181). As explained by McGinnis and Ostrom (2014) and visualized in figure 4 (p. 47), identified variables of importance in SESs are structured in tiers (different logical categories) in the SESF, whereby the lower tier variables are subdivisions characterizing the higher tier categories. The essential dimension of the first tier level compromises the Actors A (e.g. fishers) that extract Resource Units RU (e.g. fish) from a Resource System RS (e.g. coastal wetland fisheries) and otherwise interact with the different components of the system. In the extended version of the SESF, multiple of those A, RU and RS and their interrelations and feedbacks can be analysed simultaneously or separately (McGinnis & Ostrom 2014). The resource maintenance is ensured by the users and led by a set of rules, controlled by the so-called **Governance System** GS (e.g. organizations and rules that govern coastal wetland fisheries). Extraction of resources and maintenance are in the centre of the system`s **Interactions** (I) and **Outcomes** (O), where inputs are transformed by actors actions into outcomes in so called **Action Situations** (McGinnis & Ostrom 2014). The whole system which is considered as logical whole (dotted-and-dashed line in figure 4) and set into the context of **Related Ecosystems** (ECO), as well as **Social**, **Economic and Political Settings** (S) that can influence each component of SES (McGinnis & Ostrom 2014).

Drawing from the literature on the SESF the framework suits to this research in many regards. Even the framework derives from social science and Epstein (et al. 2013) as well as Cumming (2011) for instance critically remark that ecological and natural scientific knowledge is deficient in the anthropocentric framework, Binder (et al. 2013) describes the SESF as the only framework (out of 10 frameworks) that enables its user to analyse the social and ecological sub-system in approximately equal depth. Binder et al. (2013) consider the SESF as integrative, analysis-orientated and emphasize the interplay between social and ecological systems through feedbacks. It approaches the ecological system from an anthropocentric perspective with utility for humans and in return includes the impact that human resource use has on the ecological components. The integration of these process relationships by the SESF is important here, since it includes interactions (and outcomes) between components and beyond that enables the researcher to address dynamics and feedbacks related to external (social, economic and political) settings and other (related eco-)systems operating on different scales (Schlüter et al. 2014; McGinnis & Ostrom 2014). *"The processes of extraction and maintenance were identified as among the most important forms of interactions and outcomes that were located in the very centre of this framework"* (McGinnis & Ostrom 2014.p. 3), hence the examination of the fisheries suits perfectly to the framework.

The SESF further includes a "*multitier hierarchy of variables that have proven to be relevant for explaining sustainable outcomes in the management of forestry, fishery, and water resources" (*Binder et al. 2013. p. 26) and is further described by Cumming (2011. p. 40) as a "*well thought-out summary of important variables in SES dynamics* [,which] *incorporates institutional, governance and policy issues better than other frameworks*". Hence the framework does not only enable researchers to identify relevant SES variables and their interactions, it provides a hierarchical structure to organize them but further is particularly applicable in the fields of sustainable resource management and governance structures (Binder et al. 2013). Schlüter et al. (2014) further describe the SESF as one of the most holistic, theory-neutral frameworks suitable for the integration of different knowledge, theories and approaches of multiple disciplines. The interdisciplinary character of SES theory emphasizes the need of such an approach, particularly in the field of natural resource management (G. S. Cumming 2011; Glaser 2006) as it is the case in the analyses at hand. The framework is beyond that well-grounded in the field of interest (Binder et al. 2013; G. S. Cumming 2011), since it was developed accompanied by many empirical studies, whereof several analyse fishery systems (see Basurto et al. 2013; Basurto & Ostrom 2009; Cinner et al. 2013; Schlüter et al. 2014). The collected data here can therefore be organized in the SESF´s structure in a matter that facilitates comparison amongst different case studies and unifies the knowledge from different scientific fields that have the analyses of fishery resource management in common (Binder et al. 2013). Moreover it unifies several relevant factors that make it very useful for this research.

FIGURE 4 ILLUSTRATION OF THE SESF. SOURCE: MODIFIED FROM WATER DIPLOMACY, ADOPTED FROM MCGINNIS & OSTROM 2014



4.2 Additional Remarks to the SESF and Framework Extension

However, using an analytic framework, researchers always have to be aware of its real world-simplifying character. The description of a system (e.g. by a framework) simplifies the real world in favour to specifically look at the key aspects of interest (G. S. Cumming 2011). "*Frameworks are used to organize study, place bounds on inquiry, and direct attention to certain attributes of the social and physical environment, but cannot in and of themselves predict or explain outcomes. [...] In other words, a framework explains little other than identifying some attributes of a system as potentially influential, organizes them to advance systematic investigation and provides a common language with which to compare theories*" (Epstein et al. 2013. p. 434). McGinnis and Ostrom (2014) stress that the SESF is an incomplete display of the full range of meaning of their concept, as any picture of a real world phenomenon is an incomplete portrayal of system complexity. The framework only shows the systems' state at a certain point in time whereas feedbacks might also change values of components over time (McGinnis & Ostrom 2014).

Further some critics and supplements concerning actors and the incentives behind their actions, from sides of the Critical institutionalism (CI) (see Cleaver & Koning 2015) are seen as relevant here. The CI emphasizes "*the multi-scalar complexity of institutions entwined in everyday social life; their historic formation dynamically shaped by creative human actions; and the interplay between the traditional and the modern, formal and informal arrangements*" (Cleaver & Koning 2015. p.4). They claim that humans have to be seen in a more complex context than the institutional thinking based assumption of rational choice would allow. "[R]*ules, boundaries and processes are 'fuzzy'; people's complex social identities, unequal power relationships and wider political and geographical factors shape resource management arrangements and outcomes.*" Cleaver and Koning (2015. p. 4) argue that the incentives behind human choices are not necessarily based on beneficiary reasons neither are institutions always created for particular purposes. According to Agrawal (2014), Ostrom did not explicitly exclude non-utilitarian behaviour. Nevertheless he emphasizes that the importance of treating the nature of human choice-making as a dynamic, not fixed and especially context-related process should be more considered than in the SESF.

Hinkel (et al. 2015) has remarks on the capacity of the framework to capture multiple interactions between different actor groups, resource systems and resource units. According to Hinkel et al. (2015. p. 9), *"the SES framework does not capture interdependencies in complex commons where multiple types of actors carry out multiple activities that depend on and affect multiple RU and RS*". Even the framework modification by McGinnis and Ostrom (2014) allowed a possible multiple appearance of first tier components, it does not capture the appearance of multiple interrelations of these components and its application to complex systems therefore still remains challenging (Hinkel et al. 2014). It facilitates the differentiation of actor groups in sub groups, which can be defined e.g. as users and other parties that are involved in the SES otherwise than through direct use or consumption of resources (McGinnis & Ostrom 2014), but not how their actions affect and depend on other components in multiple entangled ways (Hinkel et al. 2015).

The SESF, widened up through the additional remarks from sides of the CI, serves here as analytic framing for the empirical work analysing the overall research question on **the role of the fishers and their traditional ecological knowledge and practices in the social-ecological system of the (peri-)urban wetland of the Densu Delta facing changing socio-economic and environmental dynamics**. Even Leslie (et al. 2015) states that the operationalisation of the framework has been elusive so far, the operationalisation is needed here in order to apply it on the focal system. The framework´s application features the

determination of the focus of analysis and the selection of the variables of interest (McGinnis & Ostrom 2014). The focal level hence is determined by the analytical system boundaries, by characterizing the focal actor group, by identifying the governance systems (and their boundaries) that influence their practices, as well as by specifying types of interactions (with other social and ecological system components) and outcomes related to them (see McGinnis & Ostrom 2014).

Therefore the first tier variables Actor (A), Governance System (GS), Resource System (RS), Resource Unit (RU) as well as the external factors Related Ecosystems (ECO) and Social, Economic and Political Settings (S) are updated[4] to the focal system as basic orientation and structure. In the further course of the work Action Situations (AS), representing social and human-natural interaction (I) and outcomes (O) which are the main interest of thesis, are identified. Including all second tier variables is not mandatory for the right application and is left to the researcher to decide how to modify them for the specific focal system and research interest (Cinner et al. 2013). The second tier variables in this case serve as checklist to analyse and structure the multiple components, characterize them and classify the complex interactions of the focal system. Consequently, the framework is used as orientation for the empirical work in order to assure *"that some potentially critical factor has not been overlooked"* as recommended by McGinnis and Ostrom (2014. p. 10) and finally taken to arrange and classify the results.

Since the focus of this thesis lies on the Actor group fishers, the critical remarks of the CI are included by building subdivisions and extending the framework for the components actors A → Aa (if subgroups of the fishers are identified), governance system of Actor subgroups → GSa and Interactions and outcomes of and between these subgroups → Ia and Oa. After identifying these subgroups within the fisher actor group, the second tier variables are updated, where subgroup specific characteristics, governance strategies, interactions and outcomes are present. This could be also done for other actors such as the inhabitants or actors within the governance system from different top-down governance structures. Also in these subgroups the individual background and history of past experiences can influence the incentives of actions and can be examined separately. However the focus here lays on the fishers, hence the framework is only widened in their realm.

First of all, the unit of analyses for this research project is determined by the natural entity of the Densu delta wetland and the social entity of its fishers. The governance context further narrows the system down to the fishers working within the boundaries of the Ramsar Site. The boundaries of the SES are therefore defined by the context of the problem in focus (Becker 2012): the use of TEK within the Densu Delta fisheries, the impact of changing socio-ecological dynamics, as well as constraints to sustainable fisheries and management in the delta. The SES boundaries are drawn through spatial extension of the Delta as well as through functional aspects of the fisheries, its management and interaction of its components.

[4] Second tier variables where no information was collected during the research, are not listed

4.3 Refined Research Questions for the Empirical Work

Deduced from the literature review in chapter 2, the overall research question on the role of the fishers and their traditional ecological knowledge and the structure as well as the operationalization of the SES framework leads to more refined research questions for the empirical work. In order to achieve a comprehensive understanding of the focal actor group and their interactions with other system components and aiming to update the framework to the focal system with comprehensive contextual knowledge, the verification or refusal of the hypothesis is targeted through refined research questions as followed:

Hypothesis I: The impacts of urbanisation and its related changing socio-ecological dynamics are the main pressures on the SES of the delta´s fisheries.

Which pressures on the Resource System of the Densu Delta fisheries from external and internal dynamics can be locally identified?

Can urbanisation and its associated processes be identified as major driver of perturbing changes to the Densu delta fisheries?

What interactions are triggered by these pressures related to fishers and what outcomes can be identified?

Hypothesis II: Due to changing socio-ecological dynamics, traditional governance systems related to sustainable resource use have disappeared from the Densu Delta fisheries.

What local governance systems and institutions are established in the Densu delta fisheries?

Did the governance and the institutions change over time?

Which part do traditional authorities, leaders and belief systems play?

Hypothesis III: The top-down governance approach of the "wise use" concept of the Ramsar Convention integrates traditional resource governance to work jointly to ensure sustainable fishery in the Densu delta.

What top-down governance is present on the Densu delta, how are the strategies implemented?

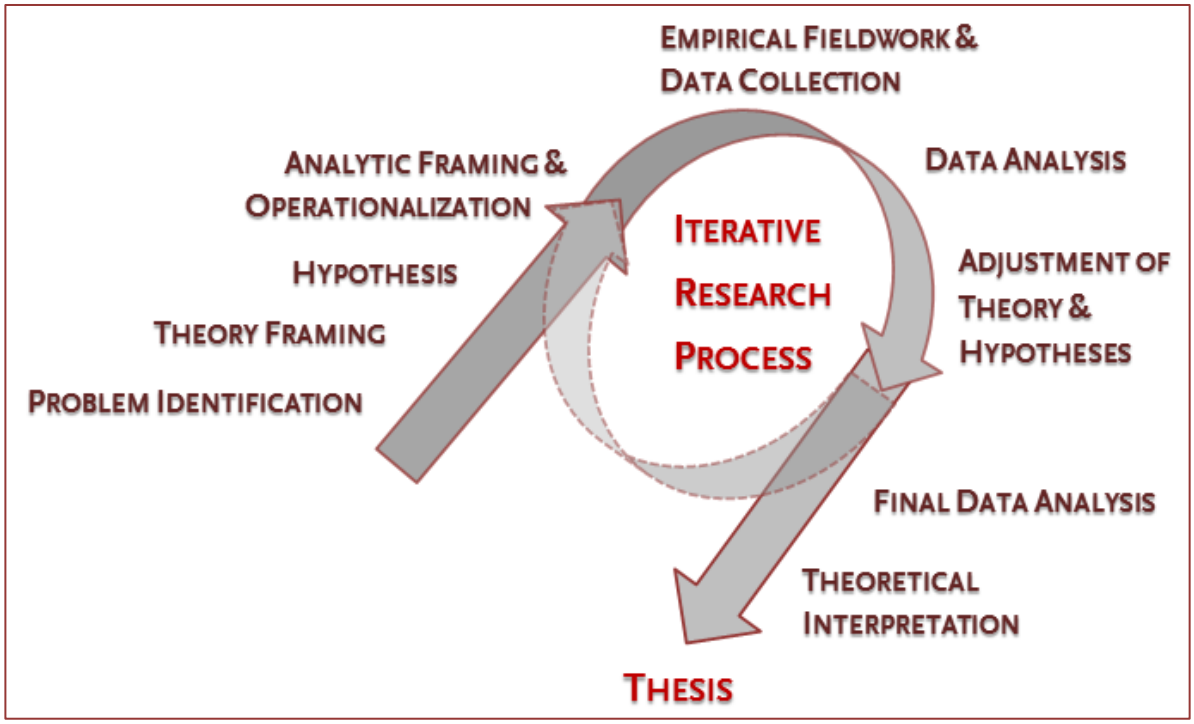
What role do traditional strategies play for the top-down management strategies?

How do different responsibilities interact with each other and with the fishers?

5 Material and Methodology

According to Berkes et al. (2003. p. 7), "*qualitative analysis is one consequence of the recognition of complex system phenomena for natural resource management*". Complex SESs behave non-linearly and many possible solutions rather than one "correct" outcome are possible (Berkes et al.2003), hence a qualitative approach and methodology is convenient and presented here. With a mixed inductive-deductive research approach (the process is illustrated in figure 5) the overall research question is used to develop hypotheses that are then refined and more pointed questions are developed in the course of the analytical framing. The fieldwork with qualitative methods for data collection is conducted in an iterative process, were obtained data is analysed repeatedly to adjust and refine theory and hypothesis. This iterative process leads to a permanent reflexion of research proceeding where method, categories and theory can be constantly tested and modified (Flick 2007). From data analysis, subsequent sampling decisions are shaped and new (or more) cases for data collection are selected until information saturation is reached and no new information is gained from data analysis. Finally the data is analysed and set into context with the theory for interpretation.

Figure 5 Research Process of the Thesis at Hand



The mixed inductive-deductive approach corresponds to the chosen SES framework which *"embodies a mixed epistemology of case-based and rule-based reasoning"* (Epstein et al. 2013. p. 436). The deductive research emphasises general causalities by testing hypotheses. Action situations represent the deductive core of the SESF. Rule-based reasoning is taken to explain social-ecological interactions guided through social institutions (rules, norms and shared actions) (Epstein et al. 2013; Ostrom et al. 2007). Relying on theories and explanations from simplified realities is one of the weaknesses of the deductive research which is offset with a mixed approach (Epstein et al. 2013). Hence inductive research is applied to draw a

different perspective on already researched phenomena or to explore new ones. And through case-based reasoning, which is associated with induction, obtained knowledge from single cases is used to explain events. In this case the research works without underlying theory and therefore stays more open to new observations (Epstein et al. 2013) which is important for the focal case since the literature review revealed large data and explanation gaps in the field of interest. The inductive approach further begins with a broader set of research questions and narrows the focus down in the course of the field work. According to Jost et al. (2014), it therefore provides more space for the inclusion of contextual social, political, cultural and environmental settings, which are of particular interest for this research project.

5.1 Case Study Area: The Densu Delta Ramsar Site

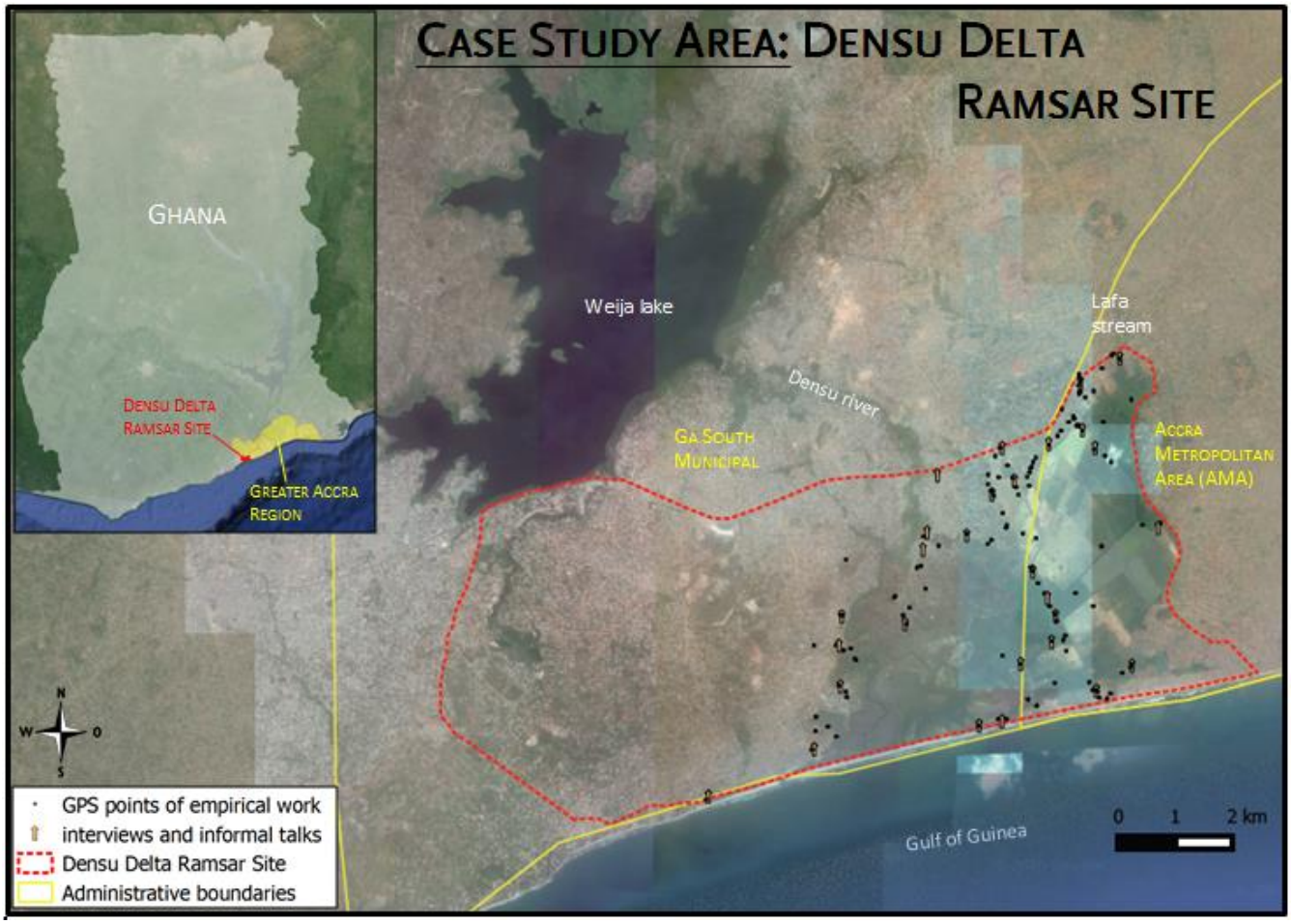
The case study area of the Densu Delta Ramsar Site (also called Sakumo I Lagoon or Panbros Salt pans (WRC 2007)), Latitude 5° 31' N and Longitude 0° 20' W, is situated about 11km west of the city centre of Accra, Ghana´s capital city (Ntiamoa-Baidu & Gordon 1991) and officially encompasses 5 892.99 ha (Ramsar Information Sheet 2015). The illustration of the site in figure 6 shows that the delta lies within two administrative districts: the Accra Metropolitan Area (AMA) in the eastern part and the Ga South Municipality in the West (Adank et al. 2011). In the South, it borders with the Gulf of Guinea, were sandbanks separate the lagoon from the marine environment and the northern Border is defined by the Accra-Cape Coast road below the McCarthy Hills. In the East the Lafa stream demarcates the wetland zone, whereas the Aplaku-Bortianor road marks the western border (Oteng-Yeboah 1999).

The Densu river is the main feeder of the wetland, draining from the North West into the wetland whereas the Lafa stream drains from the North East (see Adank et al. 2011. p. 17). The Densu river has a total catchment area of 2550 km² (Gordon 2006) and is dammed at the Weija reservoir, one of Accra`s two water supplies, 11 km upstream the river mouth (Oteng-Yeboah 1999; Ntiamoa-Baidu & Gordon 1991). The catchment downstream of Weija dam comprises 122 km² and the average water inflow to the delta is 12,673 m³/day, but can reach a peak runoff of 1,432m³/s (Adank et al. 2011. p. 75). As part of the Coastal Savanna Zone of Ghana, the average annual temperature is around 26°C with a peak in the dry season (February to March) and a relatively low annual rainfall with 672mm/year. Depending on the seasonal rainfall the water depth varies between completely dried up and a depth of over 2 m (Ntiamoa-Baidu & Gordon 1991). The water surface area of the wetland assembles the main lagoon (covering 4.125km2 in 1996 (Kusimi 2008)), located in the southwestern part close to Tsokomey, the Densu river, which divides into two river channels North of old Tetegu, some smaller lagoons and marshes fed by the Lafa stream in the North Eastern part (Adank et al. 2011) as well as the Panbros salt pans in the centre.

The Densu Delta features brackish lagoon and freshwater marshes, salt pans, scrubs, coastal sand dunes, savanna grassland and built-up areas. The vegetation is diverse and its scattered mangrove stands mainly consist of the species Avicennia africana and Rhizophora racernosa (Oteng-Yeboah 1999). The fauna encompasses around 57 bird species with an estimated population of 35,000 individual, various reptiles (e.g. snakes, lizards, and turtles) and a number of small mammals. The aquatic life includes marine as well as freshwater fish species, shellfish species (e.g. molluscs and crabs) and various invertebrates (Oteng-Yeboah 1999; Ntiamoa-Baidu & Gordon 1991).

The Densu delta is managed according to the wise-use principles of the Ramsar Convention under the authority of the Wildlife Division of the Forestry Commission of Ghana (WRC 2007, Wetlands-International 1998), which explicitly does not exclude people and resource use. Even the wetland was designated as a Ramsar site (a protected wetland of international importance) in 1992 and is officially approved as a conservation area. It is under high pressure through human impact. Besides the hydrological modification through the construction of the Weija dam, whose spillage annually leads to flooding and (Adank et al. 2011) humans are impacted on the wetland and its fisheries in multiple way.

FIGURE 6 MAP OF THE CASE STUDY AREA LOCATION MADE BY THE AUTHOR WITH QGIS 2.12.0 (DATA SOURCE: RAMSAR SITE BOUNDARY FROM ANALOGOUS MAP OF THE WLD GHANA, TRANSFERRED ON THE GOOGLE SATELLITE IMAGE WITH ZOOM FACTOR 17)



The Delta´s population, which mainly consists of Gas (58,4%) and Ewes (32,7%) has been heavily increasing for decades (Oteng-Yeboah 1999) and the dense urban settlements around and inside the Ramsar side are strikingly visible on the satellite image (see figure 6). Besides the land conversation for private housing and commercial buildings, heavy pollution through liquid and solid waste and the overexploitation of its natural resources (especially the fisheries) alters the system (Oteng-Yeboah 1999; Ntiamoa-Baidu & Gordon 1991). Due to increasing numbers of resource users the non-adherence to traditional practices and taboos, the fish resources are heavily overexploited (Oteng-Yeboah 1999). Salt mining mainly through the Panbros Salt company, cattle grazing, mangrove harvesting as well as sand mining are further activities carried out in the delta and notable altering the wetlands' ecological integrity and consequently the fisheries (Kusimi 2008; Oteng-Yeboah 1999; Ntiamoa-Baidu & Gordon 1991).

5.2 METHODS

The SES framework as analytical tool does not provide specific indicators or methodologies for data collection. As described above, it serves as analytic frame and checklist of important variables where the data from qualitative (quantitative data could be integrated) methods is structured within the framework (Partelow 2015a). The methods applied during the empirical work are listed in table 7 and include semi-structures qualitative interviews with fishers in the Densu delta as well as different identified key informants, participant observations, land cover and land use mapping and photographic documentation.

TABLE 7 METHODS OF THE EMPIRICAL WORK IN GHANA IN 2015

Empirical Fieldwork (method)	Inquired Content
Transect walks with mapping and photo documentation (about 100 GPS points with related pictures)	System boundaries, land use and land cover of the location, social-ecological interactions through resource use and degradation, impact through internal and external dynamics (e.g. pollution, degradation, encroachment, fishing techniques)
Participant observation and informal talks with fish workers and inhabitants	Property right system, interactions and outcomes (between actors and governance system): harvesting, conflicts and networking, information sharing
Semi-structured Interviews with fishers (single and group interviews with about 27 fishers)[5]	Variables of focal actor group, interactions with the ecosystem and other actors, their role in the governance system, outcomes of action situation, internal and external threats to the SES
Semi-structured Interviews with 8 **key informants from** the Wildlife Division (WLD), Fishery Commission (FC) Water Resource Commission (WRC), Accra Metropolitan Assembly (AMA); estate agent in Mallam;[6]	Characteristics of the top-down governance system and implementation, interactions with the focal actor group, outcomes of interactions with ecological and social components concerning sustainability

[5] Since not all names of fishers were noted, due to different interview situations, in the following statements of fishers are termed: fisher, age, living place

[6] Key informants are interviewed in their function as a representative of their governmental Commission or Division so their statements are termed: rep. WLD for representative of the Wildlife Division and so on.

As first step of the study a literature review on the sector of sustainable fisheries management, coastal wetlands and traditional ecological knowledge and practices related to coastal wetland fisheries in Ghana was undertaken. This review includes scientific (case) studies as well as wetland, wildlife and water resource development and management plans and Ramsar Site information sheets. The documents provided useful insights on context-related historical developments, bio-physical characteristics of the wetland, threats to the system, socio-economic dynamics of importance for the analysis as well as on governance strategies implemented in the Densu Delta Ramsar site. They were obtained through internet research, from different local libraries in Accra, as well as received from interview partners. In the course of the research the gained information served to consider new sub-topics, modify research questions and to identify additional interview partners.

Qualitative Semi-Structured Interviews with Fishers and Key Informants

Further problem-centred interviews were conducted with about[7] 27 fishers and 8 relevant key informants of the top-down management that were identified during the empirical work. The theoretical and analytical framing and knowledge gained from first data analyses in the course of the empirical phase was taken as basis for the generation and modification of the interview guidelines and leading questions for the interviews (Witzel 2000). In order to create a trust relation with respondents, the communication process was left open and flexible with largely repetitive interviews process-orientated interview situations, to gain more insights and avoid misunderstanding (Witzel 2000). The key informant interviews were semi-structured problem-centred with mostly open ending questions, open to new topics and flexible in their process, the interviews with the fishers were conducted with more narrative character (see also Paschen & Ison 2014) with biographic contents to ease the research situation (Flick, 2007).

Both interview types were conducted in face-to-face situations in English or the local language (Twi) translated by a translator.[8] The fishers were approached on site (interview duration of 10 min to 1 hour) and key informants contacted via telephone, mail or personal to arrange meetings for the interviews (with a duration of 30 min to 2 hours). New cases were chosen until a saturation of information was reached[9]. Interviews were recorded (if the trust relation with the interviewee made it possible) or/and field notes were taken and postscripts were written directly after the interviews in order to complement the notes (Flick 2007; Witzel 2000). Recorded key informant interviews were transcribed and summarized related to interview topics and the key outcomes. The interviews were coded according to the research interest based on key words (see also Witzel 2000). Categories according to the theoretical and analytical framing were chosen[10], in order to update the variables of the SESF and identify new topics of interest according to my research interest. The fisher`s interview notes were transferred to Excel and further summarized by coding them concerning fishing activity, traditional management practices, changing social and environmental dynamics, condition of the ecosystem and threats to the fisheries.

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[7] Approximate number: since several interviews started as single-person interviews but were interrupted by several other fishers that answered some questions and left the interview again. Therefore some can be considered as mixed group interviews, leading to an undefined number of interview participants.

[8] When respondents were speaking other local languages, by-standing people helped in translation.

[9] Meetings couldn´t be arranged with (key informants from the local assemblies, government commissions or NGO´s).

[10] Analyzed according to: organization, daily fishing practice, actor groups, threats and changes, drivers of change, TEK based governance, sustainable resource use, interactions (e.g. cooperation and conflicts) between components, top-down governance

Transect Walks with Land Use/ Land Cover Mapping and Participant Observation

About 30 field trips on site and to bordering communities were conducted as well as the participant observations method from July to November 2015. Most of the fieldtrips were accompanied by the Wildlife staff of the Densu Delta, facilitating direct interaction and talks on problematics sighted on site (e.g. on land use, pollution and mangrove degradation, sighted species, encroachment and Ramsar site zoning, historical development of the place). During the transect walks, land use and land cover in the Delta was mapped using the GPS (Global Positioning Satellite) location service of a Samsung Galaxy III. Points and tracks were recorded with the Locus Free application version 3.11.2 with an offline 1:4000 satellite image for orientation in the field and later transferred to QGIS. Even canoes were used, and sometimes waterbodies and shrubs had to be passed, not all areas could be reached.

Figure 7 Analogous A0 Print of a 1:10000 Satellite Image (2011) of the Study Area (provided by Fanny Frick) used During the Empirical work to Locate Lan Cover/Land Use and Threats to the fisheries

This ground truth information was visualized on a DinA0 paper print of a 1:1000 satellite image of the Densu Delta of 2011 (created and provided by Fanny Frick) and used for orientation during the empirical work phase (see figure 7). The ground truth information was then used for visual interpretation of the Google Satellite image 2015 in QGIS version 2.12.0 on zoom level 17 and 18 and served as basis for the

development of a LULC map of the Densu delta (see figure 9). The A0 print further served as orientation for group discussions during a participant observation that was conducted. Figure 8 shows two discussion situations where a fisher explained e.g. the location of dumping sites and showed their fishing areas. The participant observation was conducted to complement the data collected through interviews and further to create trust relations with the respondents (see Flick 2007). Fishers were accompanied in their daily fishing practices (canoe trips, fire wood collection, preparing meals and eating) and the relationship, hence the interview situation.

FIGURE 8 GROUP DISCUSSIONS WITH FISHER AND INHABITANTS. LEFT: DISCUSSION ON THE WASTE PROBLEMATIC FROM MALLAM LANDFILL WITH THE FISHER FAMILY. RIGHT: DISCUSSION WITH FISHERS AND INHABITANTS IN TETEGU

5.3 ACCESS TO THE FIELD AND LIMITATIONS

There are a number of factors, such as gender, culture and language differences, time and sample number limitations as well as physical inaccessibility to certain areas in the delta, that had limiting impact on the gained information field access and might as well falsify some results. These factors have to be considered, as well as the fact that each research project – even given a methodological control – is influenced by subjective perspectives of the researcher. Personal as well as professional interests, social and cultural backgrounds influence the formulation of research questions and development of hypotheses as well as the conduction of empirical fieldwork and the analyses and interpretation of data (Flick 2007).

The first limiting factors are identified in gender, culture and language differences and barriers. Being a white European female researcher conducting field work in the Ghanaian fisheries on the basis of the English language (the language of the former colonial British power) has to be critically reflected. The interviews were exclusively held with male fishers (since the activity of fishing is a mostly male realm in Ghana (Akyeampong 2007)), hence it might be possible that the female researcher is not seen as fully competent in their realm. Informal talks included also women that sell fish and female inhabitants.

Besides the gender issue, cultural aspects might have influenced the interview situations and ways of understanding. According to Flick (2014), communication habits, expression of opinions as well as freedom of expressions differ extremely from culture to culture. Whereas interviews recordings and note taking is a common and mostly known method for qualitative research, it seemed rather strange to most of the interviewees. While the first interviews were guided by a prepared list of lead questions and documented with recording and pictures of the respondent, the methodology for the following interviews was changed in favour of a trust relation with the fishers.

The interviews with key-informants were held in English, which is not the mother tongue of the researcher, hence misunderstandings might have occurred. The majority of interviews with the fishers were conducted with the help of translation to one of the local dialects (Twi, Ga, Ewe, Hausa or Fante). It has to be considered that information which is translated once or even twice can lead to misunderstandings or the loss of insights. The use of words and the absence of particular terms (such as climate change) in some local languages can further lead to misunderstandings. Besides that, the translator in most cases was the local staff of the WLD and therefore is member of the top-down governance. This problem was tested after each interview and none of the fishers knew the translator and his role, hence influences due to this can be ignored.

However, the application of qualitative research and intensive field trips opened the course of the study to new insights and consequently new aspects of the complex SES could be discovered. Particularly the repeated meeting with fishers brought up new topics and deeper insights that were not mentioned in the first interviews. Further the participation on a workshop by the Wittenveen+Bos company that was concerned with the development of sustainable management strategies for the Densu delta Ramsar site brought insight to the governance system and related interactions. The participation was enabled through the close and repetitive contact with key informants. In the course of this gained information could be shared and discussed with important stakeholders that participated in the workshop, leading to new information and important insights.

6 RESULTS

In this chapter the results of the empirical work in Ghana are presented according to the analytic framing and developed hypotheses. Beginning with a brief overview on the overall results on the SES of the Densu delta fishery and the focal user group of the fishers, the updated SES framework is presented. Beyond that, the created land cover/ land use and encroachment map of the Ramsar site protected area is visualized for better understanding. Thereafter the governance system and established institutions within the fisheries as well as the main internal and external stressors are described according to the hypothesis.

6.1 OVERVIEW OF FOCAL SOCIAL-ECOLOGICAL SYSTEM AND UPDATED SESF

In the course of the empirical work, the SES framework served as checklist for the identification of important components and action situations of the SES of the Densu delta fisheries and more importantly it helped to structure and to classify the gained data. Table 8 shows the shortened version of the updated SESF on the focal system. Here the components and variables are briefly described under each point of the framework, while the focal actor group of the fishers and the created subgroups are presented in the following and in the framework extension. Even different authors (Basurto et al. 2013; McGinnis 2015) state that not all variables are needed to be included in the analyses, here almost all variables could be at least briefly described, since data related to them was gained during the empirical phase of the research. The updated version of the SESF notably illustrates the complexity of the system and enables the reader to embed the results of the whole chapter 6, as well as the discussion in chapter 7 in a broader frame of the whole system.

TABLE 8 SHORTENED VERSION OF THE UPDATED SESF ON THE FOCAL SES

First tier: External factors	
Related Ecosystems (ECO):	Social, Economic and Political Settings (S):
ECO1 – Climate patterns: inter annual changes (temperature and precipitation) and more extreme seasonal variations	S1 – Economic development: minor use of touristic value; salt production of Panbros Salt Production and small artisanal production; small scale fishing; housing and industrial development; other small scale production and resource exploitation
ECO2 – Pollution patterns: increasing liquid and solid waste	S2 – Demographic trends: increasing population
ECO3 – Flows into and out of focal SES: water, material and energy flows; main water flows: Densu, Lafa and groundwater connection with Gulf of Guinea	S3 – Political stability: political stable
	S4 – Government resource policies: Fisheries Act, 2002 (Act 625), Fisheries Regulations 2010; other environmental laws and policies summarized in the "wise use" concept of the Ramsar Convention
	S5 – Market incentives: pressure on the Densu delta fisheries through marine fishers

1st tier	Resource System (RS) Fisheries	Resource Unit (RU): fish and crabs	Governance System (GS)[11]: top-down and traditional governance	Actor (A): here the focus lies on the fishers (main A of interaction: inhabitants, land owners and actors involved in top-down governance) Subgroups of the fisher-actor group Aa see framework extension
2nd tier	RS1 – Sector: fisheries RS2 – Clarity of system boundaries: waterbodies inside Ramsar site boundary RS3 – Size of Resource System: shrinking RS4 - Human constructed facilities: fisher lodges and encroaching, no governmental tourist facilities RS5 – Productivity of system: no proved recent assessment RS7 – Predictability of system dynamics: likely increasing threats to the system RS9 – Location: 5°33'N 0°18'E; about 11 km west from Accra´s city centre	RU1 – Resource unit mobility: medium (Weija and Ocean) RU2 – Growth or replacement rate: exact growth rate is unknown but altered by overexploitation and environmental degradation RU3 – Interaction among resource units: fish and mangroves stands RU4 – Economic value: between 80 and 104 million Cedis annually (Ramsar Information Sheet 2015); no specific list RU5 – Number of units: decreasing exact number unknown; 15 different species RU7 – Spatial and temporal distribution: species depending (needed conditions)	GS1 – Government governance responsibilities: WLD, WRC, FC, EPA, Ga South MA, AMA (diffuse information) GS2 – Nongovernment governance responsibilities: Panbros Salt Industries Ltd; different NGOs (no exact information); TEK-based governance institutions GS3 – Network structure: lack of communication and cooperation GS4 – Property-rights systems and access: pluralism of modern and traditional property rights, 1/8 is owned by Panbros Salt; no land is acquired by the government GS5 – Constitutional rules from the top down management authorities[12]: Ramsar law from merged environmental laws GS6 – Rules in use and repertoire of norms and strategies of the resource users: no consistent adherence throughout the delta GS7 – Operational rules from top-down management: no consistent adherence	A1 – Number of (relevant) actors: increasing A2 – Socioeconomic attributes: very heterogeneous, but rather weak financial status; different ethnical background A3 – History or past experiences: very heterogeneous A4 – Location: fishing location: in all water bodies of the Delta. A5 – Leadership/ entrepreneurship: no or weak leadership; organizational structure is weak A6 – Norms (trust-reciprocity)/ social capital: varies between individuals and smaller groups A7 – Knowledge of SES/ mental models: very heterogeneous: partly profound local ecological knowledge, partly less awareness of ecological condition A8 – Importance of resource (dependence): largely main income A9 – Technologies available: various artisanal gears are used.

First tier: Action Situations		
Interactions (I): related to fisheries		Outcomes (O)
I1 – Harvesting: mainly fish and crabs I2 – Information sharing: largely	I8 – Networking activities Largely missing I9 – Monitoring activi-	O1 – Social performance measures (e.g. efficiency, equity, accountability, sustainability): Obscure accountability realms in the top-down governance system; shared responsibility, but cooperation is largely

[11] As described in (McGinnis & Ostrom 2014), the top tier categories Actor and Governance might be confusing since an Actor can be part of an Governance system. Hence individuals can be considered for both categories. Acting as individuals and resource users the fishers are defined as Actors and part of the TEK-based governance system as well.

[12] G1, G2, G5, G6 and G7 are changed; modified from suggestion of (McGinnis & Ostrom 2014. Table 2)

face-to-face in between individuals and small groups I4 – Conflicts: between fishers, between fishers and other actors I5 – Investment activities: small I6 – Lobbying activities: largely missing or failed I7 – Self-organizing activities: within small groups or by individuals	ties: no holistic ecosystem monitoring or fisheries assessment; I10 – Evaluative activities: existing reports and evaluations from top-down governance actors are largely developed without cooperation	missing. Fishers see responsibility with themselves, but mainly with inhabitants and the government. Sustainability is not given since fishers are not in social secure status, economical potential of the site is not efficiently used and ecosystem is degrading O2 – Ecological performance measures (e.g. overharvest, resilience, biodiversity, sustainability): decreasing ecological condition, increasing degradation O3 – Externalities to other SESs: Urbanisation and its associated processes; regional to global changing economic dynamics in markets

As illustrated in table 8, the empirical work revealed that the number of the focal actor group is augmenting, while quantity and quality of the resource unit is declining. The focal actor group is very heterogeneous in their age pattern, ethnical as well as concerning the personal background. Beyond that, it was found that knowledge about the resource system and the resource unit as well as the participation in the governance of the system are not equally distributed amongst the members of the focal actor group. Also, there is no delta-wide organization pattern within the fisheries. The traditional hierarchical organization known from the marine sector is only present in some sub-groups. Aside from one small area in the north-eastern part of the delta (yellow circle in figure 9), which is strictly controlled by one fisher family, the resources are barely exploited according to sustainable strategies. Due to this diversity of fishers, three subgroups (the fisher family which adheres strictly to TEK-based governance strategies in their claimed territory in the north-eastern part of the Densu delta south of Mallam market[13], young fisher "gangs" that have various conflicts with other fishers and other individual and smaller groups of fishers outside the fisher family territory) were created, capturing the main identified subdivisions with important differences in the second tier variables.

The whole wetland and consequently its fisheries are under multiple pressures from internal as well as from external stressors. These stressors operate on different scales, interact in multiple ways and largely increase in short time spans. Through its location on the fringe of the constantly growing metropolis of Accra, most alteration to the focal SES can be ascribed to urbanisation and its concomitant processes. The physical spread of Accra and its suburbs far beyond the former demarcated Ramsar Site boundary as visualized in figure 9, is one of the most prominent perturbations to the wetland system and can be located in multiple areas of the site (visualized by red arrows in figure 9). Beyond that, pollution through liquid and solid waste, environmental degradation for example through vegetation cut down as well as through overexploitation of the area's resources such as fish and mangroves constitute further stressors affecting the SES.

The activities of top-down governance system (e.g. WLD, FC, WRC or NGO´s) have declined constantly since the official Ramsar site designation in 1992. Networking, monitoring and evaluation are very limited. Bird population assessment and patrols to hamper law violations (e.g. illegal fishing methods and environmental degradation) are currently the only regular activities. Community awareness pro-

[13] For better reading this subgroup is termed: the fisher family in the following

grammes and environmental assessment are largely brought down to emergency meetings in cases of urgent events (e.g. bird flu and Ebola). Networking amongst the actors involved in governance is also largely missing. Despite the cooperation of the WLD with the security of Panbros Salt Ltd, who owns the majority of the area, there is barely any networking between governance actors. The lack of communication and foremost the lack of political backing, supporting conservational activities and the governance authority of the WLD, are seen as the main problems for the well-functioning sustainable governance that could successfully challenge the increasing pressure on the SES.

Figure 9 clearly shows the city of Accra and its suburbs embracing the wetland from all sides (except the marine one) and heavily encroaching (red arrows) even in the core area via the bridge in Tetegu. The majority of still unsettled land is property of Panbros Salt (transparent white inside the wetland area), which is also seen by the top down governance as land use holding back further encroachment. The only mangrove stand that is not scattered and degraded is in the Eastern part bordering with Panbros and the territory of the Adams fisher family. The biggest source of pollution is found in the North East (red colour) and situated right next to the Mallam market.

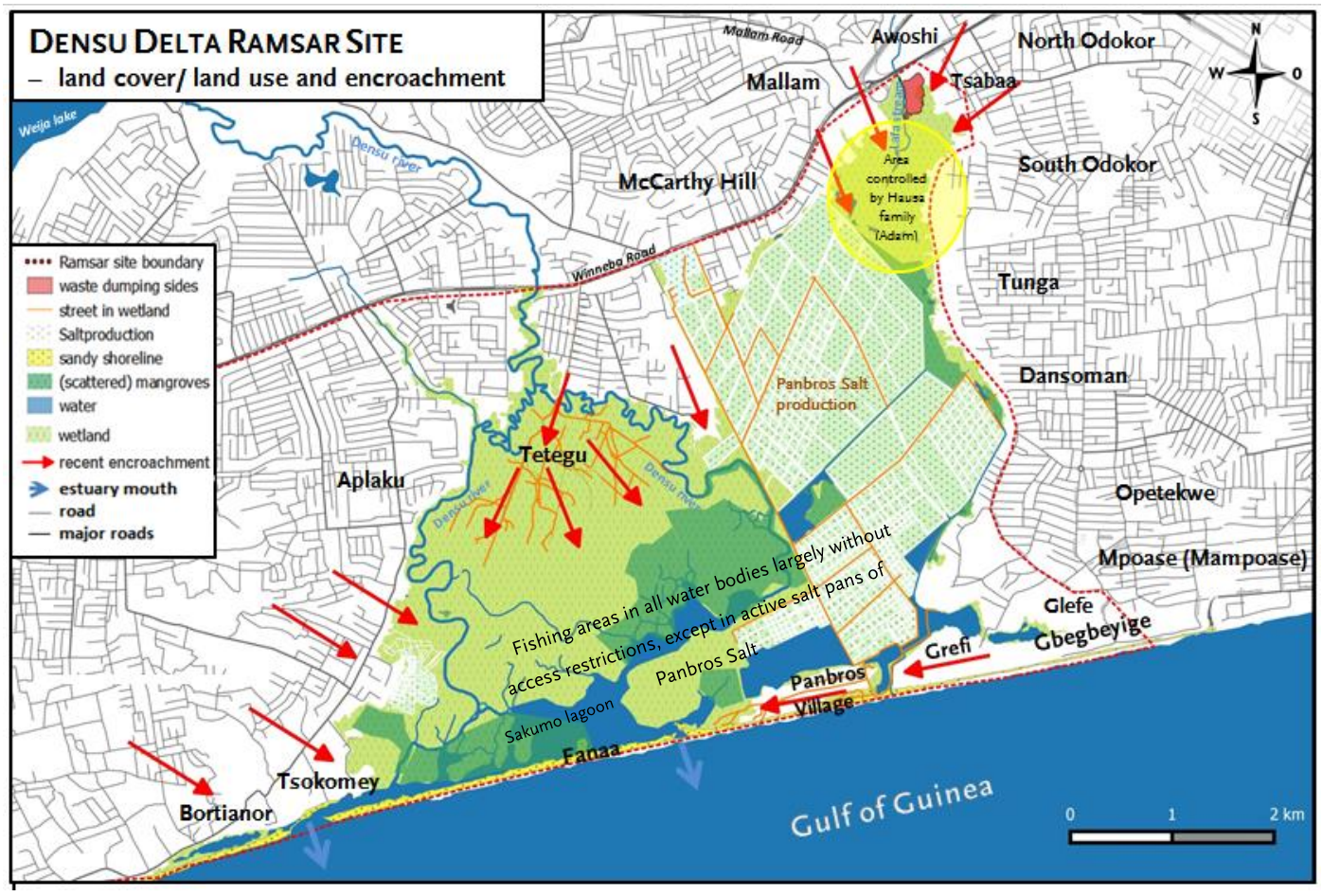

Figure 9 Land Cover and Land Use of the Densu Delta Ramsar Site. As wetland (light green) here the actual core zone, largely without settlements, was branded. While most encroachment was identified to grow from the borders into the wetland, Tetegu manifests an exception, where settlements even reach far into the core zone. Streets (orange lines) and red arrows for encroachment indicate the extent of encroachment there. Dark green areas represent mangrove stands. In the NE part, bordering Panbros Salt they are still fully grown, most stands in the central and in the SW are degraded and very scattered. [source: developed map in QGIS from collected data; underlying layer: Stamen Toner/OSM map; neighbourhoods based on collected data and Adank et al. 2011]

Focal Actor Group: the Densu Delta Fishers

The actor group of the Densu Delta fishers was found to be very heterogeneous in ethnical background, age pattern and individual life history. The respondents are between 22 as the youngest and 72 as the oldest respondent (see figure 10). They belong to four different ethnical groups with a majority of Gas (9 respondents), followed by Ewes (8 respondents), Hausa (5 respondents) and Fante (two respondents). Most fishers are living in communities nearby or in the wetland such as Tunga, Panbros Village, Grefi, Mpoase, Tetegu, Fanaa, Dansoman and Bortianor (see figure 9 for location of the communities), however also people from more distant communities of Accra like Nima come to fish in the Delta. 21 of the respondents are Densu Delta fishers since their childhood, 6 had migrated from Central and Volta Region and other families had immigrated some generations before. The latter had different occupations and professions before (e.g. teacher, seller), nevertheless they have been fishing in the Delta for at least 10 years. They became fishers due to personal issues and difficult work conditions or followed other family members that immigrated to Accra.

Due to profound differences in the actor-characterising variables as well as in their TEK-based governance three actor subgroups were defined: On the one side the majority of the fishers (that is still not totally homogenous) that harvests fish in divers waterbodies of the delta except the north-eastern part (see yellow circle in figure 9), partly adheres to some TEK-based norms and has medium knowledge about the ecological system, on the other hand young groups of Ga fishers that do not respect governance regulations and often get into conflicts with other fishers and local authorities and finally the five-headed fisher family that controls the waterbodies in the north-eastern part (yellow circle in figure 9) and established a TEK-based governance system and strictly adhere to it.

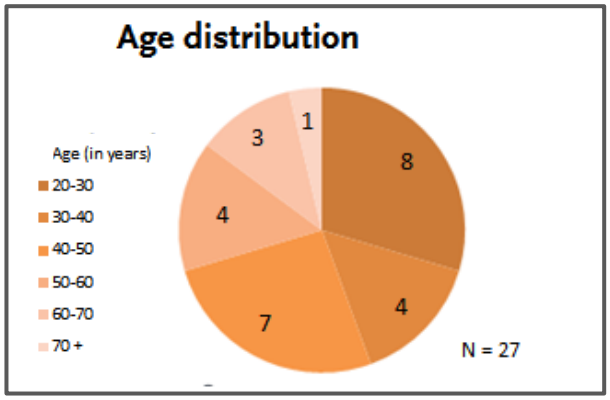

Figure 10 Age Distribution of the Interviewed Fishers in the Densu Delta

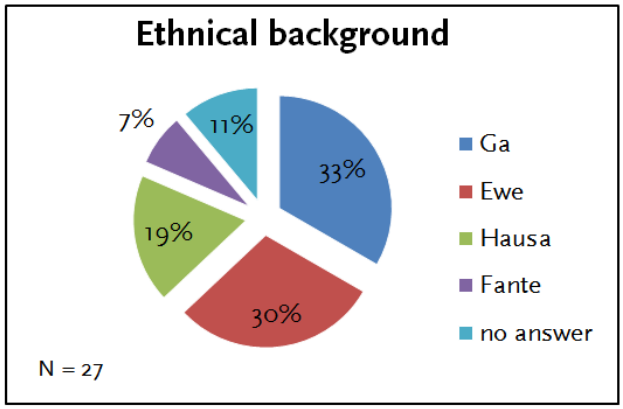

Figure 11 Ethnicity of the Interviewed Fishers in the Densu Delta

6.2 Urbanisation as the Main Driver of Change in the Densu Delta Fishery

Hypothesis I postulates that: *The impacts of urbanisation and its related changing socio-ecological dynamics are the main pressures on the SES of the delta´s fisheries.*

Hypothesis I is confirmed, since urbanisation (in combination with non-functional planning, lack of law enforcement and in transparent land tenure) is identified as major driver of changing dynamics that affect the Densu Delta fisheries. Identified on local level, most stressors to the fisheries relate in direct or indirect way to the growth of Accra and associated processes.

Changing socio-demographic, economic and natural dynamics that impact the Delta`s fishery were identified to operate from within the system as well as from outside on local (e.g. community pattern change or pollution) to a global (e.g. changes in fish resource markets) scale. Stressors that are linked with urbanisation, such as *land conversion for built-ups, pollution, overexploitation and (reinforcement of) flooding,* can be identified on a local scale, however their pattern of interlinkage and the drivers behind are operate scale-crossing and are very complex. The major identified stressors and their consequences for the local fishery are presented in the following (see table 9 for the summary).

The encroachment of built-up areas into the wetland due to the vast spread of Accra Metropolis is one of the main challenges to the Densu Delta fisheries and the wetland itself. As illustrated in the land cover/land use map (figure 9), settlements are encroaching into the actual wetland from almost all directions. Since its demarcation as Ramsar site in 1992, the wetland diminished to a core zone around the riverbeds, the lagoons and the Salt production area, to around 23 km² (including Tetegu, because it is situated inside the wetland area), while the surrounding is characterized by dense settlement areas. Water and swampy land, that naturally form the landscape of the delta and inhabit wildlife and vegetation, so the WRC, is

Figure 12 Children Fishing with Mosquito Net in Water Surrounding Houses in Tetegu. In Front of the Unfinished House a Wall heavily Affected by Water Erosion can be seen.

acquired by filling the area up with sand and stones for foundation of new houses (pictured in figure 13). Consequently vegetation is heavily declining, nursing and breeding places for fish and other species especially in the mangrove forested areas disappear. Beyond that, the size of open water surface and the available fishing areas for the local fishers decreased noticeably.

> *"The Delta is supposed to be built out of fingers of streams and in between these fingers there is land that seeks through the sand. It is land and water. Now there are structures on these areas in between and around the streams and on the sandbars. Areas like Glefe and Dansoman are heavily built now.* [rep. WRC, 9.10.2015].

According to the WRC, former wetlands (as in the study area) were unattractive for buildings due to their watery and muddy characteristic. Socio-economic dynamics (such as migration to the city close area due to lack of employment in rural areas and more vacancies in the urban areas) and the growth of Accra increased the pressure on land to an extent that even swampy areas are now settled. In different places (such as Aplaku, Grefi and Dansoman) the riverbed of the streams still stops further encroachment, however the construction of bridges like in Tetegu facilitate encroachment far into the wetland (see land cover map figure 9). Figure 12, 15 and 17 illustrate well, that houses are even constructed inside (seasonal) waterbodies, hence are highly affected by water erosion. According to an inhabitant, the houses get destroyed after about 7 years, if they are not renovated before.

> *"When the population was small, there was no pressure on those wetlands. The wetlands were not interesting for buildings and their ecological condition was good. Now that there is pressure on the land and there are no jobs in the hinterland, the people are moving down stream and the cheapest lands are in those wetland areas. The people built cheap structures that lack basic measures for buildings on this cheap ground. Other tribes are moving down here to do those things. [...] The situation becomes worst because more and more people come."* [rep. WRC, 9.10.2015].

The focal actor group is consequently also negatively affected by the physical spread of settlement as the following statements show. By clearing vegetation like the mangroves and filling up the waterbodies with rubble, the fishers physically lose their fishing grounds and beyond that, many of their target species lose important feeding, breeding and nursery grounds. Also the habitat of other wildlife, such as grass cuter and antelopes, which served as additional income and nutrition supply for some fishers vanished with increasing settlements.

> *"There was more open water when we were young and the vegetation was less inside and around the waterbodies. Around the Densu, there were more mangroves and other trees. Also the hills were forested and we were hunting grass cuter and antelopes. Now there are much more houses in the area."* *[Fisher, 28, Tunga]*

> *"As the vegetation is completely condemned, the fish can´t get a place to breed anymore, because the people cut all the trees surrounding the river. The land is open and plane now. The fish cannot breed any longer, because there are no places where they can hide themselves. So we don`t have enough fish anymore."* [Fisher, 65, Tetegu]

> *"Most places where we went fishing turned into building places. They are filled with stones and garbage."* [Fisher, 64, Tetegu]

The pollution of waterbodies and bordering lands through solid and liquid waste (see figure 16, 18 and 19) from domestic and industrial sources represents another major stressor to the fisheries in the Densu Delta. The water bodies and various places of the surrounding land in the delta are of dark colour and charged with plastic and other solid waste. Waterbodies and fish stocks get degraded, fishing nets get blocked and destroyed and the waste further constitutes an injury and health risk to the fishers. According to the WLD, the wetland as also the whole coastal zone is affected by this waste problematic and increasing population will exacerbate the situation. The WRC also sees a scale-crossing problematic, since waste that enters the Densu finally ends up in the marine environment and hence not only affects the SES of the Densu delta, but further related ecological and social systems on other scales.

Figure 16 Lafa Stream with Dark and Bad Smelling Water with Garbage Close to Mallam Market Dumping Side

Figure 14 Unfinished House Surrounded by Water and Reed in Tetegu

Figure 15 Small Dumping Site in the Wetland South of McCarthy Hills

Figure 18 Silted Waterbody South of Mallam Market Dumping Side Full of Plastics

Figure 17 Built-Ups Close to the Water South of McCarthy Hills

Figure 13 Recently Filled up Wetland for Land Reclamation South of Mallam

The WLD states that there are diffuse entries of refuse to the delta. Draining through gutters such as the Lafa, (figure 16), which is the largest of this area and being washed back from the sea, the waste from system external and internal communities enters the wetland. Beyond that, different sizes of dumping sites (figure 14) are located inside and around the wetland. While most of these waste disposal places serve for close by communities, according to the AMA waste department, garbage from communities all over Accra is deposited in the illegal landfill south of Mallam market. Thus one of Accra´s two fastest growing illegal dumping sides is situated on the north-western end of the Densu Delta within the wetland. Further liquid waste such as waste water from gutters (from private houses and industries), oil from car workshops, landfill leachate and other liquids enter the waterbodies.

"When they started to bring the bad water into the river around ten years ago, they scared the fish. This is because this water seems to be something like poison and when it gets into the river the fish cannot breed anymore. [...] The people also spill garbage into the river, so when it rains the water washes the garbage into the river and the fish are not breeding anymore. In former times we got different types of fish. That changed and we don't have those fish any longer." [Fisher, 64, Tetegu]

FIGURE 19 FISHER NET OF ONE OF THE FISHER FAMILYS` MEMBERS IN THE WATERBODY SOUTH OF MALLAM MARKET

According to the fishers, the situation is aggravating since decades and catches are declining due to the growing amount of refuse and "poisonous" water that drains through the gutter into the waterbodies. Most of the fishers complain about declining amount and size of fish, decreasing species numbers and one fisher even reported of changing texture and taste of the fish since the decline of water quality. Besides the ecosystem degradation, several fishers complained about decreasing catches due to blocked nets with plastic (see figure 19). Formerly they could leave their nets for longer periods inside the water, while they have to be clean and repair those more frequently now. Sharp metal and glasses further constitute the risk of injury for the fishers during work.

Pollution of the gutters and waterbodies is not only contaminating the fishery resources, but further aggravating other threats like flooding. The following statement of the AMA waste department shows how this contamination is even potentiated by annual floods. Additionally to the daily wastewater from private households and companies that drain into the wetland, the faecal sludge and liquids are pumped into the drains during flood events, severely contributing to the pollution of the fishing grounds.

> "*Waste water from the houses flows into the drains. We have one of the major drains there, the Lafa. [...] I heard it was a river before.[...] It ends up in the catchment through a channel through Panbros and then ends up in the Densu. The toilets are not connected to the drains, they are serviced. Except at times when it is flooding. The people pump the effluent into the drains during the flood events. When are not able to trace them during floods. And the water carries the sewage away. So the flood brings everything. It brings garbage and effluent.*" [AMA waste department 1.10.2015]

Despite a changing rain pattern, with increasing numbers of extreme floods that were reported from almost all fishers, anthropogenic impact further aggravates the outcome of those events. The vast urbanisation is accompanied by ground-sealing through encroachment until the streambanks, the congestion of gutters with solid waste and the lack of appropriate water management of the Weija dam and leads to an exacerbation of floods. The spread of settlements until the riparian zone of the Deltas streams destroys the river bank vegetation and increasingly exposes the constructions to flooding. The situation described by the WRC in the following statement also applies for the Lafa stream, which affects the eastern part of the Delta including its fishing grounds.

> *"The wetlands after the Weija dam are highly susceptible to flooding because of the periodical opening of the dam. This has become worse because people have been building where they shouldn't build. Upstream the Densu delta there is also more urbanisation now, so downstream the flooding becomes worse. There is more run off so the flooding increases downstream. "[WRC, 9.10.2015]*

Also the fishers, particularly from flood exposed areas such as the waterbodies fed by the Lafa in the North East of the delta, reported of increasing flood events in the recent years and report of different impacts on their work. Despite the contamination of their fish resources, their fishing huts in the delta are destroyed and gears and canoes are washed away or destroyed. This development is reported to have aggravated in the last decades and fishers complain about increasing workload and difficult working conditions during times of flooding. The loss of gears, the relocation of their fishing lodges and the compulsory work break during extreme high water level challenges the resource users.

The growing population in the surrounding communities and the expansion of settlements leads beyond the increasing land conversion also to rising demand in resources and increasing numbers in resource users. Even all fishers stated to have been fishing more than 10 years in the delta; they also confirmed increasing numbers of fishers. According to the WLD and the FC, the area´s natural resources, particularly the fish stocks are overexploited. Besides the heavily overexploited land, the exploitation of resources through cattle grazing, sand winning, farming or salt production – even observed in the study area – was not identified as overexploited by the interviewees. The clearing of mangrove for construction

material and fishing methods such as Atijah[14] (see figure 20) however can be seen throughout the delta and constitutes a big challenge to conservation and sustainable governance efforts. Also the fishers are aware of this system-internal problem, however the brush parks are utilized all over the delta.

> *"The vegetation is less because there are so many people that use it for construction and Atijah fishing. When there were fewer fishermen and fewer houses there was more vegetation and it was fine to use them for Atijah."*
>
> [Fisher, 36 years from Fanaa]

FIGURE 20 VARIOUS BRUSH PARKS (ATIJAH) IN THE EASTERN ARM OF THE DENSU RIVER CLOSE TO THE PANBROS SALT PANS

> "T*he changes are first of all due to people`s degradation through encroachment and overfishing. There are fishers that use too small fish net mesh sizes and so the fish population is reducing. The young fishermen catch very small fish and throw them away. This is a waste of fish and so the next fish population will be smaller again."*
>
> *[Fisher, 60, Panbros Village]*

The latter quote shows that some fishers are quite aware of the impact of their and other people's activities in the delta. The amount of fish has been declining for decades, so the FC and consequently the fishers started to use more intensive and largely harmful illegal methods like small mesh sizes (e.g. mosquito nets) and pesticides for fishing, to meet their needed catches for their livelihood. The majority

[14] Atijah (also Acadja or Atsidza) are brush park fish traps.

of the interviewed fishers are aware of overexploited resources, however the cutting of mangroves for example is practiced by many fishers, even those who say it would not be sustainable. Besides increasing population in the surrounding communities, the FC also relates the increasing fishing pressure in the lagoon to reducing catches and growing concurrence with big trawlers in the artisanal marine fishery. Further several fishers were complaining about others, destroying the river by using chemicals and explosives for fishing, in order to achieve higher catches. A group of young fishers from Dansoman reported that they had witnessed DDT fishing. They further agreed that the fish was poisonous, hence they wouldn´t eat it. However they would sell it on the market.

As summarized in table 9, the results show that there are multiple systems, internal as well as external perturbations that alter the Densu delta fisheries. While the outcomes of unsustainable fish exploitation severely alter the resource system and are ascribed to the actors themselves, the drivers behind are related to external pressures and changing socio-economic and cultural dynamics related largely to urbanisation. Increasing population also affects the demand of resources and increases the number of resource users. Further, other accompanying effects of urbanisation, such as increasing pollution of system internal waterbodies but also related ecosystems, rising land prices and the spread of built-ups and the aggravation of natural phenomena like floods and erosion increases the pressure on the system. Hence urbanisation is the main driver of change, however larger scale dynamics such as collapsing marine fish stocks, international markets and demographic developments also impact the delta´s fishery.

TABLE 9 MAIN IDENTIFIED STRESSORS TO THE DENSU DELTA´S FISHERIES

Stressor related to urbanisation identified on a local scale	**Sources/drivers**	**Constraints to fishers**
Encroachment	Increasing land pressure from growing Accra Metropolis combined with lack of urban planning and non-transparent land tenure Land conversion for private and commercial built-ups	Less waterbodies/surface for fishing areas Habitat and biodiversity loss
Pollution through: - **Plastics and other solid waste**	waste dumping sites on various places in the delta Big dumping site at Mallam market serving huge parts of Accra Solid waste gets flooded through the gutters into the delta	Nets get blocked and destroyed, hence trapped fish is reducing Fishers get injured from sharp metal and glasses Grazing animals in the wetland feed on waste Waterbodies fill up with waste
- **Liquid waste/ sewage**	Leakage from dumping sites Sewage influx through gutters from surrounding (and inner Delta) communities Faecal liquids and sludge are lead into the gutters during flooding and through open defecation inside the wetland Oil and gasoline from car workshops and huge companies Landfill leachate from Mallam market and landfill at Oblogo	Habitat degradation Odor nuisance and health risks Water quality decline Open water surface decline through siltation and spread of aquatic weeds Fish contamination and stock depletion Health risks Habitat degradation
Aggravation Flooding	Basic change: Changing rain pattern with increasing extreme events Lafa: impact of flood events get aggravated through blocked gutters by waste and changed waterways by encroachment Densu: spillage of Weija is uncoordinated and miscommunicated, hence floods have bigger impact	Loss of canoes and traps and other gears, Removing huts from areas with high flood risk No fishing / income in the times when the water level is too high
(Over)exploitation of resources (such as aquatic species and vegetation)	Increasing demand for firewood, construction material and fish resources Increasing number of fishers Land conversion for expanding Salt production	Fish stock and size decline Habitat and biodiversity loss

6.3 Disappearance of Traditional Resource Governance Systems

Hypothesis II postulates that: *Due to changing socio-ecological dynamics, traditional governance systems related to sustainable resource use have disappeared from the Densu Delta fisheries.*

Hypothesis II is rejected to a certain extent, since dynamics of changing community pattern and other socio-economic changes were found to influence the structure of traditional resource use and governance systems as well as their practices. However they are not vanished completely from the Densu delta´s fishery. The traditional structure of fishing communities seems to be weakened and former established institutions and traditional instruments that shall ensure the adherence to them appear to be forgotten or ignored to a large extent. Nevertheless, some traditional rules and regulations are still known and respected (see table 10). One wetland area (see figure 9 and figure 22 yellow circle) was even found to be strictly and exclusively managed by a fisher family that established a TEK-based governance system on their own and strictly adheres to regulations to sustainable governance.

According to the FC, the structure of organization within the fishing communities in the marine sector is much more organized. Whereas in small lagoons and also in non-commercial fishing systems official organizational structure would be largely absent and the traditional authorities (such as chief fishermen) would not be that strong anymore. Equally different representatives of the WLD confirm that traditional institutions, which are accordingly essential for conservation and sustainable governance of natural resources, are stronger in rural areas. They fear that growing population, as experienced in the case study area could in still rural regions also lead to a decimation of traditional institutions and organized community structures.

This following exemplary statement of fishers from Dansoman, Tetegu and Grefi show that traditional institutions and authorities within the Densu Delta fishery are gradually dissolving. The fishers work as individuals or in small groups and mostly deny having a chief fisherman as traditional leader, or state that the current one would not be active in organizing meetings. Even some fishers stated that new fishers would have to ask permission of chief fishermen, in the majority of the fishing communities these traditional authorities were reported to be in active or not known.

> "*We have no chief fisherman. We organize ourselves. If you have a problem, you face it yourself!*" [Fisher, 24, Dansoman]

> *"Everybody can just go to fish free of charge. It is different than in the marine fishery. In the sea there are traditional chief fishermen, but in the lagoon and the river fishing is free for everybody. The sea is divided into territories for each community. Not here."* [Fisher, 64,Tetegu]

> *"There was a fishermen association before that supported and represented us here in Tetegu, but now everybody works on their own. It´s like this in the whole area. I was also working alone. In the seaside they have groups, but not here. In former times the chief fishermen cared about the river and the fish. People where punished if they didn´t treat the river nice. They had to face the traditional law. But now, there are no meetings anymore."* [Fisher, 65, Tetegu]

"I was working in a group before, but now the others left so I am working alone. Before we were meeting with the other fishers of the area, also with fishers from far. We still have a chief fisherman but we never meet with him." [Fisher, 72, Grefi]

In former times or in functioning community structures, the role of the chief fisherman as traditional leader, embraces important functions within the fishing communities. According to the fishers and the WLD, the chief fisherman informs his community about problems concerning the fisheries and serves as facilitator of meetings and propagator of information. He further is responsible for conflict resolutions, as well as the protection of fish resources and to ensure that fishers adhere to (traditional) rules and regulations. In the Densu delta, fishers reported about conflicts with inhabitants about environmental degradation and encroachment and territorial conflicts and theft of trapped fish by other fishers. These conflicts are solved by themselves through modification of fish traps with thorn bushes and by contacting other actors of the top-down governance system, such as the security of Panbros Salt or the police. The elder fishers stated that they would be afraid of young groups of fishers that are stronger than themselves.

While the traditional institutions appear to be weakened, according to several fishers and the WLD, the traditional techniques and fishing gears have not changed for generations. The TEK transmits intergenerational and in some fisher families and groups, the rules and norms and not only the gears and techniques still are also maintained.

"We are fishing since we were young. Our grandfathers came to Tunga Kadda from the North. They found this area unused and so they started to do bush work like hunting, fishing and farming. So they started to use it and we and our sons do the same. We learned everything from our fathers. The techniques didn´t change since then." [Fisher, 42, Tunga]

Just like this fisher from Tunga, most of the fishers stated that they had learned their fishing techniques from their fathers and nothing would have changed since then, considering the gears and their utilization. A diversity of techniques and gears is used in all waterbodies of the Densu delta. They encompass different net and trap types such as cast-nets, gillnets, driftnet, different fish and crab traps (out of branches or bottles), fishing rods, brush parks called Atijah as well as hand gathering. Complex knowledge about the construction, application as well as about the target species, the characteristics of the waterbody and the time of the year is required to achieve good catches. The mangrove branches for instance have to be dried before using them for Atijah, otherwise fish wouldn´t use them as hiding places, according to one fisher.

Traditional institutions related to the fisheries however are not widely distributed amongst the fishers in the Delta, but they still can be found. Strategies and regulations of TEK based governance systems that were found in the Densu delta fishery are known and followed only by individuals or small groups.

"No [we don´t perform any rituals], *we believe in God. There were old rituals that our grandparents performed. But we saw that it was not helping, so we don´t do them anymore."* [Fisher, 24 years from Dansoman]

This statement of a young fisher from Dansoman (part of a six-headed fishing group) showed that the beliefs that were part of the governance system, performed by the elder generation tend to disappear.

Out of the identified instruments of the TEK-based governance system that had developed in the Densu delta fishery, besides the prohibition of small mesh sizes, none was named by all interviewees. Fishers reported about recent or formerly obeyed regulations, but each taboo or tradition that was named by one respondent (except the ones related to the Homowo festival) was denied by at least one other fisher. Some fishers did not know of any rituals or taboos concerning the fisheries at all and others stated that they were not practiced anymore.

TABLE 10 REPORTED TRADITIONS, REGULATIONS AND TABOOS OF THE DENSU DELTA FISHERY:

The prohibition of small mesh sizes. This regulation is seen as taboo and further one of the only fishing laws that is reported to be controlled by the top-down management
Traditions related to the Ga Homowo festival were mentioned three times: worship of the lagoon god called Sakumo at a special place in Fanaa, that nobody should approach the place during one month; fishing break of two weeks when the Homowo festival starts. Fishing in any place of the lagoon is than punished by tradition.
Tradition of the Ga people that ***forbids the fishing in the Densu river branch on the side of Aplaku*** on Fridays. Even no fisher explicitly stated to ignore these taboos of fishing in the area of concern and the time of the Homowo festival, many fishers and key informants reported that fishing is practiced every day, all year in all waterbodies of the study area.
No fishing on Sundays. According to several fishers it is not forbidden to fish on Sundays, but most people go to church on Sundays. It was mentioned several times, however respondents stated that only some people would adhere to it. The fisher family reported, they would not fish on Friday and Sunday, whereas they would go to the mosque on Friday and take Sunday to rest and give the fish a break.
Taboo of fishing in the lagoon when the estuary is closed. According to one fisher, fishing in the closed lagoon is forbidden. Before the people are allowed to open it and fish again, they are supposed to ask a local fetish priest (that is responsible for the whole area beyond the fisheries) for permission to reopen it. Nevertheless the fisher stated that people forced the lagoon open in the past year without permission, but nothing happened. Even some fishers knew about this taboo, they stated that people would not adhere to it anymore and go fishing at any time in the lagoon.
Taboo of women crossing the Densu when they menstruate. The former taboo was explained to be forgotten by the people for a long time.
Fishing off-season for recovery and reproduction of the fish resources. Only the members of the fisher family knew about this practice and have been adhering to it for three generations due to fish stock recovery.

As shown in the following, the drivers of the loss of TEK-based governance in the delta are divers. They encompass a system internally as well as externally changing dynamics in socio-cultural and economic processes that affect the community pattern, the development and stability of institutions and finally the implementation of traditional practices.

> *"The level of catchment was always decreasing and the fishermen became discontent and became lawless. They accused the fishery commission to not enforce the law against illegal fishing methods* [in the marine fishing sector]. *The big trawlers, often from other countries, come into the area of the artisanal fishermen. Consequently their catches are reducing and they are pushed into the lagoon. The fish species composition changes and the size reduced. The lagoon fishermen therefore became lawless, by using small net sizes and chemicals.. They said they have to become lawless, because they do not get enough fish anymore. There are certain times, when nobody is supposed to go fishing into the lagoon because marine fish come there for breeding but the people ignore this now. Nobody cares about the resting times anymore."* [rep. FC, 6.10.2015]

Summarizing this statement, the growing pressure on the resources through heavy overexploitation from the marine fishery sector (mentioned in the chapter above in relation to overexploitation) influences the adherence of sustainable traditional resource management practices. Accordingly, the local lagoon and river fishers are forced to use illegal, mostly unsustainable fishing methods, in order to meet their need of catches and consequently ignore traditional governance regulations such as off-seasons. While no fisher admitted to use illegal fishing methods himself, several confirmed the use of DDT and small mesh sizes by others. Exemplarily shown by the following statement of a young group of fishers (that was accused of DDT fishing by elder fishers), they are aware of different drivers behind the declining fish catch numbers. However their reaction to the decreasing fish in the delta´s waterbodies is increasing working times and the catch of even smaller sized fish, as seen in their following statement.

> *"There is less fish in the delta. Today we fished for six hours and just got one small Tilapia. It is only here* [in the territory of the Hausa family south of Mallam market] *where you still can get the big fish. In the river* [Densu] *and the lagoon the fish are small now. What should we do? We have to work longer and take what we get. There are too many people here and in Accra. There is also more houses and plastic. This is bad for the fish. And the flooding became stronger so it's difficult during that time to get fish."* [Group of young fishers, 22-30, Dansoman]

Beyond that, the change of community patterns through immigration leads according to several key informants to the loss of importance of traditional authorities. According to Mr. Dickson (WLD) the hierarchical organization of the communities, as it largely still can be found in rural lagoon and river fishing communities, is determined by families and clans. The WLD states that in more rural areas "*the traditional leaders and their rules are more accepted and respected*" (18.08.2015), hence wildlife conservation and sustainable resource management regulations are handled via traditional authorities and the governmental law is considered only in the second place. According to the FC, the situation is different in the urban wetlands, where communities get mixed and always change through new people from various regions and ethnic groups. So the traditional structures as well as their authorities lose their meaning, hence the fisheries management becomes, according to the FC, unregulated and unsustainable.

"The more people move to the area, the more people go fishing. They fish too much in the lagoons and even take the small fish. They become lawless. People from different places move there who have no traditional structure anymore. They do not respect off-seasons. In the end the fish cannot reproduce that fast and the catches are reducing. This is not sustainable and will not be able to support more people in the future." [rep. FC, 6.10.2015]

FIGURE 21 YOUNG GROUP OF FISHERS FROM DANSOMAN WITH THE CATCH OF THREE HOURS (ONE FISH IN THE HAND OF THE THRID FISHER FROM THE RIGHT)

Nevertheless there is one area in the Densu Delta that is governed by the already mentioned fisher family in strict adherence to TEK-based governance strategies. The five-headed family claims the areas where the Lafa enters the delta (see figure 22) as their fishing territory since three generations and restricts entrance to other fishers. The three brothers and two sons from Tunga govern the fish resources of the area according to TEK-based sustainable practices and stick to different rules and practices that are ignored in the rest of the Densu delta fisheries. The following statement of the oldest family member (64 years), who is considered as their chief fisherman, shows their responsible interaction with the exploited resources and their concern about the state of the ecosystem they depend on.

"Other fishers use very small nets. They even use mosquito nets. But the small fish have to stay in the water, because then they grow and we can catch them when they are grown. If we see the people, we stop them. If we allow someone to fish in our territory, we control the nets. Other people use chemicals for fishing. This is illegal and destroys the river. Dumping plastic and spilling oil in the river is also illegal. So we have to protect this area, we are responsible." [Fisher, 64, Tunga]

The family takes a three-month off-season from August to October, to give the river and the fish a break, as they say. Two days a week they do not go fishing to attend the mosque and again to give them-

selves and the fish a break. They reported about using big mesh sizes, only to catch smaller fish to use them as bait for the bigger ones and further to control the nets of fishers that they allow access in exceptional cases. Their fishing lodge, situated on the south eastern corner of their territory (see figure 22) serves as shelter for guarding the area throughout the year. They collect waste to keep their area clean, reported cases of pollution to the Panbros security and try to stop encroachment by contacting the local police. They stated not to have a community chief fisherman but their own family rules and structure. Considering the size of their catches (see figure 23, 24 and 26), which were the biggest observed in the whole delta, their strategy seems to work. Other fishers and the WLD staff confirmed that fish species of the territory and size would be exceptional in the Densu delta. However, the family also reported declining catches, increasing pollution and the disappearance of other wildlife species, such as snakes and reptiles in their area. Hence even they established a sustainable governance system for their territory. There are perturbations from outside their system that degrade the resources, but are out of their control.

In sum, the results in this chapter show that TEK-based governance is indeed breaking down in the majority of fishing communities in the delta. Chief fishermen seem to be absent or inactive and fishers largely regulate conflicts on their own. Former regularly meetings within fisher communities and even between the communities are not taken place anymore. However there are still fishers that adhere to sustainable regulations for the fisheries. While some only know about former traditions and other just respect few of them, the fishers' family in the north eastern part of the delta established their own self-organised governance system and feel themselves responsible for the resource system. The effectiveness of various implemented strategies can be seen in their catches and is confirmed by other resource users that largely respect the territory of this family.

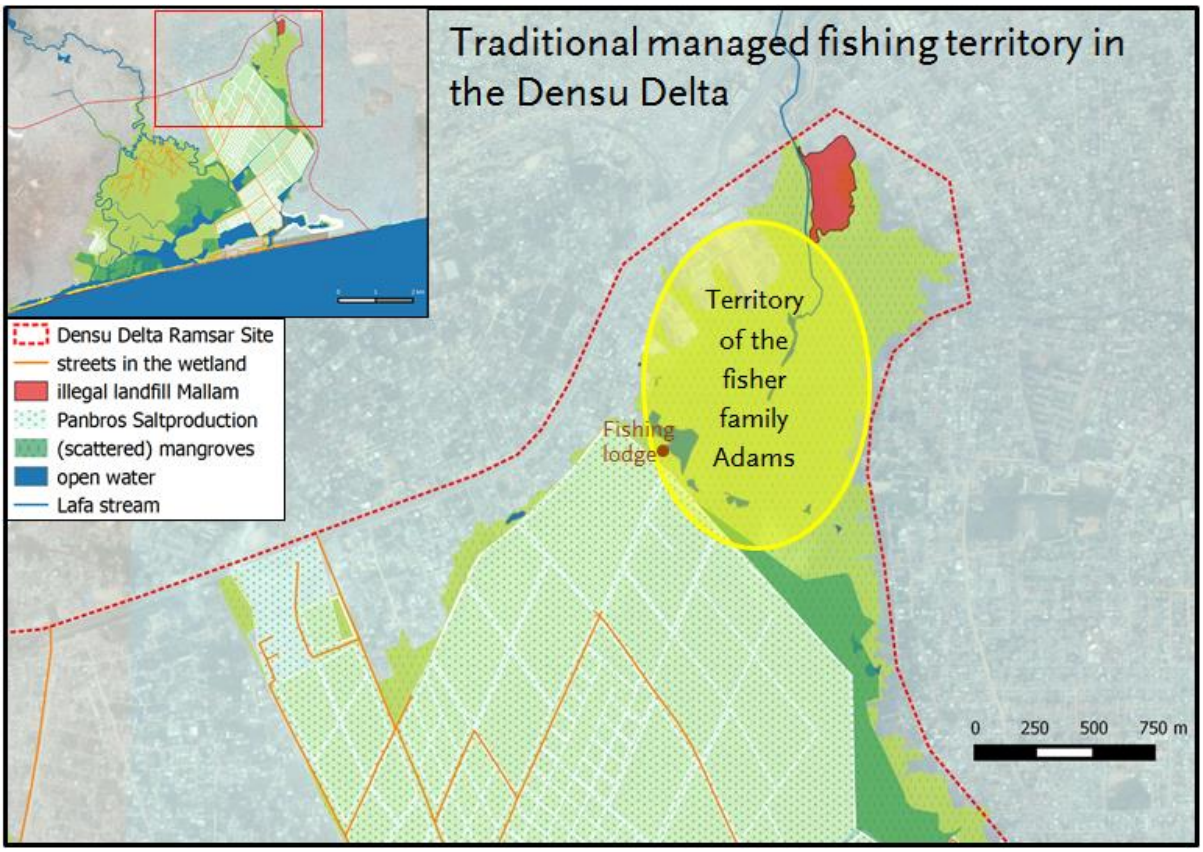

FIGURE 23: TERRITORY OF THE ADAMS FAMILY (YELLOW CIRCLE) LOCATED IN THE NORTHEASTERN PART OF THE DENSU DELTA IN THE LAFA STREAM AREA

FIGURE 23 TILAPIA CATCH FROM THE FISHERS´ FAMILY TERRITORY

FIGURE 24 Catfish Catch from Inside the Fishers´ Family Territory

FIGURE 25 Fish Catch from Outside the Fishers´ Family Territory that is considerably smaller

FIGURE 26 Skin of a Large Fish Species that is only Found in the Family´s Territory

6.4 Top-Down Resource Governance in the Densu Delta

Hypothesis III: *The top-down governance approach of the "wise use" concept of the Ramsar Convention integrates traditional resource governance to work jointly to ensure sustainable fishery in the Densu delta.*

Hypothesis III is rejected, since there are no persistent functioning top-down governance strategies of the fisheries found in the Densu Delta. Neither are fishers nor their traditional governance system and former institutions assessed and supported. Different efforts by various authorities were identified, however none of the key informants reported about any successful long-term strategy implementation for sustainable resource use and governance in the focal system. Besides the stressors that are presented in the previous chapter, the sustainable governance of the SES in the Densu Delta fisheries is challenged by various factors, such as the lack of clearly defined responsibilities and a holistic decision authority, the lack of political backing and the lack of cooperation between the responsible commissions and other actors, such as the fishers. Hence the top-down governance system neither specifically includes traditional structures, nor manages to successfully ensure sustainability.

The study area is part of the 1992 officially designated Densu delta Ramsar site and is therefore governed according to the "wise use" concept of the Ramsar Convention under authority of the Wildlife Division, one of the three divisions of the Forestry Commission of Ghana. The on-ground responsibility is shared between the local assemblies, Panbros Salt, the WLD and the communities. Most of the interviewed fishers are aware of the Ramsar status of the wetlands and know about the restriction regarding the fish resource use (e.g. mesh size above 25 mm, prohibition of chemicals and explosives and the cutting of mangrove) (for further restrictions see box 1). However almost all restricted activities according to the Ramsar concept can be identified in the delta (see box 1). The WLD has only one technical assistant who works permanently in the area, hence the patrol capacity is very limited. Conservatory activities have been brought down to basics (e.g. bird population assessment and the control of law violation) and community meetings have not been organized for years.

Water pollution through solid and liquid waste disposal (observed and interviews)
Use of poisons and explosives for fishing (interviews)
Used nets with mesh size below 25mm (observed and interviews)
No consistent close season throughout the delta (interviews)
Removal of woody vegetation and cultivation in the core area (observed and interviews)
Sand winning and earth removal (observed and interviews)
Hunting and disturbing of nesting birds (observed and interviews)
Livestock grazing in bird nesting areas and in the core area (observed and interviews)
Bushfire within the Ramsar Site (observed)

Box 1 Identified Volation of the Wetland Management (Ramsar Site) Regulations (see Ramsar Regulations 1999)

The Wetlands Coordinator of the WLD states that the site has been extremely negatively changed in size and characteristic since its zoning in 1992. Aside from some baseline studies in the 1990s, there are no continuous ecosystem assessments and studies would be conducted irregularly, by local universities but not by the WLD. Accordingly, also the activities of NGOs in the Delta largely stopped and were transferred to the Sakumo Ramsar site, since the natural aspects there would be of greater interest. Based on the experience of the past 23 years, his estimations for the future development of the Densu Delta Ramsar site are quite pessimistic, as shown in the following statement:

"We will lose all those qualities that were supporting us through local, regional, national ecosystems. In the sense that these waters are getting polluted fast. They are getting silted, are drying off, mangroves are vanishing, fish stocks are reducing. So my fear is that in future we may lose the status [of the Densu delta] *as a Ramsar Site. [...] We are more or less helpless with this encroachment that is coming. Looking at with what they started off from, the beauty of the site and where we are now, with all the effort we put in."* [rep.WLD 24.7.2015]

According to the interviewed key informants of the FC, the situation is even worse. Calling for the urgency of the situation in the coastal wetlands, the FC states that, *"[i]f we are not going to work on it, we are going to lose our inland fishery."* (6.10.2015. The inland fishery sector is the neglected part of the fishery in Ghana and not considered as a major topic. There is no data on Ghana's inland fishery despite some minor assessments of the Lake Volta production. The only attempts by the FC to implement fishery governance strategies and assess catches were initiated by the former zonal officer. According to her, fishers were very enthusiastic about possible cooperation, but the efforts to start catch data assessments and set up community based fishery management committees (co-governance approach) as it exists for the marine fishery, failed due to missing support from the commission. The officer clearly sees the responsibility at the FC and says it would be surprising that the lagoons, which are important breeding grounds for marine fish are not tackled yet.

The WLD sees serious problems in the planning and implementation of strategies on the top-down governance side. The lack of political backing and the assemblage of the power of decision under one authority hamper efficient governance, so he states. Since the Ramsar law is a collection of borrowed laws from different environmental fields, the WLD depends on other government commissions and the district assemblies for final decisions. Responsibilities are shared between different fields, such as water, fisheries, forestry, and waste management, but there is no cooperation. Hence the implementation of laws in total would be not possible, since they are not controlled by one authority.

"The Ramsar law is too flexible. We can just borrow laws, for example the fishing law. But therefore, we as the WLD have to run to the Fishery Commission to record the law violation. Only the responsible governmental agency can bring then the people to court. The Ramsar law is not controlled by one organization and this is causing huge problems. There is no collaboration that links to this different organization. This is why the Ramsar concept in urban areas has failed. The nation has to improve in this field. There is a big gap. The nation has to find a way to harmonize the laws and a way of networking. Contacts have to be created and the personnel has to be there that knows all the laws of concern and has contact with the responsible people in the different fields. There should be a common legal officer. All this issues should sit at one ministry of environment linking all the fields of environment." [rep. WLD 24.7.2015]

Similar to the latter statement, other key informants agreed on a shared responsibility of the Densu delta Ramsar site governance, but complain about missing collaboration between the different involved actors. So, the FC stresses the need of a better communication and a permanent structure that encompasses all involved actors. However, only the actors of the top-down governance system are named. Accordingly many programmes that should include different fields and institutions are planned without cooperation. This problem also became visible in the meeting of the Densu Delta workshop organized by the Dutch consultancy and engineering company. Various members of the different commissions, NGOs and assemblies related to the delta were invited, but their state of knowledge about already conducted

studies or programmes by other institutions was little. Further the workshop programme was only planned in cooperation with the Water Resource Commission, while the FC or the WLD had been informed only a few days ahead. Beyond that, no member of the fishers as directly involved resource user groups had participated.

According to different key informants, the explicit recognition of the presence of people in the Ramsar concept is another basic problem to sustainable governance of the area. The collaboration with actors like the local inhabitants and resource users is seen as a burden and reported to be complicated. The WLD says the restriction of entrance or resource exploitation is not in the sense of the "wise use" concept, however it is difficult to regulate to which extent settlements can encroach and resources can be exploited. Neither the land, nor the resources are government-owned, therefore the conservation heavily depends on the local inhabitants and authorities.

> *"The area is not acquired by the government. It is still owned by the people themselves and therefore it is up to them to make a choice. The financial benefit the people get from selling the land or agreeing to any business partnership on the land is higher than the profit they can get from the wetland protection, fishing or the mangroves. Therefore it is difficult to apply any kind of government regulations. There was no compensation payed. [...]All the area apart from Panbros seems to be highly competitive in terms of the community to make a choice. Either its kept to be protected like the WLD is saying or it is sold for buildings. The laws are weak. [...] The WLD has to talk to them or lobby the district assembly to convince them so we can stop the people. It is a long process and the range and rate that everything is happening overtakes the capacity of the WLD. "[rep., WLD 24.7.2015]*

> *"The land of the area belongs to people, clans and tribes, here to the Ga. It is their decision what to do with it. Their economic benefit is bigger when they sell it off to private people or real estate agencies. So it is difficult to find solutions in favour of wetland conservation and sustainable management issues. [...] The people know in their hearts that they shouldn't sell the lands but there is no management that stops people that are ignorant."* [rep. WRC, 9.10.2015]

According to the WLD, the cooperation with communities concerning wetland governance in rural areas is less complicated, whereas the situation in urban areas is quite challenging. On the one hand the land tenure in rural areas mostly consists of traditional structures and is more transparent, while in urban areas land is more valuable and multiple actors are involved in its market. On the other hand, communities in rural areas are less fluctuating, while urban areas are characterized by fast changing community pattern, hence long term cooperation is limited. The following statements from the WLD further illustrate the situation:

> *"We plant the mangroves together with the communities to make them sensitive for the issue. Also here the land and water are owned and controlled by the different clans and families of the area. So the conservation also depends on the good will of the chiefs and families. This is complicated at times, but up to now it works out. We have known them for a long time and the communities do not change so fast, as they do in urban areas. The question is how long and what will happen when population and pressure on the land continues to grow like it does presently".* [rep. WLD, 18.08.2015]

> *"In the urban areas like the Densu area, the dynamics of this population changes very fast. New people come in every day. Therefore it is difficult to collaborate with them, because you even don't know who you have talked to last year. In the rural areas, it is still the same people, who we have started off with. They pass it on to their children."* [rep. WLD, 24.07.2015]

Accordingly the cooperation with local actors is hampered through their fluctuation and the lack of awareness. The WLD reported to approach fishers via the chief fishermen of the communities in cases of problem occurrence or the need to share information. According to the local staff of the WLD, the TEK of the resource users is not assessed and the only controlled regulations are the fishery law restrictions of mesh size, chemical use and mangrove cutting. Neither the conflicts between the fishers about resource degradation, nor the TEK-based governance system of the fisher family in the north eastern part of the Delta is known to the WLD, the FC or the WRC. Consequently the cooperation in governance and the support of the traditional system is largely missing. According to the WLD, there were attempts to support the communities with local investment funds, but the lack of cooperation on the sides of the fishers and the change of government on the side of the top-down governance system lead to the abundance of the programme. Hence all attempts that were made from side of the FC, the WLD or the WRC were stopped after some time and also from sides of the fishers, there are no consequent attempts to cooperate with the top-down governance system.

In summary, the interactions between the focal actor group and the top-down governance system are reduced to the control of some fishery laws. Due to the insufficient personnel that work directly in the delta, the area is not covered. There seems to be no cooperation, since the communication is implemented via the chief fishermen, regardless that most of the fishers stated, not to have any active leader. The representatives of the commissions see a problem in the needed governance cooperation with other actors due to the "wise use" concept, thus, potentials for a jointly developed governance strategy remain unused. Former traditionally developed institutions are ignored and forgotten by most of the resource users and the resource system is degraded through overexploitation and other harmful human activities. Yet there is the potential of TEK-based sustainable governance structures that are locally developed and implemented by the fisher family in the north-eastern part of the delta. However this potential is unknown and unassessed. And the outcomes of their efforts towards sustainability of the system are challenged by encroachment and massive pollution of their fishing grounds through external pressures like the Mallam market dumping site.

7 Discussion and Outlook

The overall goal of this thesis is to examine the role of the fishers and the traditional governance system in the Densu delta Ramsar site, facing changing internal and external dynamics of the SES. In the following the results of the empirical work are embedded in a broader context and the role of the focal actors is discussed and linked to sustainable governance of the SES and related interactions and outcomes. Further the usefulness of the SESF as an analytic tool to examine the role of the fishers in the thesis at hand is discussed.

7.1 System Complexity Challenges the Efforts Towards Sustainable Governance

As shown in the results, the threats to the Densu delta fisheries are multiple, complex and operate scale crossing. By overexploiting the resources, the fishers are just one out of multiple stressors to the SES, however in the Densu delta they are seen, as in other Ghanaian wetlands, rather as burden than as potential fish managers and contributors to sustainable governance strategies. While most of the pressing threats on the SES can be localized on local scale (including overexploitation), the drivers behind it are embedded in a complex web of catalysts and impacts that operate scale crossing. Hence they need complex thinking, scale crossing governance strategies that are developed in all actor-involving processes across all relevant levels and fields, including the fishers as actual resource users. Therefore it is argued, that the fishers and their potential to foster the combat of threats and develop strategies towards sustainable governance in the focal system is underestimated and largely ignored by top down governance authorities.

> "Without doubt, the increasing complexity of the world's socio-economic reality has immediate relevance for sustainable development and there is now a pressing need for the exploration of approaches that have been explicitly conceived to address complexity in the organisational and societal domain." (Espinosa & Walker 2011. p. 5)

As explained in chapter 2, social-ecological systems, such as the Densu delta fishery are characterized by complex cross-scale and non-linear dynamics. The interactions of actors and the ecological system are influenced by internal as well as external dynamics and various stable states are possible, so Gunderson in Berkes et al. (2003). The author states that this behaviour particularly constitutes challenges for the implementation of sustainable governance of the system´s resources, where the understanding of those SESs dynamics and scales is crucial. Ostrom (2007) emphasizes that multiple dimensions as well as the specific local contexts have to be absolutely necessary. Eponymous of complex SESs are the complex interactions of the components more than simply their number. In the case at hand, this means that solutions towards sustainable governance cannot be found as straightforward as it might appear in the first place. Sustainability is "a process, rather than an end product, a dynamic process that requires adaptive capacity for societies to deal with change" (Berkes et al. 2003. p. 2). A sustainable governance system therefore has to co-evolve with the system, adapt to changes and accept the processual charac-

ter of the system as well as the multifaceted actors and particular the scale crossing interactions (Holling 2001; Berkes et al. 2003).

Cinner et al. (2013. p. 1359) state that there is an increasing awareness amongst scientists that governance systems that recognize *"the role of existing common property institutions, decentralized management, and increased empowerment of local authorities and fishers"* foster sustainable outcomes for local fishery systems. Yet it still remains challenging to distinguish between efficient and inefficient governance since *"*[w]*e still lack an adequate framework to understand governance, which would enable us to design and implement methods which are more likely to lead to a sustainable society"* (Espinosa & Walker 2011. p.24). In this context, Ostrom´s SES framework (2007 and Ostrom 2009) provides an important tool that has helped since its publication to accumulate this knowledge on small-scale fisheries where governance is leading towards more sustainability and to identify promising variables and interactions that lead to better outcomes (Cinner et al. 2013).

The focal system is formally governed according to the Ramsar Convention concept that understands the cooperation amongst all actors as crucial to successful governance outcomes and particularly highlights the importance of the traditional institutions and authorities on local scale. As shown in the following guideline of the Ramsar Convention, it clearly emphasizes the need of traditional ecological knowledge and resource practices and most striking the active involvement of local resource users "at all relevant levels". "T*he traditional knowledge, innovations and practices of indigenous peoples and local communities relevant for the wise use of wetlands and their customary use of wetland resources are documented, respected, subject to national legislation and relevant international obligations, and fully integrated and reflected in the implementation of the Convention, with a full and effective participation of indigenous peoples and local communities at all relevant levels* (Ramsar Convention 2016. p. 10).

Yet the involvement of actors and the cooperation amongst face different constraints and is first of all challenged by the complexity of threatening dynamics. The problematic of pollution and its consequences for the fisheries in the Densu delta exemplify this complexity as well as illustrate the challenges for sustainable governance of the Densu delta fisheries. Islam & Tanaka (2004. p. 643) describe coastal aquatic pollution as *"characterized by inter-connectedness, complicated interactions, uncertainty, conflicts and constraints, making it difficult to control the problem."* They further see the *"[p]rotection of the aquatic environment from pollution [as] the most essential theme of environmental management,"* and call for needed holistic and cross-scale governance approaches to support fishers in the protection of fish resources. Yet, they see the scope of action of fish managers (here the fishers) as very limited. "*The institutional and legal settings in most nations are such that the fishery managers can, in fact, do little, even if pollution is identified as the major cause for fishery decline. They can only manipulate their fishery, e.g., gear management, stock enhancement etc. However, as the pollution continues, degradation of fishery also continues"* (Islam & Tanaka 2004. p.644).

In the focal system, the pollution is also one of the major stressors, as showed in chapter 5. Different scientists confirm these findings for Ghana´s wetlands and its fisheries in general (see Okyere et al. 2011; Aheto & Mensah 2011; Koranteng et al. 2000; Baffour-awuah 2014a; Darkwa & Smardon 2010; Addo et al. 2014) and for the Densu delta in particular (Willoughby et al. 2001; Ntiamoa-Baidu & Gordon 1991). Ghana´s coastal wetland fishers are however mostly identified as affected by pollution (see Entsua-Mensah et al. 2000) or as contributor by using harmful fishing methods (e.g. chemicals and explosives), hence their role is largely rather seen as burden to the system (see Willoughby et al. 2001)

than as part of the governance system and possible strategy developers against pollution. Even the potential of traditional strategies is considered in several publications (Entsua-Mensah et al. 2000; Ntiamoa-Baidu & Gordon 1991), their knowledge about the stressor and the negative health implications of contaminated fish are mostly not assessed or seen as rather unimportant (Baffour-awuah 2014a; Baffour-awuah 2014b).

However, the combat of contamination and degradation of the resource system by pollution needs cooperation amongst multiple actors and this involves the fishers. The case of the illegal landfill of Mallam market exemplarily shows the multifaceted interactions and actors that are involved. Located on the north-eastern fringe of the wetland, the Mallam landfill is one of Accra´s two illegal but fastest growing landfills[15], whose leachate and floating waste severely affects the deltas fisheries. According to the AMA waste department representative, it is the focal point of informal working waste collecting tricycles that successfully supplement Accra's official waste collection system by collecting about 20% of the city´s waste. Since the tricycles are not able to drive long distances to the official landfills out of Accra, the collected waste from multiple communities is unloaded in the centre-close dumping site. Without an alternative infrastructure (which has been planned for a long time) for this informal waste collecting system, the shutdown of the site would just geographically shift the problem. Further constraints to the shutdown of the landfill are economic and local political interests that are behind the dumping ground. On the one hand the dumping site generates huge economic profit for the operator and the land owner. On the other side, the waste serves as filling material for further land reclamation of swampy wetland ground in order to extent the Mallam market site and to create a needed parking place. The incentives and potential economic benefits of local land owners and political authorities behind the maintenance of the dumping site are very complex and apparently of more importance than the interest in wetland conservation and possible consequences for the fisheries.

This complexity might lead to the assumption that the fishers have no potential to influence the complex problem, besides adapting to it in cleaning their nets and accepting contaminated resources. To some extent this may be true, since the interactions operate on higher scales and the realms of Accra´s waste management, political decisions and economic interests are out of their scope of action. However on local scale, there is a range of possibilities to involve the fishers and gain valuable knowledge from them. The interviews revealed that many fishers are quite aware of the increasing pollution, the different sources and the negative health implication (namely e.g. oil, soap, solid waste, chemicals) for the resource as well as for themselves. Fishers in Tetegu and the fisher family[16] just above Mallam, are collecting waste in their area and burn it on the place[17], in order to avoid that it enters the river. Depending directly on the resources, they largely have no opportunity to avoid the polluted places and the fisher family sees themselves as responsible for the resource system. Some of the fishers have become active and tried to cooperate directly with other governance authorities to combat the problem. The Panbros security was called by the fishers to arrest people that were dumping waste in the delta, the police was called when estate developers wanted to construct a toilet within the wetland with success.

[15] The newly published Google Satellite image of 2016 that was published after the land use/ land cover map (figure 9) was made, shows a large new expansion in direction of the wetland that happened only within one year

[16] For better reading in the following termed as: *the fisher family*

[17] From an ecological point of view this might seem as just shifting the problem to air pollution, however it is common in Accra and besides accumulating garbage in dumping sides largely the only alternative to treat waste after collection.

Further cooperation between the actors involved in the governance system (traditional as well as top-down) however failed alternately due to missing willingness or possibilities to cooperate on both sides. Fishers in Tetegu contacted a local assembly member to help in stopping liquid waste water from entering into the Densu. The cooperation failed and the situation between inhabitants that lead waste water into the Densu and the fishers who complain about decreasing water quality is tensed. The former Ga South zonal manager of the FC emphasized the enthusiasm of fishers to cooperate with the commission to assess changes of fish catches and water quality in the delta, however the promising project did not get support from its office and was abandoned. On the other side, efforts from the top-down governance side failed due to missing willingness of cooperation from the fishers. The fisher community support programme gave loans for investments to the fishers and provided community places, however the loans were not paid back and the structures remained unused, so the programme was stopped. Besides these failed attempts from the top-down governance side, there are neither long-term assessments and in depth-analyses of fish and water quality, nor are the fishers considered as source of knowledge. Even the WRC occasionally advices resource users about alarming sample results of single location tests, the information is not widely spread and there is little cooperation with other governance structures such as the FC or the WLD. The ecological knowledge about the conditions of water and fish resources facing the burden of heavy pollution on sides of the fishers is not assessed at all.

While the scope of action on higher scale might be limited facing the complexity and range of interactions involved, their potential for knowledge generation on a local scale is important to be considered. The entries of pollution into the waterbodies are diverse but identifiable on a local scale. The resources users are working in the delta on a daily basis and know about locations of pollution sources and moreover about the changes of the resource system concerning pollution and contamination. The fisher´s observations on changing colour, shape and texture as well as on the distribution and disappearance of species can give important insights for the degree of contamination and even for the identification of thresholds. All fishers stated to have been working for more than 10 years, some even for 40 years in the delta, hence their potential to have knowledge about historical conditions and developments is great. The role of the fishers could be newly defined as guards and active part of the governance system rather than as burden to the system. Devolved responsibility could lead to positive outcomes for sustainable development in the wetland and expand their scope of action from "simply" adapting the gears to changing conditions to actively find solutions.

This example shows that strategies for sustainable governance of the wetlands fishery concerning the pollution, have to work across scales and include the fisheries, wetland conservation, waste management as well as city planning, political and economic interests in the wetland. As Basurto et al. (2013) show for benthic small scale fishers, the potential of TEK is large and relevant for top-down governance and can successfully compliment to scientific knowledge, but therefore it has to be assessed and collected before (Glaser 2006). For the cooperation, a trust relation between resource users and top-down governance is needed as Hollup (2000) shows in a study on user-group participation in Mauritius fisheries. When the contact between the actors is largely reduced to control and educative process from "top-down" direction (as it is the case in the Densu delta), a trustful relation is difficult to be established and also the enforcement of laws becomes ineffective (Hollup 2000). Since solutions towards more sustainable governance stretch from infrastructural development of waste collection and disposal, over political backing and the enforcement of laws concerning environmental pollution to the contribution of local actors such as inhabitants and resource users, cooperative governance is essential.

Further research is needed to gain a holistic picture of the complexity of interactions in small-scale coastal inland fishery in Ghana and possible outcomes have to be considered on different scales. By identifying the sources of threats as well as the effects on the resource system, resource unit, actors and governance system, the scope of action of different actors as well as important realms of cooperation can be identified. Further in depth-analyses of fish and water contamination are needed to evaluate the condition of the ecosystem and to quantify and qualify the consequences of pollution for the fishers. TEK knowledge and the capacity of on the ground working resource users can foster this process greatly. Since the fishers are directly affected by pollution, their involvement in the assessment and better dissemination of information on the degree of resource contamination is essential. Beyond that, the range of cross-scaling consequences should be assessed by analysing fish resource market patterns. Since the fish is sold to local or even regional markets, not only the sources of pollution are scale-crossing, but also the impact of contaminated fish can reach consumers on different scales.

7.2 Potential of TEK-Based Resource Governance and Self-Organization

> *"Obviously, there is a need for detailed scientific study of the traditional beliefs and taboos associated with coastal lagoons, to evaluate their effectiveness as conservation tools. Once this is done, it should be possible to strengthen and promote the enforcement of the more effective traditions through the provision of modern legal backing. Such legal systems, based on the local people's traditional beliefs would be more likely to receive the local people's support and participation, to ensure the rational use of coastal lagoon resources and prevent overexploitation"* (Ntiamoa-Baidu 1991. p. 45).

As already argued in the previous chapter, this statement from the beginning of the 1990s emphasizes the importance of TEK-based governance practices and strategies for the conservation of wetland resources in Ghana. However the author states in a publication of the same year (Ntiamoa-Baidu & Gordon 1991. p. 9), that *"as a result of Christianity, western influence and education, and the immigration of people from other ethnic groups who may neither believe nor respect local fetishes and taboos, these traditions and taboos are no longer respected. This has resulted in the undermining of the effectiveness of the traditional strategies as conservation tools to such an extent that the system can no longer be relied upon for the conservation of Ghana's coastal wetlands."* Dankwa et al. (2004) and Entsua-Mensah (2000) report that particularly urban wetland areas record this process and according to Oteng-Yeboah (1999. p. 11) *"[u]rbanisation appears to be the major cause of the breakdown of traditional norms with regard to exploitation of the resources of the Densu delta"*.

The common narrative on small-scale fisheries of collapsing stocks due to ecosystem degradation and the breakdown of local sustainable governance (Cinner et al. 2013) seems to reproduce in Ghana´s coastal wetland fishery and particularly in the urbanised Densu delta. Entsua-Mensah et al. (2000) claims in a study on the fishery in Ghana´s Ramsar sites, that none of the identified principal traditional practices of the five lagoon systems, namely the *restriction of certain gears, regulation of entry, taboos, closed fishing days, seasons and areas and mesh size regulation* would apply for the Densu delta. This was confirmed by the key-informant interviews, who repeatedly claimed that changing community patterns,

pressure through marine fisheries, decreasing catches and Christianity would lead to the breakdown of traditions and the ignorance of traditional rules and regulations. In rural areas this would not yet be the case, so the WLD, however particularly in urban wetlands the systems would have broken down.

Also the observations and the interviews of the fishers could reproduce these narratives, when drawing the conclusion from the majority behaviour of the fishers. The majority of the fishers confirms the assumption and complains about the breakdown of traditional hierarchical community structure, inactive traditional authorities and states to ignore traditions such as off seasons, weekly rest days or taboo species. However the results also show that there are still several strategies and practices that resource users adhere to and various fishers know about former rituals and traditional regulations. There are even small groups of fishers and individuals that strictly adhere to them and show self-established institutions. They manage their fishing territory according to traditional resource governance strategies related to sustainability, control other fishers and show profound knowledge about the processes of resource system and the resource unit.

Further several members of the focal actor group reported that they would not fish on Sundays and the western arm of the Densu is which in respect of a Ga tradition closed for fishing on Fridays. According to Oteng-Yeboah (1999. p. 11), this is a resting day to perform rituals for *"land gods who take stock of the activities of the land after every six days"* and further refers to a former general fishing taboo on Fridays for all gods from river, land and sea. Fishing is also prohibited for some weeks during the annual Homowo festival and when the lagoon is closed, the latter rule is largely ignored though. Sacred places for different gods (so Oteng-Yeboah 1999) in the Densu delta are confirmed by the local WLD staff, to be located in Bortianor and Aplaku, where people pour libation for nature gods on Tuesdays. All over the delta fishers know about the prohibition of mesh sizes below 25 mm. And further in one arm of the Densu River women were not allowed to cross the river during their menstrual period and were excluded from bathing in the river. This taboo was still known, but is not respected anymore.

As explained above, several authors (Oteng-Yeboah 1999; Entsua-Mensah et al. 2000; Ntiamoa-Baidu 1991) see urbanisation and other changing dynamics such as "*immigration of people from other ethnic groups who neither believed nor respected the local fetishes and taboos"* as well as "*Christianity, western influence and education" (*Ntiamoa-Baidu 1991. p. 45) as major drivers of the breakdown of traditional governance systems. All results illustrate that these drivers have extremely increased in the study area for decades. According to Willoughby et al. (2001. p. 223), *["b]uilt up or residential land is expanding rapidly in and peripheral to several* [Ramsar] *sites, most notably Densu and Sakumo." And already in the 1990s "[t]he eastern and north eastern sections of the wetland are heavily, settled (Dansoman, Malam, Mendskrom and Mccarthy Hill)"* (Ntiamoa-Baidu & Gordon 1991. p. 74), which was confirmed through the fieldwork. Even the breakdown of traditional systems could be confirmed for a great part of the delta´s fishery, the case of the fisher family strongly contradicts this assumption. Contrary to the logical conclusion, that the most urbanized areas would inhabit the weakest TEK-based governance system, the above mentioned highly urbanized and polluted area in the North East matches exactly with the territory of the mentioned fisher family and is the only area in the Densu Delta that is governed under strict adherence to multiple traditional strategies related to sustainability.

The territory is closed for fishing for three months a year, as well as on Fridays and Sundays. This is, according to the family members, in favour of fish reproduction. The entrance is prohibited to other fishers, except if they ask permission and can give an appropriate reason (e.g. wedding or funeral). The

family patrols their territory with dogs and stays rotatory in their fishing lodge in the delta, to be on guard. They claim not to fish juvenile fish except for baitfish and they also control the mesh sizes of other fishers. All the observed nets and traps approved this. They also patrol the land surrounding their fishing ground to scare off people that dump their refuse or even call the police to report illegal constructions and dumping sites. Their knowledge about seasons and fish species is profound. They seasonally avoid fishing in certain breeding areas and know about the growth rates and reproduction process of various species. Most likely as a result of their governance restrictions, the fish in their territory was observed to grow to a larger size than in any other waterbody of the delta, indicating the well-functioning system of sustainable resource exploitation by this family.

While various fishers referred to their belief in god as reason for the disregard of rituals and taboos related to nature gods and key informants blamed fast changing community patterns through in-migration as driver of non-adherence to traditional rules and the loss of traditional community structures. The fisher family states not to perform any rituals for nature gods of the Densu delta, nor are they of local Ga origin. Their family immigrated 80 years ago to the area and they are Muslims and belong to the Northern ethnic group of the Hausa. Hence neither their ethnicity or belief in local goods, nor their religion particularly unifies and binds them to the wetland area. They are further not part of an active hierarchically structured fishing community and define their eldest member as "kind of" a chief fisherman. However, they established their own institutions and strictly adhere to them. The observed fish quantity and size confirms the effectiveness of their practices.

The results of the empirical work show that the role of the fishers and their TEK-based governance system is cross-linked with various components and complex interactions of the SES. Equally like studies of other authors (see Dankwa et al. 2004; Ntiamoa-Baidu 1991; Baffour-awuah 2014; Darkwa & Smardon 2010; Addo et al. 2014; Koranteng et al. 2000), the case of the fisher family in the Densu delta fishery shows that TEK-based governance can be considered as effective tool for sustainable development and conservation of the coastal wetland fisheries. It is not even possible to draw general conclusions about a single case in the Densu delta, it shows that individuals and small groups, independently of local beliefs, local hierarchical structures of the fisheries and ethnicity can establish self-organized sustainability-orientated traditional resource systems. Basurto (2013) shows that local fishery systems can differ extremely in their governance and outcomes, even if of close proximity to each other. This thesis shows that within one SES on local scale (the Densu delta) even smaller SESs can exist (here the fisher family) that extremely vary in their governance systems and outcomes.

One of the most striking differences of the fisher family territory and the other waterbodies of the delta is the restricted access. The factor of self-organized access control to the resource system that is observed here, is according to Basurto (2013) very effective for sustainable outcomes of the resource exploitation. The development of an individual set of operational rules to restrict access to their fishing grounds is based on the family cohesion and the intergenerational developed knowledge and implementation of rules. The established self-organized governance system of the family so far resists its location in one of the most threatened areas of the delta and the general observed breakdown of traditions in the larger related SES. Several second tier variables, that are associated with self-organization by Ostrom (2009), match with the fisher family (see table 11) and still seem to be able to combat the not given predictability due to vast external perturbation (increasing floods, pollution and encroachment) which is, according to the family members, extremely challenging.

TABLE 11 VARIABLES ASSOCIATED WITH SELF-ORGANIZATION IN LOCAL RESOURCE SYSTEMS (OSTROM 2009)

Variables associated with self-organization	Situation in the fisher family system
Size of the resource system	Small
Productivity of the system	enhanced through their controlled exploitation, but heavily altered by pollution
Number of users	Small – only family members
Collective choice rules	self-developed and enforced set of rules
Predictability	not given due to uncertainty about encroachment, property rights and increasing pollution
Mobility of resource	rather large, since the area is connected to the Lafa, the Sakumo lagoon and the Densu
Knowledge	profound knowledge about the resource unit, system and threats to them;
Leadership	They explained to see their eldest as chief fisherman, however each member has its own territory within the area and they appeared equitable also in decisions
Norms	strong and accepted by all family members and other fishers
Importance of the resource	high, but they go hunting in addition and the sons also have further occupations

In summary, the case shows that even in urban wetlands there are cases that contradict the common narrative of down breaking TEK-based governance systems at least on a small and very local scale. However, the narrative on resource degradation and collapsing stocks due to external drivers seems to be confirmed and increasing in urban areas. The FC also sees the governance concept of the fisher family as promising and the self-organization is essential since the enforcement of rules such as a restricted entrance by top-down governance would cause huge conflicts. Initiated from the grass-rout level, natural resource governance is more easily accepted and respected on a local level (Hartter & Ryan 2010), hence the system should be supported in the (larger) focal system. The self-organized TEK-based governance system of the family could, in combination with scientific knowledge and the support of the top-down governance, foster sustainability in the whole delta

Since this work had limited time and work capacities, not all but a small sample of the delta´s fishers could be questioned and probably not all traditional resource practices and related beliefs could be assessed. Particularly the mechanisms behind the self-organized governance system of the fisher family would be of great interest. It would be interesting to identify personal motivations as well as the social and cultural dynamics that facilitate the establishment and maintenance of such a system. The assessment of the acceptance of other fishers, to have restricted access to the family`s territory, as well as the incentives and ecological knowledge behind the development of their strategies could lead to more understanding. Beyond that, a holistic assessment of TEK-based governance systems in other urban wetlands could be used for profound theory building. Several threats in the territory of the fisher family are highly associated with urbanisation. The questions whether pressures from external perturbation

outweigh the fisher´s governance efforts in the long run, and how the system could be supported, could give important insights to research on the effectiveness of TEK-based governance of urban wetland fisheries and finally lead to the development of governance implications for already urbanised wetland fisheries under severe threats and those that are about to face these challenges associated with mega-trends such as urbanisation.

7.3 Challenges of Shared Responsibilities for Sustainable Governance of Natural Resources

The complexity of pollution and the constraints to combat the threat to the fisheries already indicated another major challenge to effective sustainable governance in the focal SES, which lies in the lack of communication and cooperation amongst the actors involved in governance. Formally the Densu delta fishery as a natural resource system is under the authority of different environmentally related governmental commissions and their sub-divisions. All interviewed key informants confirmed to have – together with the local communities and assemblies – a shared responsibility for the deltas fishery and the wetland as a whole. While the formal mandates are clearly defined on paper, the responsibilities and accountabilities for the wetland governance and conservation on the ground appears to be very fuzzy. Laws and policies from different realms such as water, wildlife conversation and protection and the fishery sector regulate the fishing and related activities. However the range of accountability and delegated power of the various governance fields is not very clear.

The Forestry Commission´s subdivision for Wildlife which is in charge of Ghana´s Ramsar Sites and therefore also of the Densu delta Ramsar site, has the mission "[t]*o ensure conservation, sustainable management and development of Ghana's wildlife resources for socio-economic benefit to all segments of society*" (WLD, 2016). Furthermore, the Water Resource Commission has the governmental *"mandate to regulate and manage the sustainable utilization of water resources and to coordinate related policies"* (WRC, 2016). And as the executive organ of the Ministry of Fisheries and Aquaculture Development, the objective of the Fisheries Commission of Ghana *"is to regulate and manage the utilization of the fishery resources of Ghana and co-ordinate the policies in relation to them"* (MOFAD 2016). Therefore *"[t]he Government of Ghana has overall responsibility for perpetuating wetland areas, and also administers a range of social, economic and environmental programmes which impact on wetland management throughout the country. However, local communities are directly responsible for the management and "wise use" of wetland resources in their localities"* (Ministry of Lands and Forestry Ghana 1999).

The governance of the fisheries touches all of the named realms, leading to an unclear situation on the ground. The results show that in-transparent accountability and authority realms as well as the lack of cooperation hinder sustainable governance of the delta´s fish resources. All key informants emphasize a lack of communication and cooperation between the commissions and the local assemblies and traditional leaders. Particularly in urban areas, where there are multiple actors and who are frequently changing this problem would be striking. The following statement of the wetland Coordinator of the WLD illustrates the problem.

> *"There are management conflicts when it comes to issues like water or fisheries. The question rises whether it is the AMA, the EPA* [Environmental Protection Agency of Ghana]*, the WLD or*

the FC, who is responsible. [...] In the urban areas it becomes so complex. I even don't know all the responsible people in the assemblies for example. The Densu is even divided in two municipalities. Most urban wetlands cut across these boundaries, therefore the management is complicated." [rep. WLD, 24.07.2015]

Murray et.al. (in Allen & Garmestani 2015) stress that a successful governance of natural resources needs lateral as well as vertical communication that crosses levels, roles and disciplines. Particularly in a complex social-ecological system *"the problem requires ongoing committed cooperation and collaboration by a range of stakeholders"*. (Fabricius & Currie in Allen & Garmestani 2015). Gunderson (in Berkes et al. 2003) further emphasizes the importance of the capacity of resource governance to adapt to changing system conditions by learning and modifying governance concepts. Changing dynamics have to be constantly monitored and evaluated in order to serve for an adjustment of strategies. If communication between all involved actors and governance structures is missing, the current governance strategies cannot be evaluated and revised, hence the system´s governance lacks of adaption to changing dynamics and sustainability is challenged.

In the case study system, these essential interactions such as information sharing (I2 in Ostroms framework), investment activities, networking, monitoring or evaluating are not happening within the top-down governance system in the focal SES or they were brought down due to the lack of communication and cooperation amongst involved actors. Adank (2011) states that *"responsibilities for different aspects of water management and planning [in Accra] are fragmented and the enforcement of existing plans is weak."* The same accounts for the coastal inland fisheries and the governance of Ramsar sites. Attempts in this direction, such as the implementation of a Ramsar site committee as platform for all representatives, were non-functional and abandoned some years ago, due to lack of attendance. According to the FC, programmes concerning the wetland are often planned independently by the different commissions, even various fields are affected. The poor existing data is kept with the institutions and no collection point or list of available studies is available.

Besides the lack in communication and cooperation, the "*unresolved relationship between rule systems with different sources of legitimacy",* states another problem, since it "*undermines both the authority of nascent local governments and the performance of customary institutions"* (Benjamin 2008). According to Benjamin (2008), this problem is associated with the decentralization process of governance of natural resources in many developing countries, where the implementation of cooperative and joint designed governance processes failed. In the focal system, chiefs and local assemblies have the responsibilities and power for overlapping realms, however their cooperation is untransparent or complicated. Even the Ramsar concept explicitly includes both systems on a cooperative basis, the translation to a functioning governance system seems to be hampered.

The loss of fishing ground and mangrove forests through heavy encroachment in the study area is one out of many examples that illustrated the paralysis of governance interventions due to parallel governance structures and the lack of communication. Even the delineation of the Ramsar site clearly defines the area designated for wetland conservation, the original size of the not settled Ramsar site halved in only about 25 years. Since the land is privately owned by local chiefs, families and companies, it remains with the land owners to decide for economic benefit by selling the land or wetland conservation, where no compensation is paid. With increasing urbanisation, the land prices in Accra have risen and consequently also the pressure on formerly unattractive land. It was reported that different chiefs (as

land owners) started to sell their land for built-ups or also waste dumping sites (e.g. in Mallam), when promised compensation for conserving it was not paid. According to the key informants, the legitimate authority to stop encroachment or even demolish houses lies by the local assemblies, where interest in wetland conservation has to combat economic benefits. The WLD staff that patrols on the site, can report law violation, but has to lobby the assemblies to enforce the law. Since the assembly members are voted by the communities, their position depends on a positive image in the communities, hence political or personal interest overweigh conservational interests for the wetland, as said by the WLD.

The issue of encroachment of urban wetlands in Ghana has been known for decades for various wetland sites (Willoughby et al. 2001; Koranteng et al. 2000; Oteng-Yeboah 1999) and even for the Densu delta Ramsar site, management plans include the topic (Oteng-Yeboah 1999; Ntiamoa-Baidu & Gordon 1991). In 1999 Oteng-Yeboah (p. 20) describes *"apparent rapid urbanisation and land encroachment spreading into the wetland [posing] great danger to the stability of the ecosystems of the wetland."* He further states that the top-down governance structures are authorized by the government *"to regulate physical development outside the core area but within the site. Consequently, the site has to be properly demarcated and zoned to provide adequate protection against pollution and degradation"*. Other authors, such as Aheto & Mensah (2011) also suggest proper zoning of the site to indicate areas prohibited for settlement in order to stop further encroachment, which was also named as solution by different key informants.

It is argued here that a renewed zoning of the area would fail the goal to stop encroachment. All over the study area, houses can be found with signs that say: *"stop construction. Produce permit!"* indicating that the houses are constructed without permission. The signs are made by the assemblies (AMA and GA South) and displayed various dates with repetitive warnings of demolition. It was reported by fishers, that people would even create those signs by themselves to avoid confrontation with officials from the assemblies. Inhabitants and the local assemblies are hence aware of unauthorized buildings in the wetland, but the restrictions are still ignored and construction is continuing all over the delta. Key informants accused the local assemblies for acting out of financial interest, since they would be paid by the inhabitants. However the key informants also admitted that it would be a structural problem, since the assemblies are responsible for their own revenue and hence would use every chance. Further the authority of the chiefs in these realms, being routed in the customary system, has to be respected and cooperation has to take place instead of mutual assignments of liability for the problem.

Considering the multiple actors, responsibility realms, parallel governance systems, dependencies and incentives of actors, the development and implementation of a successful governance inevitably has to be collaborative and constantly evaluated and revised. Communication and cooperation between the different fields is necessary to constantly update the governance system about changing dynamics concerning the Ramsar site and hence the fisheries. The actual land owners who settle in the area have to be seen in the broader context of the housing market and the complex interactions between political authorities, private land owners, companies and estate agencies. Individual, cultural and social group incentives as well as market dynamics impact on these developments. The pluralism of customary and formal systems has to be considered leading to a cooperative governance plan with clarified responsibility and duty realms. Further research should be done on the appropriate distribution of governance responsibilities and accountabilities. Further problems deriving from legal pluralism have to be tackled, resulting in a clarification of accountabilities and the development for practical implications for on the ground situations that would empower staff in the field to take actions without long bureaucratic decisions and waiting times.

7.4 Application of the SES Framework on the Fishery of the Densu Delta Ramsar Site

The SES framework by Ostrom (2007a) and McGinnis & Ostrom (2014) is a useful structure to analyse the role of the focal actor group and their TEK-based governance system in the Densu delta. The frameworks served as an appropriate checklist to avoid the oblivion of important variables in the system and it was particularly helpful in classifying obtained information. But as McGinnis & Ostrom state, a *"complete representation of dynamic linkages among concurrent action situations operating in complex SESs remains a distant goal"*. Hence the heterogeneity of the focal actor group and consequently the diversity in interactions and also in governance made some additions necessary to get a more holistic picture and foster the understanding of interactions. In order to approach this goal, the inclusion of extending criticism on the SESF from other authors, particularly from the Critical Institutionalism helped to widen up the framework with separately examining governance systems and action situation as well as second tier variables of actors for created subdivisions of the actor group.

The critical remarks by Hinkel et al. (2014) about the capacity of the framework to capture multiple interactions between different actor groups, resource systems and resource units were very helpful in the focal analyses. The relevant interactions related to the fishers mainly encompass the groups of inhabitants, land owners and actors of the top-down governance system (mainly from the WLD and WC). Even the appearance of multiple first tier components (including different actor groups) is given in the modified framework by McGinnis and Ostrom (2014), to capture the complex web of interaction between the multiple parallel appearing actors and governance systems remains challenging, since a further differentiation in subgroups was identified as necessary, but not scheduled in the framework. Also a deeper analysis of the complex interconnectivities between the actor groups within and between subdivisions of one group appears to be difficult.

This differentiation is important due to the heterogeneity of actors within one group that are characterized by multiple interactions on a lower tier level. The fishers for example differ extremely in knowledge, social, as well as in cultural backgrounds and hence in their behaviour. This is especially seen in the different interactions and outcomes of the TEK-based governance systems in use. Even the majority of the fishers does not adhere to various traditional regulations, there are still small groups and individuals found that do so in a remarkable successful way and even advise others to do so. McGinnis & Ostrom state that *"[d]ifferent sets of actors may be engaged in extracting or producing different types of resource units drawn from one or more resource systems, and their activities may be guided by rules drawn from overlapping governance systems."* Here the framework was enhanced by creating the identified focal actor group subdivisions of the fisher family, the young fisher groups and others fishing outside the fishing territory of the fisher, recognizing the existence of heterogeneous individuals and subgroups within one actor group.

McGinnis& Ostrom (2014) understand actors in the SESF as collective entities, and subscribe the actions of individuals in most cases to be actions on behalf of the entity. Here it is argued, that the entity of the focal actor group is too diversified in their members in order to confirm this assumption. The individuals can be engaged in different social and actor groups, to have a lot of different levels of knowledge about the ecosystem and pressing stressors, to show different reactions and adaptation strategies to changes, have sense of responsibility for the resource system and interact in different ways

with other actors and to be affiliated to governance systems in different ways. Hollup (2000) reports about the reproduced stereotypes about Creole fishers that describe them as poor, uncooperative and disrespectful with fish stocks. The reproduction of this narrative, which exists for many small-scale fishery systems influences governance cooperation (Cinner et al. 2013). The findings of Hollup (2000) that the fishers are much more diversified than these narratives report also matches for the focal system.

The stereotype of the poor uneducated small-scale fishers particularly in urban poor neighbourhoods in developing countries is persistent in the narrative on fisheries, even various authors proved different (Hollup 2000; Cinner et al. 2013). While the narrative could be possibly drawn for a large group of the fishers in the Densu delta, the diversity of the group supports the findings of the latter authors. Several fishers in the focal system fluently speak English, some were teachers before and others have profound ecological knowledge, hence their level of education is not low as described in many reports about fishers. As shown by Hollup (2000), the fishers in Mauritius were a huge part of fishers saving parts of their incomes for times of bad catches, also in the Densu delta this can be found. The fisher family for example saves parts of their money for the off season each year and two other fishers reported that they had switched to agriculture due to decreasing catches and bought land from their savings.

Defining the fishers as actors that are characterized by group specific variables, bears the danger to oversee the reasons for individual behaviour and the potential for the whole group. The focus lies then on the activities of the majority, as it happens in the Densu delta. The fishers are consequently described as burden to the system, due to overfishing, the use of illegal fishing methods and the degradation of mangroves. They predominantly do not adhere to traditional resource practices that have great potential for sustainable development. The fact that individuals and small groups do adhere to traditional regulations is largely not known by the key informants, hence the narrative is the breakdown of TEK-based governance systems and cooperation potential is not seen. The identifications of different subgroups within the focal actor group could give essential implications for sustainable development approaches. The subgroups that are cooperative and show efforts to foster sustainability in the fisheries can function as first entry points for cooperation and function as facilitator between top-down governance and the resource users. Further their knowledge could be assessed and experiences used for a cooperative development of sustainable strategies.

Concerning this findings, the link to the critical remarks on the SESF by Cleaver & Koning (2015) fostered the analysis. If the fishers are seen as a group of individuals or subgroups the personal incentives and motivations to act and to react, as well as to form institutions and arrangements is emphasized. According to Cleaver & Koning (2015), the Critical Institutionalism sees this as a weakness of the SESF and state that behaviour of actors should be seen more differentiated and not necessarily exclusively related to rational thinking . *"People's motivations to cooperate in collective arrangements are a mix of economic, emotional, moral and social rationalities informed by differing logics and world-views"* (Cleaver & Koning 2015. p. 4). The authors further argue that the incentives are not necessarily based on beneficiary reasons. Personal backgrounds of people, such as family bounds or ethnicity, exposure to stressors of their particular fishing territory or individual experiences in cooperation or conflicts with other actor groups have great influence on individual behaviour and consequently on the individual and consequently also on the group behaviour.

Shifting the attention from actor groups to governance structures, the formation of institutions within the system and especially the role of individuals in these systems, further critics from sides of the CI are

assisting to approach more holistic understanding of processes in the focal SES. "*From a CI perspective, actors do indeed strategize, innovate and negotiate in their engagement with institutions and management of natural resources. However, the particular ways they do so are shaped by their multi-layered social identities, changing contexts and the web of relationships within which they live their lives* (Schnegg & Linke in Cleaver & Koning 2015. p. 8). This statement emphasizes the importance of individual incentives as shown for the actor groups also within the governance structures. "*Understanding people's actions and the ways these affect institutions goes further than merely tracking practices and social relationships – there is a need to uncover meanings, world views, forms of legitimisation and authority – all aspects which may or may not be visible in public decision making contexts* (Cleaver & Koning 2015. p.9).

The understanding of several examples in the case study analysis was improved with these complementary critics. The top-down governance structures as well as other actors groups showed these examples of individuals that act due to personal past experiences that are not necessarily linked to the established governance structure or common behaviour. So the Densu delta staff for example avoids certain places in the delta due to negative past experiences, whether he has personal friends in other regions of the delta or not, hence patrols them more often. Law violations or other dynamics in the delta are consequently homogenously recorded due to personal experiences and social bounds. Another example is identified in the attempt to integrate the Densu delta fishers in the annual farmer day that is generally in Ghana, only applied to the marine fisheries. These efforts are attributable to the personal engagement of the former zonal FC officer for Ga South without backing of their office. She engaged fishers and reported positive reactions, however with her resignation of the post, the programme ended. Finally the case of a real estate agent of one local chief in Mallam shows that also the advance of encroachment is highly influenced by personal decisions. The former agent sold land of the chief reaching far into the wetland area, until he decided to stop at a certain point. He told the chief there would be no more land to sell. The chief consequently looked for another estate agent and sold land deeper inside the wetland.

The cases demonstrated here may not explain the incentives behind the behaviour of each actor or the different actors as groups and the dynamics of institution development, they rather serve to emphasize the importance of considering individual factors when analysing a complex SES. These individual incentives and at times complex social and cultural mechanisms behind certain actions that are essential for the understanding of changing dynamics or the persistence to encouraged changes in a SES. To fully understand the interactions and the incentives behind the fisher´s behaviour, a lot more research is needed and a bigger sample of respondents has to be taken. Particularly, the local historical contexts of individual fishers, TEK-based governance, local institutions and cooperation amongst the different governance systems and actors would be of great interest. The knowledge about past experiences can help to understand today's interactions and drivers behind them.

In conclusion, the discussion has shown that the SESF was very helpful to identify components, variables and action situations of the focal SES and put them into relation to each other and into the larger setting of changing social-ecological dynamics. It also enables the researcher to classify obtained knowledge which is very important when dealing with a huge and complex interlinked set of information. Further it facilitates follow-up studies to compare findings and to create new theories in the long run. Nevertheless, it is not sufficient to holistically assess the complex dynamics between actors such as the fishers and other system components. With the additional critics of the Critical Institutionalism, emphasizing the importance of individual incentives however, the depths of analyses can be greatly enhanced when focusing on individuals, actor groups, governance systems and their interrelations.

8 Conclusion

The basic assumption that can be drawn from the results of this thesis is that individuals and small subgroups of the focal actor group (as well as of other actor groups) can pay a huge role in the urban Densu delta fisheries and its governance. However, the dynamics of change on local to global scale that are altering the focal SES might outweigh any sustainability effort of these small groups in the long run. Since the global trend of heavily increasing urbanisation is also projected for the coastal zone of West Africa (UN-Habitat 2014). Beyond that, the global growth of human population and the range and rate that we alter global ecosystems will probably exacerbate situations and abrupt environmental changes can no longer be excluded (Rockström et al. 2009). As it was shown here, SES are interlinked with systems on lower as well as on higher level, hence if thresholds are reached in smaller or larger systems the changes can trigger the trespassing of certain thresholds in one system can cascade up or downscale and provoke drastic changes on different level through non-linear feedbacks (Espinosa & Walker 2011).

Drawn from the literary review and confirmed by the results of the empirical work, the situation of urban wetlands in Ghana can be summarized as even more urgent as assumed before this work. Multiple external and internal threats to the focal SES were identified by scientists decades ago (Willoughby et al. 2001; Koranteng et al. 2000) and are part of governance plans of different governmental commissions for a long time (see Ntiamoa-Baidu & Gordon 1991), however they are aggravating due to vast urbanisation processes in and around the study area and have notable negative impact on the delta´s fishery and the SES as a whole. The most polluted area of the delta, south of Mallam market was identified as such already by Ntiamoa-Baidu & Gordon in 1991, still the nearby dumping site is not under control. Likewise the overexploitation, siltation, biodiversity loss and mangrove degradation of the delta that were observed have been known for more than 20 years (see Oteng-Yeboah 1999). Even the fisheries still seem to be adaptive to the perturbation threats, but thresholds that shift the whole system to a probably undesirable state for humans and other organisms could be reached in the near future.

Top-down governance showed an overall resignation or disinterest in Ghana´s small-scale inland fisheries that is also stated by Nunoo & Asiedu (2013). There is not only a lack of up-to-date data on the Densu delta fishery, but there is a general lack of holistic data on Ghana´s wetland fishery facing dynamics of change. The claim, Ghana´s fishery would not be well understood and underestimated (Akyeampong 2007) also applies for the focal fishery system. Even governance implications from divers studies highlight the need to foster TEK-based systems in the fisheries (Dankwa et al. 2004; Ntiamoa-Baidu & Gordon 1991; Baffour-awuah 2014a), these systems lack of understanding. The effectiveness of these practices is emphasized (see Entsua-Mensah et al. 2000) as well as the need of cooperation with fishers (Darkwa & Smardon 2010; Ramsar Convention 2016), but practical implications for on the ground proceeding are rare or fail in their implementation. In the Densu delta, neither the TEK-based governance system is known, nor is cooperation and regular communication between actors of the two governance systems fostered.

Nevertheless, it has to be considered that the identification of responsibilities for this lack of data, lack of interest and lack of sustainable governance implementation is very challenging, if not barely possible. The complexity of interactions of the components of the Densu delta fishery challenges not only the attempt to define accountability realms but further is the main constraint to sustainable development in the delta. Behind each identified threat to the system, a complex web of interactions on different scales and an enormous number of involved actors with various incentives unfolds. Parallel legal systems of customary authorities and local governments complicate the situation. Local pollution is

connected with the waste management of the whole of Accra and flooding is not only related to climate change, but also to water engineering and city planning. Encroachment of built-ups in return is not only interacting with political decisions, power and economic benefits, but further with traditional land tenure systems, questions of poverty and estate markets. Hence the accusation and the difficulty in allocating accountability realms for the Densu delta governance that were observed, are challenging to solve. The problem of non-existent cooperation and communication is probably the most striking constraint that hampers the basic need to foster sustainable governance, such as a holistic assessment of the actual state and the identification of all involved actors.

The fact that the system seems to be under the described threats for decades has to be further considered. All the stressors have been identified for about 20 years and are increasing ever since. However the fisheries system still remains more or less functioning which indicates a high capacity of adaptation to disturbance and the resilience of the SES (Walker et al. 2004). Even the fish production is reported to be decreasing for decades and the observed fish sizes are considerably small (except in the fisher family´s territory), there are still multiple resource users living from and within the SES of the focal area. They adapt to increasing pressure by moving their lodges and replacing their gears when floods are coming. To the destruction of their hunting territory they react by moving to more distant places. They develop natural defence constructions from thorn brushes to protect their fish traps against theft and guard or patrol fishing grounds with dogs to restrict access and fight environmental degradation. However the question arises how long the system will remain in this "stable" state and when a threshold (see Scheffer et al. 2001) will be reached leading to a total collapse of the fisheries and the well-functioning of the ecological part of the system.

The example of the fisher family shows that there are still fishers in urban wetlands that preserve largely respected traditional approaches of fishery governance, due to intergenerational knowledge transmission and family cohesion. Even they are not bound to the place and the resource system on a basis of ethnicity or traditional community structures, they govern the resources in a traditional and sustainable way. The fisheries still determine the living rhythm and livelihoods of their families. The collapse of the ecological system most likely would also lead to the collapse of this strongly related social system through multiple interactions. Considering the location of their territory in the most polluted and highly encroached area of the delta, the threshold could be very close.

As stated in chapter 3, Ghana has about a hundred lagoons (Gordon 2006), of which only five are formally governed according to the Ramsar concept (Willoughby et al. 2001) and of which particularly the urban wetlands are under increasing threats. Most likely each coastal wetland system in Ghana still inhabits TEK based governance systems and consequently has unassessed knowledge with large potential for sustainable governance strategies. The analyses of small-scale fishery systems of the Densu delta SES can be used for the accumulation of knowledge on SES and their complex dynamics. The complexity of threats, the capacity of the system and its subsystems to adapt to changes, the strategies that the different actors use and the outcomes of their interactions can be used for comparison with other systems (see Ostrom 2007a) and help in the urgent need to develop strategies towards sustainable governance in small-scale fisheries and even more striking to implications for their implementation on the ground (Kittinger et al. 2013; Jentoft & Chuenpagdee 2015). The developed strategies could enhance resilience and the capacity to adapt to changes that will arise through increasing urbanisation and therefore help to sustain the functioning of the SES that provides the base of livelihood and nutrition for thousands of people in Ghana, the habitat of multiple organisms and is part of the divers' cultural heritage of the country.

9 LITERATURE

Adank M, Darteh B, Moriarty P, Osei-Tutu H, Assan D, van Rooijen D (2011) Towards integrated urban water management in the Greater Accra Metropolitan Area. Current status and strategic directions for the future. SWITCH/Resource Centre Network Ghana, Accra

Addo C, Mensah A, Takyi R (2014) The fisheries and primary productivity of the Keta Lagoon, 6, pp.15–27.

Addo K (2013). Assessing Coastal Vulnerability Index to Climate Change: the Case of Accra–Ghana. *Journal of Coastal Research*, (65), pp.1892–1897.

Addo K, Adeyemi M, (2013) Assessing the impact of sea-level rise on a vulnerable coastal community in Accra, Ghana, pp.1–8.

Adger WN (2006) Vulnerability. *Global Environmental Change*, 16(3), pp.268–281.

Afful S, Anim A, Serfor-Armah Y (2010) Spectrum of organochlorine pesticide residues in fish samples from the Densu Basin. *Research Journal of Environmental and Earth Sciences*, 2(3), pp.133–138.

Agrawal A (2014) Studying the commons, governing common-pool resource outcomes: Some concluding thoughts. *Environmental Science and Policy*, 36, pp.86–91.

Aheto D, Mensah, E (2011) Spatio-temporal analysis of two coastal wetland systems in Ghana: Addressing ecosystem vulnerability and implications for fisheries development in the context of climate. *Archives of Applied Science Research*, 3(3), pp.499–513.

Ahulu AM, Nunoo FKE, Owusu EH (2006) Food Preferences of the Common Tern, Sterna hirundo (Linnaeus, 1758) at the Densu Floodplains, Accra. *West Africa Journal of Applied Ecology*, 9, pp.1–7.

Akyeampong E (2007) Indigenous Knowledge and Maritime Fishing in West Africa : The Case of Ghana. In E. K. Boon & L. Hens, eds. *Indigenous Knowledge Systems and Sustainable Development: Relevance for Africa*, pp. 173–182.

Allen CR, Garmestani AS (2015) *Adaptive Management of Social-Ecological Systems*, Dordrecht Heidelberg New York London: Springer.

ATFALCO (2012) *Fishery and aquaculture industry in Ghana*, The Ministerial Conference on Fisheries Cooperation among African States States Bordering the Atlantic Ocean (ATFALCO).

Atta-Mills J, Alder J, Rashid U (2004) The decline of a regional fishing nation: The case of Ghana and West Africa. *Natural Resources Forum*, 28, pp.13–21.

Baffour-Awuah E (2014a) Health Implications of Polluted Tilapia Consumption – The Perception of Fosu Lagoon Fishermen in Cape Coast , Ghana, 4(10), pp.78–87.

Baffour-Awuah E (2014b) Perceptive Views of Fishermen on Sustainability of Fishing in the Fosu lagoon in Cape Coast , Ghana, 5(10), pp.94–104.

Bailey PB. Accounting for effort when comparing tropical fisheries in lakes, river-floodplains and lagoons. Limnol Oceanogr 1988;33:963–972.cited in Pauly, D., Yañez-Arancibia, A., 1994. Fisheries in coastal lagoons. Elsevier oceanography series (60). In: Kjerfve, B. (Ed.), Coastal Lagoons Processes. Elsevier, Amsterdam, pp. 377–396.

Basurto X (2005) How Locally Designed Access and Use Controls Can Prevent the Tragedy of the Commons in a Mexican Small-Scale Fishing Community. *Society & Natural Resources*, 18(7), pp.643–659

Basurto X, Gelcich S, Ostrom E (2013) The social-ecological system framework as a knowledge

classificatory system for benthic small-scale fisheries. *Global Environmental Change*, 23(6), pp.1366–1380.

Basurto X, Ostrom E (2009) Beyond the Tragedy of the Commons. *Economia delle fonti di energia e dell'ambiente*, pp.35–60.

Becker E (2012) Social-Ecological Systems as Epistemic Objects. *Human-Nature Interactions in the Anthropocene: Potential of Social-Ecological Systems Analysis*, (Folke 2006), p.232.

Béné C, Belal E, Baba MO, Ovie S, Raji A, Malasha I, Njaya F, Na Andi M, Russell A, Neiland A (2009) Power Struggle, Dispute and Alliance Over Local Resources: Analyzing "Democratic" Decentralization of Natural Resources through the Lenses of Africa Inland Fisheries. *World Development*, 37(12), pp.1935–1950.

Benjamin CE (2008) Legal Pluralism and Decentralization: Natural Resource Management in Mali. *World Development*, 36(11), pp.2255–2276.

Berkes F, Folke C (eds) (1998) Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge, UK: Cambridge Univ. Press.

Berkes F, Colding J, Folke C (2003) *Navigating Social-Ecological Systems. Building Resilience for Complexity and Change* Berkes F, Colding J, Folke C eds., Cambridge: Cambridge University Press.

Berkes F, Colding J, Folke C (2000) Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Adaptations*, 10(October), pp.1251–1262.

Berkes F, Seixas CS (2005) Building resilience in lagoon social-ecological systems: A local-level perspective. *Ecosystems*, 8(September 2003), pp.967–974.

Biermann F, Betsill MM, Gupta J, Kanie N, Lebel L, Liverman D, Schroeder H, Siebenh€uner B, Conca K, da Costa Ferreira L, Desai B, Tay S, Zondervan R (2009). Earth system governance: people, places and the planet. Science and implementation plan of the Earth system governance project. ESG Report No. 1. The Earth system governance project, Bonn, IHDP

Binder CR, Hinkel J, Bots PWG, Pahl-Wostl C (2013) Comparison of Frameworks for Analyzing Social-ecological Systems. *Ecology and Society*, 18(4).

Bruns A, Frick F (2013) Coastal Cities at Multiple Risks – The Case of Accra. , pp.59–76.

Cinner JE, MacNeil MA, Basurto X, Gelcich S (2013) Looking beyond the fisheries crisis: Cumulative learning from small-scale fisheries through diagnostic approaches. *Global Environmental Change*, 23(6), pp.1359–1365.

Cleaver FD, Koning J de (2015) Furthering critical institutionalism. *International Journal of the Commons*, 9(1), pp.1–18.

Codjoe SNA, Issah AD (2015) Cultural dimension and adaptation to floods in a coastal settlement and a savannah community in Ghana. *GeoJournal*.

Cumming GS (2011) Conceptual Background on Social-Ecological Systems and Resilience. In *Spatial Resilience in Social-Ecological Systems*. Springer Netherlands.

Cumming GS (2011) *Spatial Resilience in Social-Ecological Systems*, Dordrecht Heidelberg New York London: Springer.

Dankwa HR, Shenker JM, Lin J, Ofori-Danson PK, Ntiamoa-Baidu Y (2004) Fisheries of two tropical lagoons in Ghana, West Africa. *Fisheries Management and Ecology*, 11, pp.379–386.

Darko HF, Ansa-asare O, Paintsil A (2013) A Number Description of Ghanaian Water Quality — A Case Study of the Southwestern and Coastal Rivers Systems of Ghana. *Journal of Environmental Protection*, 4, pp.1318–1327.

Darkwa S, Smardon R (2010) Ecosystem Restoration : Evaluating Local Knowledge and Fishermen in Fosu Lagoon, *Environmental Practice*, 12 (3)(September), pp.202–213.

Darwall WRT, Smith KG, Allen DJ, Holland RA, Harrison IJ, Brooks EGE (eds) (2011) The Diversity of Life in African Freshwaters: Under Water, Under Threat. An analysis of the status and distribution of freshwater species throughout mainland Africa. Cambridge, United Kingdom and Gland, Switzerland: IUCN.

Denis E, Moriconi-Ebrard F (2009) Africapolis - ATLAS. Urbanisation Trends 1950–2020: A Geo-Statistical Approach – West Africa. Paris p.123.

Diop S, Barusseau JP, Descamps C (eds.) (2014) *The Land/Ocean Interactions in the Coastal Zone of West and Central Africa*, Series: Estuaries of the World, Springer International Publishing Switzerland

Directorate of Fisheries Ministry of Food and Agriculture, Ghana (2004) Information on Fisheries in Ghana.

Entsua-Mensah M, Ofori-Danson PK, Koranteng K (2000) Management Issues for the Sustainable Use of Lagoon Fish Resources. In T. M. F. and R. S. . P. E.K. Abban, C.M.V. Casal, ed. *Biodiversity and sustainalbe use of fish in the coastal zone*. ICLARM Conf. Proc. 63, pp. 24–27.

Epstein G, Vogt JM, Mincey SK, Cox M, Fischer B (2013) Missing ecology: integrating ecological perspectives with the social-ecological system framework. *International Journal of the Commons*, 7(2), pp.432–453.

Espinosa A, Walker J (2011) *Series on Complexity Science. A complexity approach to sustainability. Theory and Application* Vol. 1, London: Imperial College Press.

Flick U, Kardorff E von, Keupp H, Rosenstiel L von, Wolff S (2007) Handbuch Qualitative Sozialforschung Eine Einführung. Rohwolts Verlag. Hamburg

Flick U (2014) Challenges for Qualitative Inquiry as a Global Endeavor: Introduction to the Special Issue. *Qualitative Inquiry*, 20, pp.1059–1063.

Folke C, Carpenter S, Walker B, Scheffer M, Elmqvist T, Gunderson L, Holling CS (2004) Regime Shift, Resilience, and Biodiversity in Ecosystem Management. *Annual Review of Ecology, Evolution, and Systematics*, 35(1), pp.557–581.

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

Frimpong A (2014) Perennial Floods in the Accra Metropolis : Dissecting the Causes and Possible Solutions. , 6(1).

GADM Global administrative Areas. Access 13.05.2016 [http://diva-gis.org/gdata]

Gbogbo F (2007) The importance of unmanaged coastal wetlands to waterbirds at coastal Ghana. *African Journal of Ecology*, 45, pp.599–606.

Glaser M, Krauser G, Ratter B, Welp M (2008) Human-nature interaction in the Anthropocene: Potential of social-ecological systems. GAIA 1/08: 77-80.

Glaser M (2006) The social dimension in ecosystem management: Strengths and weakness of human-nature mind maps. *Human Ecology Review*, 13(2), pp.122–142.

Gómez-Baggethun E, Reyes-garcía V (2013) Traditional Ecological Knowledge and Global Environmental Change: Research findings and policy implications. *Ecology and Society*, 18(4), p.art72.

Gordon PC (2006.) Dams and Development Ghana. *Background Paper for The Multi-stakeholder consultation process for dams development in Ghana*

Grove JM (2009) 13 Cities: Managing Densly Settled Social-Ecological Systems. In F. S. Chapin, G. P.

Kofinas, & C. Folke, eds. *Principles of Ecosystem Stewardship. Resilience-Based Natural Resource Management in a Changing World*. Springer, pp. 280–294.

GSS Ghana Statistical Services (2002) 2000 population and housing census; summary report of final results. Ghana Statistical Service, Accra, Ghana. In **Adank** M, Darteh B, Moriarty P, Osei-Tutu H, Assan D, van Rooijen D (2011) Towards integrated urban water management in the Greater Accra Metropolitan Area. Current status and strategic directions for the future. SWITCH/Resource Centre Network Ghana, Accra

Gunderson L, Holling CS (2002) *Panarchy. Understanding Transformations in Human and Natural Systems*, Washingtin, DC: Island Press.

Gunderson, L. H. (2003) Adaptive dancing: Interactions between social resilience and ecological crises. In: Berkes F, Colding J, Folke C (2003) *Navigating Social-Ecological Systems. Building Resilience for Complexity and Change* Berkes F, Colding J, Folke C eds., Cambridge: Cambridge University Press.

Gyekye AK (2011) Geomorphic Assessment of Floods within the Urban Environment of Gbawe-Mallam, Accra. *Ghana Journal of Geography*, 3, pp.199–229.

Gyekye AK (2013) Environmental change and flooding in Accra, Ghana. *Sacha Journal of Environmental Studies*, 3(1), pp.65–80.

Halliday A, Glaser M (2011) A Management Perspective on Social Ecological Systems: A generic system model and its application to a case study from Peru. *Human Ecology Review*, 18(1), pp.1–18.

Hartter J, Ryan SJ (2010) Top-down or bottom-up?. Decentralization, natural resource management, and usufruct rights in the forests and wetlands of western Uganda. *Land Use Policy*, 27(3), pp.815–826.

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

Hinkel J, Cox ME, Schlüter M, Binder CR, Falk T (2015) A diagnostic procedure for applying the social-ecological systems framework in diverse cases. *Ecology and Society*, 20(1).

Hinkel J, Bots P, Schlüter M (2014) Enhancing the Ostrom social-ecological systems framework through formalization. *Ecology and Society*, 19(3).

Holling CS (2001) Understanding the Complexity of Economic, Ecological, and Social Systems. *Ecosystems*, 4(5), pp.390–405.

Hollup O (2000) Structural and sociocultural constraints for user-group participation in fisheries management in Mauritius. *Marine Policy*, 24(5), pp.407–421.

Islam MS, Tanaka M (2004) Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: A review and synthesis. *Marine Pollution Bulletin*, 48(7-8), pp.624–649.

Jennerjahn TC, Mitchell SB (2013) Pressures, stresses, shocks and trends in estuarine ecosystems - An introduction and synthesis. *Estuarine, Coastal and Shelf Science*, 130, pp.1–8.

Jentoft S, Chuenpagdee R (eds) (2015) *Interactive Governance for Small-Scale Fisheries.* Global Reflections. Series: MARE Publication Series, Vol. 1

Jost C, Ferdous N, Spicer TD (2014) Gender and Inclusion Toolbox: Participatory Research in Climate Change and Agriculture. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), CARE International and the World Agroforestry Centre (ICRAF). Copenhagen, Denmark.

Kittinger JN, Finkbeiner EM, Ban NC, Broad K, Carr MH, Cinner JE (2013) Emerging frontiers in social-ecological systems research for sustainability of small-scale fisheries. *Current Opinion in*

Environmental Sustainability, 5(3-4), pp.352–357.

Koranteng KA, Ofori-Danson OK, Entsua-Mensah M (2000) Fish and fisheries of the Muni lagoon in Ghana, West Africa. *Biodiversity and Conservation*, 9(4), pp.487–499.

Kusimi J (2008) Stream processes and dynamics in the morphology of the Densu River channel in Ghana. *Int Arch Photogr*, pp.1177–1182.

Lawson R, Robinson M (1983) Artisanal fisheries in West Africa. Problems of management implementation. *Marine Policy*, pp.279–290.

Lee SY, Dunn RJK, Young RA, Connolly RM, Dale PER, Dehayr R, Lemckert CJ, Mckinnon S, Powell B, Teasdale PR, Welsh DT, (2006) Impact of urbanization on coastal wetland structure and function, Austral Ecology 31, pp.149–163.

LePage BA (2011) *WETLANDS. Integrating Multidisciplinary Concept* B. LePage, ed., Dordrecht Heidelberg London New York: Springer.

Low B, Ostrom E, Simon C, Wilson J (2002) Redundancy and diversity: do they influence optimal management? In: Berkes F, Colding J, Folke C (2003)*Navigating Social-Ecological Systems: Building Resilience for Complexity and Change*, Cambridge: Cambridge University Press. pp.83–108.

Marquette CM, Koranteng KW, Overa R, Aryeetey EBD (2002) Small-scale fisheries, population dynamics, and resource use in Africa: the case of Moree, Ghana. *Ambio* A Journal of the Human Environment, Royal Swedish Academy of Sciences, 31(4), pp.324–336.

McGinnis MD (2015) Updated Guide to IAD and the Language of the Ostrom Workshop : A Simplified Overview of a Complex Framework for the Analysis of Institutions and their Development , pp.1–36.

McGinnis MD, Ostrom E (2014) Social-ecological system framework: Initial changes and continuing challenges. *Ecology and Society*, 19(2), p.30.

Mens MJP, Klijn F, de Bruijn KM, van Beek E (2011) The meaning of system robustness for flood risk management. *Environmental Science and Policy*, 14(8), pp.1121–1131.

Mensah M, Koranteng K, Bortey A, Yeboah D (2006) *The State of World Fisheries from a Fishworker Perspective : The Ghanaian Situation* K. KG, ed., Sri Venkatesa Printing House, Chennai: International Collective in Support of Fishworkers.

Ministry of Lands and Forestry Ghana (1999) Republic of Ghana Managing Ghana´s Wetlands: A National Wetlands Conservation Stretegy

MOFAD Ministry of Fisheries and Aquaculture Development. *Mofad.gov.gh*. Access 16. 05. 2016 [http://www.mofad.gov.gh/?q=the-fisheries-commission]

Monney I, Boakye R, Buamah R, Oppong F, Anyemedu K, Odai SN, Awuah E (2013) Urbanization and pollution of surface water resources in the two largest cities in Ghana, 1(6), pp.279–287.

Niang I, Ruppel OC, Abdrabo MA, Essel A, Lennard C, Padgham J and Urquhart P (2014) Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TJ, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265Nixon, S.W. et al., 2007. Anthropogenic enrichment and nutrients in some tropical lagoons of Ghana, West Africa. *Ecological Applications*, 17(5), pp.S144–S164.

Norberg J, Cumming GS (eds.) (2008) Complexity theory for a sustainable future. New York: Columbia University Press.

Ntiamoa-Baidu Y (1991) Conservation of coastal lagoons in Ghana: the traditional approach. *Landscape and Urban Planning*, 20, pp.41–46.

Ntiamoa-Baidu Y, Gordon C (1991) Coastal Wetlands Management Plans: Ghana, pp.1–140.

Nunoo FKE, Asiedu B (2013) An Investigation of Fish Catch Data and Its Implications for Management of Small-scale Fisheries of Ghana. , 2(3), pp.46–57.

Nyarko, B.K., 2002. APPLICATION OF A RATIONAL MODEL IN GIS FOR FLOOD RISK ASSESSMENT IN Accra, Ghana. *Journal of Spatial Hydrology*, 2(1), pp.1–14.

Odum HT (1994) Ecological and General Systems: An Introduction to Systems Ecology (rev. ed.). University Press of Colorado, Niwot. 644 pp.

Okyere I, Aheto DW, Aggrey-fynn J (2011) Comparative ecological assessment of biodiversity of fish communities in three coastal wetland systems in Ghana. , 1(2), pp.178–188.

Olsson P (2003) *Building capacity for resilience in social-ecological systems*,

Osei J (2010) Application of Multivariate Analysis for Identification of Pollution Sources in the Densu Delta Wetland in the Vicinity of a Landfill Site in Ghana. *Journal of Water Resource and Protection*, 02(December), pp.1020–1029.

Ostrom E (2007a) A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Sciences of the United States of America*, 104(39), pp.15181–7.

Ostrom E (2009) A General Framework for Analyzing Sustainability of Social-Ecological Systems. *Science*, 325(5939), pp.419–422.

Ostrom E (2007b) Sustainable social-ecological systems: an impossibility. *Presented at the 2007 Annual Meetings of the American Association for the Advancement of Science, "Science and Technology for Sustainable Well-Being,"*, 15–19 Febr, pp.1–28.

Ostrom E, Janssen MA, Anderies JM (2007) Going beyond panaceas. , 104(39), pp.15176–15178.

Oteng-Yeboah AA (1999) Ghana Coastal Wetland Management Project. Development of a Management Plan for the Densu Delta Ramsar Site. *For the Wildlife Division of Forestry Commission Ministry of Lands and Forestry*, Ghana.

Palma C, Pallares P, Ortiz M, Kell L (2012) Review of the Available Ghana Statistics on Tropical Fisheries. , 68(3), pp.1180–1193.

Partelow S (2015a) Coevolving Ostroms social-ecological systems (SES) framework and sustainability science: four key co-benefits. *Sustainability Science*, (April), pp.1–12.

Partelow S (2015b) Key steps for operationalizing social–ecological system framework research in small-scale fisheries: A heuristic conceptual approach. *Marine Policy*, 51, pp.507–511.

Paschen JA, Ison R (2014) Narrative research in climate change adaptation-Exploring a complementary paradigm for research and governance. *Research Policy*, 43(6), pp.1083–1092.

Ramsar Convention (2016) The 4th Strategic Plan 2016 – 2024 The Convention on Wetlands of International Importance especially as Waterfowl Habitat – the " Ramsar Convention ." , (June 2015), pp.1–9. [http://www.ramsar.org/sites/default/files/documents/library/4th_strategic_plan_2016_2024_e.pdf]

Ramsar Convention Secretariat (2007) *Wise use of wetlands: A Conceptual Framework for the wise use of wetlands* 3rd ed., Gland, Switzerland: Ramsar Convention Secretariat [http://www.ramsar.org/sites/default/files/documents/library/hbk4-01.pdf]

Ramsar Information Sheet (2015) Ramsar Information Sheet Ghana Densu Delta Ramsar Site, (564), pp.1–25. [https://rsis.ramsar.org/RISapp/files/RISrep/GH564RIS_1508_en.pdf]

Ramsar Regulations Ghana (1999) Wetland Management (Ramsar Site) Regulations 1999 [http://faolex.fao.org/docs/pdf/gha101175.pdf]

Rockström J, Steffen W, Noone K, Persson A, Chapin FS III, Lambin E, Lenton TM, Scheffer M, Folke C, Schellnhuber H, Nykvist B, De Wit CA, Hughes T, van der Leeuw S, Rodhe H, Sörlin, Snyder SK, Costanza R, Svedin U, Falkenmark M, Karlberg L, Corell RW, Fabry VJ, Hansen J, Walker B, Liverman D, Richardson K, Crutzen P, Foley J(2009) Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society 14(2): 32.

Scheffer M, Carpenter S, Foley JA, Folke C, Walker B (2001) Catastrophic shifts in ecosystems. *Nature*, 413, pp.591–596.

Schlüter M, Hinkel J, Bots PWG, Arlinghaus R (2014) Application of the SES framework for model-based analysis of the dynamics of social-ecological systems. *Ecology and Society*, 19(1), p.36.

Schnegg, M. and T. Linke. 2015. Living Institutions: Sharing and Sanctioning Among Pastoralists in Namibia. World Development 68:205–2014. In: Cleaver FD, Koning J de (2015) Furthering critical institutionalism. *International Journal of the Commons*, 9(1), pp.1–18.

Sengupta A (ed.) (2006) Chaos, Nonlinearity, Complexity. The Dynamical Paradigm of Nature. Springer Verlag Berlin Heidelberg

Smit B, Wandel J (2006) Adaptation, adaptive capacity and vulnerability. *Global Environmental Change*, 16(3), pp.282–292.

Smith KG, Diop MD, Niane M, Darwall WRT (Compilers) (2009) The Status and Distribution of Freshwater Biodiversity in Western Africa Gland, Switzerland and Cambridge, UK : IUCN.

Songsore J (2009) The Urban Transition in Ghana: Urbanization, National Development and Poverty Reduction. *Africa*, p.26.

Tanner T, Mensah A, Lawson ET, Gordon C, Godfrey-Wood R, Cannon T (2014) *Political Economy of Climate Compatible Development: Artisanal Fisheries and Climate Change in Ghana*.

UN-Habitat, U.N.H.S.P. (2014) *The state of African cities 2014. Re-imagining sustainable urban transition*, Nairobi, Kenya.

Vitousek PM (1997) Human Domination of Earth's Ecosystems. *Science*, 277(5325), pp.494–499.

Vörösmarty CJ , Douglas EM, Green PA, Revenga C (2005) Geospatial indicators of emerging water stress: an application to Africa. *Ambio*, 34(3), pp.230–236.

Walker B, Holling CS, Carpenter SR, Kinzig A (2004) Resilience , Adaptability and Transformability in Social – ecological Systems. *Ecology and Society*, 9(2), p.5.

WARFP (2010) *Republic of Ghana Fisheries and Aquaculture Sector Development Plan, 2010-2015*,

Welcomme R (2011) *Review of the State of the World Fishery Resources : Inland Fisheries*, FAO Fish Aquac Circular 942(2):97 pp. Rome, FAO

Water Diplomacy (2014): „Framework Perspectives for Water: a small sample of the range of frameworks for addressing questions about water - Water Diplomacy Network Blog". *Water Diplomacy Network Blog*. Access 12.03.2016 [http://blog.waterdiplomacy.org/2014/01/framework-perspectives-for-water]

Westley F, Carpenter RS, Brock WA, Holling CS, Gunderson LH (2002) Chapter 4. Why Systems of People and Nature are not just Social and ecological Systems. In: Gunderson L, Holling CS (2002) *Panarchy. Understanding Transformations in Human and Natural Systems*, Washingtin, DC: Island Press.

Wetlands-International (1998) *Ramsar Wetlands Information Sheet*. Ghana.

Willoughby N, Grimblw R, Ellenbroek W, Danso E, Amatekpor J (2001) The wise use of wetlands: Identifying development options for Ghana's coastal Ramsar sites. *Hydrobiologia*, 458, pp.221–234.

Witzel A (2000). The problem-centered interview [26 paragraphs]. Forum Qualitative Sozialforschung / Forum: Qualitative Social Research, 1(1), Art. 22,

WLD The Wildlife Division. *Fcghana.org*. Access 16. 05. 2016 [http://www.fcghana.org/page.php?page=46&section=22&typ=1&subs=254]

Wolanski E, McLusky D, Diop S (2011) *The Coastal and Marine Environment of Western and Eastern Africa*, Elsevier Inc. pp. 315-355.

Wolanski E, McLusky D, Williams BJ (2011) *Linking Ecology, Modeling, and Management in Coastal Systems*, Elsevier Inc. pp. 441-458.

WRC Water Resources Commission Of Ghana. *Wrc-gh.org*. Access 16. 05. 2016 [http://www.wrc-gh.org/]

Yankson PWK, Bertrand M (2003) Challenges of Urbanization in Ghana. In E. Ardayfio-Schandorf, P. W. K. Yankson, & M. Bertrand, eds. *The Mobile City of Accra. Urban Families, Housing and Residential Practices*. Dakar: Council for the Development of Social Science Research in Africa, pp. 25–46.

10 Appendix (shortened Version)

10.1 Historical Background on Ghana´s (Marine) Fishery

A brief history on Ghana's (marine) fishery

Ghana´s marine fishery predominantly has its roots in the arrival of the Europeans (Marquette et al. 2002). In the 17th and 18th century artisanal Fante fishers started to exploit the marine fishing resources along the Ghanaian coast. Starting to expand in foreign fishing grounds, they migrated to Benin, Ivory Coast, Nigeria and even as far as the Republic of Congo between 1800 and 1940 (Atta-Mills et al. 2004). Until today Ghana´s marine fishery is characterized by regional to international short to long term migration due to work and trade dynamics and related to seasonal changing fish stock distribution along the coast (Marquette et al. 2002). Commercial fisheries started not until the 19th century when the technical facilities allowed the river boats to enter the strong currents of the sea. By the middle of the 20th century Ghana's vessels had developed semi-industrial fisheries in many West African waters and the country was known as a great fishing nation. This changed after independence, when inshore stocks were heavily exploited and even high investment of the public and private sector in off shore equipment and vessels didn't work. Due to the lack of good management, financial and operational backing, infrastructure and the loss of fishing grounds to big foreign fleets from Europe and Asia (that also illegally enter the Inshore Exclusive Zone (IEZ) of Ghana that was created to protect the artisanal fisheries) the sectors performance declined (Marquette et al. 2002). Even inshore stock catches per unit effort are declining since the 1990 Ghana's fish trading companies are still growing to meet the increasing demand. Ghanaian fishers can still be found all over West Africa as crew members and officers, but there are no more Ghanaian vessels in any foreign water (Atta-Mills et al. 2004). Although the artisanal sector showed to be much more stable and managed to increase landings until the 1990, it is also declining since then (Atta-Mills et al. 2004) The total fish catches have increased since the middle of the 20th century but increasing modernization of techniques, equipment's and fishing efforts per fish unit have to be taken into account. Demersal trawling is increasing total catches but at the same time contributing to the depletion of certain stocks. Thus the reduction of species diversity and deterioration of marine biological communities leads to an overall decline in production (Goussard & Ducrocq In: Diop & Cyr 2014).

WaterPower is a laboratory for experimenting with novel ways of doing research based on the integration of multiple disciplines, approaches, methods and non-academic knowledge through dialogue and collaboration.

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Our analyses critically study the interplay of socio-political and ecological processes and how they configure place and scale.

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