Chapter 16
Adapting to the Inevitable: The Case of Tanbi Wetland National Park, The Gambia

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Abstract The role of human activities in degradation of estuarine resources has been well documented. Besides the effects of climate change, activities such as clearing of mangroves for tourism, use of inappropriate fishing gear and excessive use of pesticides for agricultural productivity are the most powerful ecological stressors. In the Sahelian climate zone, hydrological regimes are changing due to reduced river flow and increase in atmospheric temperatures leading to the formation of inverse estuaries. The evaluation and documentation of local adaptation practices is one way to prevent "conservation bottlenecks" and encourage sustainable use of estuarine resources. This study used a questionnaire-based approach to evaluate local adaptation strategies to climate-induced ecological changes in the Tanbi Wetland National Park (TWNP) over the past three decades, targeting the communities that are engaged in the four major socio-economic sectors in the wetland i.e. Fishing, Agriculture, Oyster collection and Tourism. The agricultural zone presented the best local adaptation techniques employed as a response to ecosystem changes in the TWNP (23.53 %), followed by tourism zones (7.35 %) and fishing (5.88 %). With the disappearance of many fish species within the same timeframe, this leaves much to be desired. Bearing in mind that fisheries and tourism are the second and third largest contributors to the Gambia's GDP, this paper provides useful recommendations for management of this important wetland.

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Introduction

The effects of climate change on human systems have been reported by many, although the responses to recent changes are hard to identify due to adaptation and the presence of many non-climatic driving forces (IPCC 2007). In its fourth assessment report, the IPCC highlighted that Africa is one of the most vulnerable continents to climate variability and change because of multiple stresses and low adaptive capacity. The report goes further to predict a decline of up to 50 % in yields from rain-fed agriculture by 2020 due to a reduction in arable land and changes in length of growing season in the arid and semi-arid areas. Fisheries resources, it states, will also decline due to rising water temperatures, exacerbated by continued overfishing; meanwhile, up to 30 % of global coastal wetlands are already lost due to continued mangrove ecosystems degradation and sea level rise (Church and White 2006).

Adaptation strategies to the aforementioned climate-induced ecosystem changes are gaining momentum as confidence in climate projections is getting higher. As the achievement of the Millennium Development Goals (MDGs) and successful implementation of the Poverty Reduction Strategy Papers (PRSPs) in developing countries are being achieved, adaptation strategies are now viewed as important goals (Mertz et al. 2009). In the earlier years, and to the contrary, the focus was mostly on climate mitigation (IPCC 2007). Mertz et al. (2009) pointed out that most climate data studies are done in developed countries and as such more information is needed in developing countries with tropical and subtropical climates for more knowledge in vulnerability and adaptive responses.

Over the years, research into the drivers of climate change, the magnitude of its impacts on livelihoods and the adaptations strategies have also increased, especially for the tropics where the physical impacts are predicted to be more severe. Africa for instance is expected to be warmer than the global mean, with a general decline in annual rainfall (Mertz et al. 2009). This will have great consequences for countries in arid and semi-arid zones that depend on the exploitation of natural resources from fragile ecosystems such as mangrove estuaries/wetlands, for sustenance of their socio-economic sectors. Due to the decline in agricultural productivity in countries such as The Gambia, dependency on estuarine resources has risen tremendously over the past couple of decades and now the biggest contributors to The Gambia's GDP are Agriculture, Fisheries and Tourism i.e. 27 %, 12 % and 8 % respectively (Government of The Gambia 2010).

The ecosystem services provided by mangroves are valued at US$ 900,000 per year (Corcoran et al. 2007), one can safely assume that mangrove estuaries, while serving as favorable nursery grounds for diadromous fish species (Baran 2000) and as a hub for socio-economic activities in the tropics and sub-tropics, are thus at an ecologically precarious state; especially in arid zones where they grow slowly because of climate-induced hypersaline conditions, low humidity, high

temperatures, and extreme light conditions (Alongi 2008). Hence, the superimposition of climate-induced changes such as prolonged tidal inundation on other impacts resulting from human activities such as over fishing, pollution and habitat loss put these coastal areas under great stress (Chen 2008).

Mangroves occupy sensitive intertidal zones that are more prone to the immediate effects of climate change. Drastic changes in hydrology for instance was reported to induce stunting of *Avicennia marina* stands and denaturing of terminal buds in *Rhizophora mangle* seedlings in the USA (Kathiresan 2002). Austin et al. (2010) also suggested that modest changes in rainfall and temperature caused significant reductions in mean annual run off and increased stream salt concentrations in Murray-Darlin Basin (Australia), resulting in loss of mangrove vegetation. The frequent fluctuations between climate events such as extreme floods and prolonged droughts have also been reported to cause massive mangrove diebacks in Sub-Saharan countries such as Senegal and The Gambia (Dia 2012).

With an 80 km long coastline and a continental shelf area of about 4000 km^2 (IUCN 2010), The Gambia boasts of 68,000 ha mangrove estuary that accounts for 2 % of the total coverage for Africa (Spalding et al. 1997). This important part of the Western Africa Marine Eco-Region (WAMER) shelters about 600 species of fish, 26 species of cetaceans, 6 species of Turtles and more than 200 species of birds (Lee et al. 2009). But like many ecosystems in Sahelian countries, climate change has taken a serious toll on the stability of coastal and estuarine services due to erratic rainfall, increase in atmospheric temperatures and persistent droughts for the past three decades following the great Sahel drought in the 1970s (Dai et al. 2004). Annual rainfall in The Gambia has decreased by 30 % between the year 1950 and 2000 alone (Fig. 16.1), now remaining at a range of 850–1200 mm, the bulk of

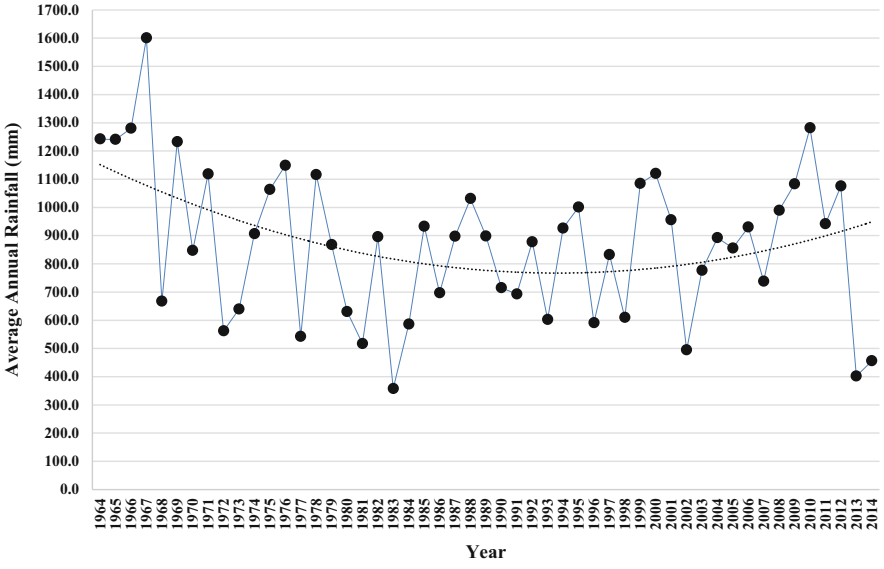

Fig. 16.1 Long-term rainfall pattern for Banjul, 1964–2014 (*Source*: The Gambia Meteorological Unit, 2015)

which occurs in August causing heavy floods in one-third of the country (Lee et al. 2009).

The progressive increase in atmospheric temperatures over the past five decades are not helping matters either. Long-term atmospheric temperatures for Banjul are shown in Fig. 16.2 below.

The Gambia's economy is heavily dependent on rain-fed agriculture, and as such the sector suffered the most decline (30 %) since the early 1970s (Government of The Gambia 2007). Like most countries in the Sahel, The Gambia responded by adapting and ratifying most (if not all) international climate-related accords including the UNFCC, Kyoto Protocol, Rio + 10 etc. (Lauer and Eguavoen 2016). In order to implement these accords at national level, The Gambia recently initiated programs such as the Program for Accelerated Growth and Employment (PAGE), the Gambia-Senegal Sustainable Fisheries Project, the Adaptation to Climate induced Coastal Changes Project etc., with the help of international bodies such as the UNDP, USAID and GEF (Lauer and Eguavoen 2016). In addition, positive changes were also effected in policies guiding the judicious use of natural resources. These include the formulation and enforcement of the Anti-littering Regulations to prevent indiscriminate waste dumping, and the Fisheries Regulations for safe-guarding the ecological integrity of fragile ecosystems such as the coast, which is already heavily influenced by the effects of Climate change (Government of The Gambia 2010).

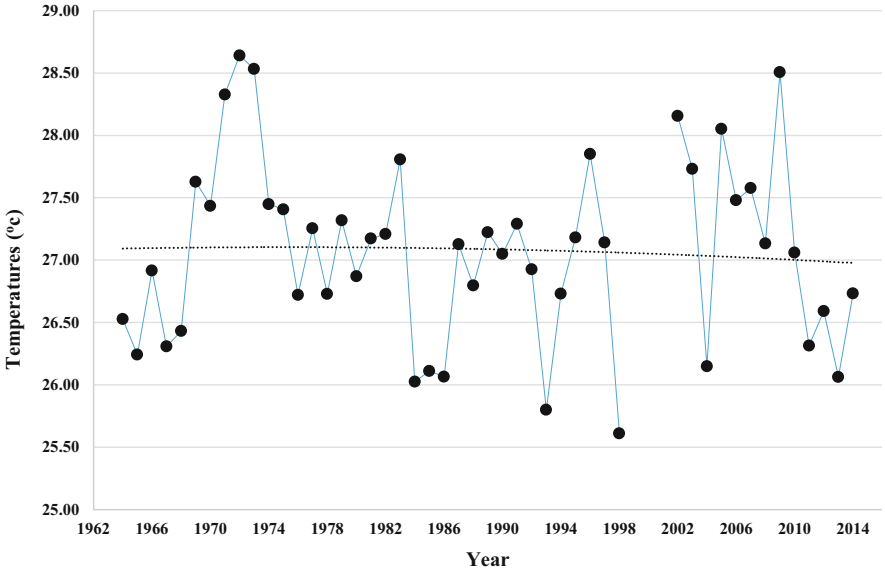

Fig. 16.2 Long-term atmospheric temperatures for Banjul, 1964–2014 (*Source*: The Gambia Meteorological Unit, 2015)

Making sure that the benefits of the aforementioned accords are felt by the local communities, farmer incentives such as provision of the drought resistant rice (NERICA) was introduced, to improve livelihoods of the poor communities involved in subsistence agriculture, as well as to create continued awareness of the farmers through agricultural extension workers and state-organized workshops (personal communication, Gambia Department of Agriculture). Successful implementation of projects such as the Gambia-Senegal Sustainable Fisheries project also gave birth to a bottom-top management approach to the fragile coastal resources such as the Tanbi Wetland National Park (TWNP), leading to the formulation of a co-management plan, which gave management rights to user groups such as the women oyster collectors. This, of course, is all based on the fact that there is an existent multi-sectoral team (comprised of all the relevant government institutions, CBOs and NGOs involved in conservation of natural resources, environmental sustainability and community development) (USAID-BANAFAA Project 2012).

Notwithstanding all the above, the socio-economic standing of vulnerable coastal communities in The Gambia leaves much to be desired. Socio-economic groups such as the fisher folks and tourism workers are not benefitting much from the institutional frameworks set up to reduce vulnerability of coastal communities within The Gambia. While abiding by all the rules set in conservation accords, these groups have little or no knowledge of the appropriate response strategies to apply/adopt at an individual level when faced with drastic ecosystem changes in their work environment. This leaves an information gap for the coastal communities, which needs to be urgently addressed for successful implementation of The Gambia's Climate Change adaptation strategies.

This paper aims to assess the socio-economic implications of climate-induced ecosystem changes in the mangrove estuaries of the River Gambia, where such information is almost non-existent. Using a questionnaire-based approach, this paper focused on evaluating relative vulnerability and adaptive capacity of the major socio-economic groups, an area that has not been well investigated in Sub-Saharan Africa. Filling this information gap will contribute toward successful implementation of National Adaptation Plans for mangrove-dependent countries such as The Gambia. Therefore, the main aim of this research was to gather and document local knowledge on climate-induced ecosystem changes, local adaptation practices adopted by the various socio-economic groups involved in Agriculture, Fisheries, Tourism, and Oyster collection, as well as the perceived changes in their economic gains in the TWNP.

Materials and Methods

Study Site: Tanbi Wetland National Park (TWNP)

The Tanbi Wetland National Park (TWNP) (Fig. 16.3) is a lowland area with a mean altitude of 1–1.6 m extending between 13°23–13°26 N and 16°34–16°38 W (The Ramsar Convention on Wetlands 2012). Located at the mouth of the River Gambia estuary, TWNP covers an area of about 6300 ha (Lee et al. 2009) and connects the three main urban settlements within the Greater Banjul Area (GBA). These are Banjul City (BC), Kanifing Municipality (KM) and Brikama (BA) (Government of The Gambia 2010). Due to its ecological richness, this wetland was designated a Ramsar wetland of importance in 2007 (Project 2012).

The TWNP falls within the Sahelo-Sudanian climate zone (Simier et al. 2006), having a long dry season (October–June) and a short rainy season (June–October) (Camara 2012). Mangrove vegetation in TWNP is comprised of *Rhizophora mangle* (red mangrove), *Avicennia germinans* (also known as *Avicennia africana*/black mangrove), *Laguncularia racemosa* (white mangrove) and *Rhizophora harisonni* (Maniatis 2005).

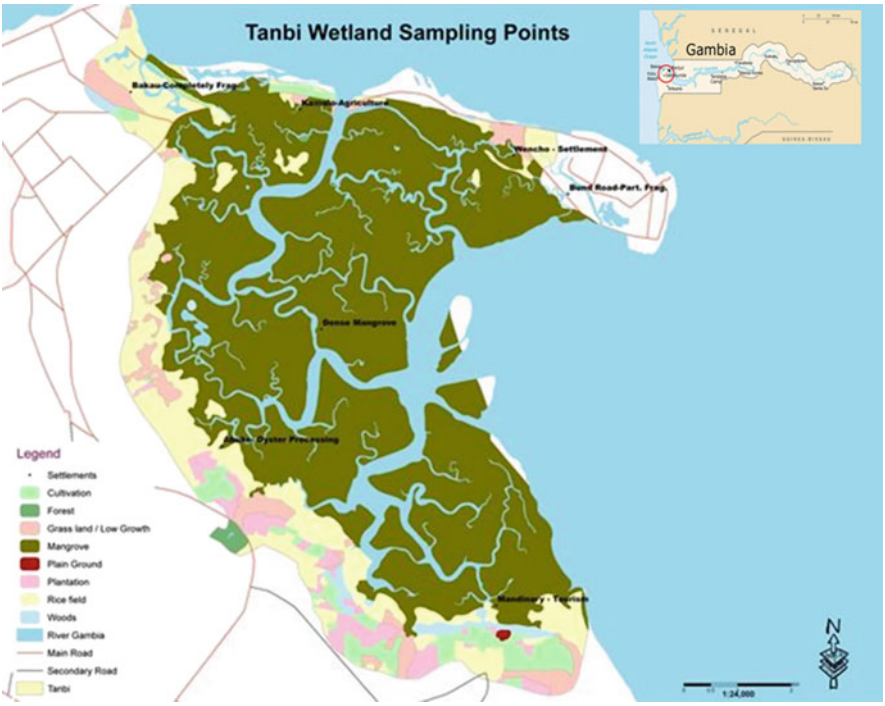

Fig. 16.3 Location of and socio-economic focus areas in Tanbi Wetland National Park on the Map of The Gambia

This mangrove habitat serves as an important nursery ground for fish species such as shad (*Ethmalosa fimbriata)* and sardine *(Sardinella maderensis)* (Baran 2000), African tilapias (*Sarotherodon* and *Oreochromis* species) (Albaret et al. 2004), as well as the pink shrimp (*Paneaus notialis)* and oysters (*Crassostrea gasar)* (Darboe 2002).

Economic activities in this area are dominated by Fisheries (including shell fishery) and Tourism (Satyanarayana et al. 2012). Agricultural activities (e.g. rice cultivation and gardening) are also common (USAID-BANAFAA Project 2012).

Methodology

Questionnaires

Questionnaires for this study were formulated to feature sustainability issues such as long-term (herein, three decades) ecosystem changes in TWNP. In addition, climate change matters were also included and their relationship with socio-economic setup based on the four categories below:

1. Ecosystem changes in TWNP (physical changes in terms of water quality, soil, vegetation and fisheries).
2. Climate change (as understood by the socio-economic groups in TWNP).
3. Economic status (as recorded in increase/decrease in daily earnings of the socio-economic groups in TWNP.
4. General observations (focusing on general understanding of the subject matter by the local people that are gainfully employed in TWNP).

Subject Groups (Interviewees) and Interviews

A group of 138 people belonging to four occupational groups were interviewed. These include: Farming, Fisheries, Tourism and Oyster collection. A subgroup of people residing within the wetland (in Wencho, locally known as Ndangane) were also interviewed. As this study was aimed at the local people's understanding of long-term changes in the ecosystem, the age group target was set at 18 years and above. For proportionate representation of the socio-economic groups, 15 tourist workers, 19 residents, 20 oyster collectors, 40 farmers and 44 fisher folks were interviewed.

Interviewers' group was comprised of five people (two from the National Environment Agency, one from the Water Resources Department, one from the University of The Gambia and the actual researcher). This team was put together based on their background in environmental monitoring, conservation and community development work. In addition, each of the team members is fluent in at least

two local languages for translation purposes. All together the team is fluent in the four major local languages in The Gambia (Mandinka, Fulla, Wollof and Jola). To prevent any biases in the way questions were administered, the team prepared by "practice-asking" each other all the questions in the questionnaire and adopting a uniform introduction of the purpose and scope of the research in the four major local languages to ensure a uniform understanding of the questions.

Interviews were conducted under an informal roundtable chat with each socio-economic group at their place of work in TWNP. Where possible questionnaires were translated into the respondents' native language for better understanding. Interviews for each respondent lasted about 30 min. Questionnaire details are in appendix I.

Data Analysis

For statistical analysis, responses from the interviews were pooled in a similarity matrix and subjected to Principal Component Analyses (PCA) using Statistical analysis software R version 2.15.2 (2012). Descriptive statistical analyses were done using STATA 12 for windows. The methodology of this research was adapted from Satyanarayana et al. (2012).

Results

Based on the responses garnered during this study, 132 (95.65 %) out of the 138 respondents believe that the ecosystem of TWNP has changed over the past three decades, while the other 6 (4.35 %) disagreed/were undecided (Fig. 16.4).

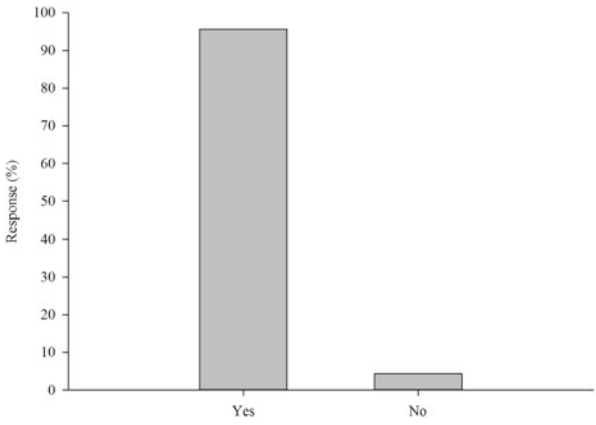

Fig. 16.4 Responses to the occurrence of ecosystem changes in TWNP

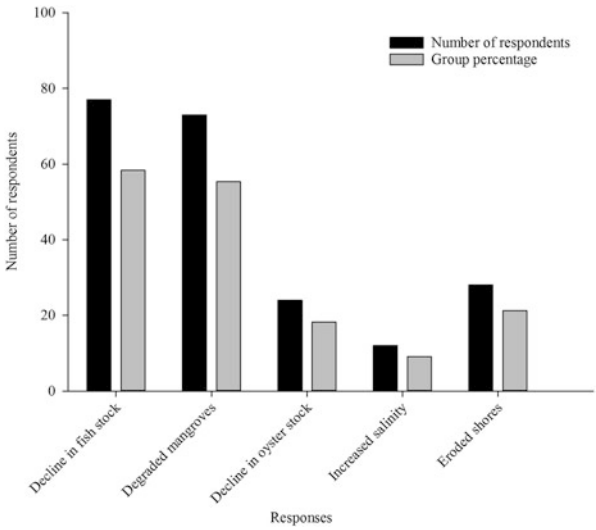

Fig. 16.5 Local perspective on specific ecosystem changes in TWNP

When asked about the specific changes within the TWNP, 58.33 % of the respondents mentioned a decline in fish stocks along with the disappearance of key species such as the giant African threadfin, which commands an attractive price compared to other native fish species. 55.30 % mentioned mangrove degradation, and 21.21 % of them mentioned soil erosion, while 18.18 % mentioned a decline in oyster stock (Fig. 16.5).

The local people's understanding of climate change is high despite the low literacy rates in The Gambia. 103 out of the 138 people (74.64 %) interviewed said they have heard of climate change before while 35 (25.36 %) said they have never heard of the concept before. When asked about the manifestations of climate change, 77.67 % of the respondents associated it with changes in rainfall pattern, 45.63 % associated it with changes in atmospheric temperatures, and 11.65 % to droughts (Fig. 16.6a and b).

Only one respondent was encountered (within the fisher folks group) who did not believe in the concept of climate change. Among those who have heard of the concept of climate change, 46.60 % claimed to have heard about it through the media, 26.21 % through workshops, 8.74 % from schools, 6.80 % from agricultural extension workers and 5.83 % from visiting tourists (Fig. 16.7).

Local understanding of climate-induced ecosystem changes such as seasonal variability and hyper-salinity was very high among the socio-economic groups in TWNP. On a scale of 0–10 (0 being poorest and 10 being excellent), the oyster collectors' group presented the highest level of awareness (8.25), followed by the fisher folks (7.52), residents (6.79), tourism group (6.53) and the least score was recorded with the farmers' group (6.23). In terms of awareness on seasonal hyper-salinity, responses followed a similar trend with the oyster collectors scoring 9.10,

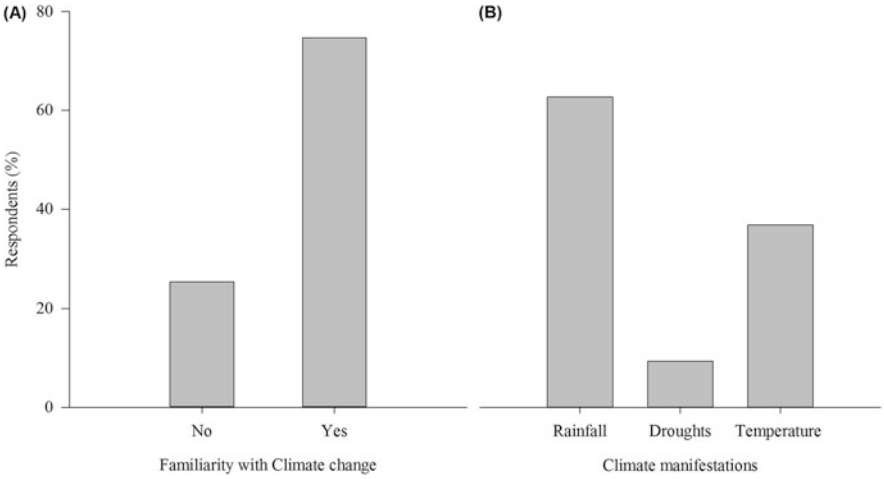

Fig. 16.6 Familiarity of the socio-economic groups with climate change concept (**a**) and local perception on manifestations of climate change (**b**)

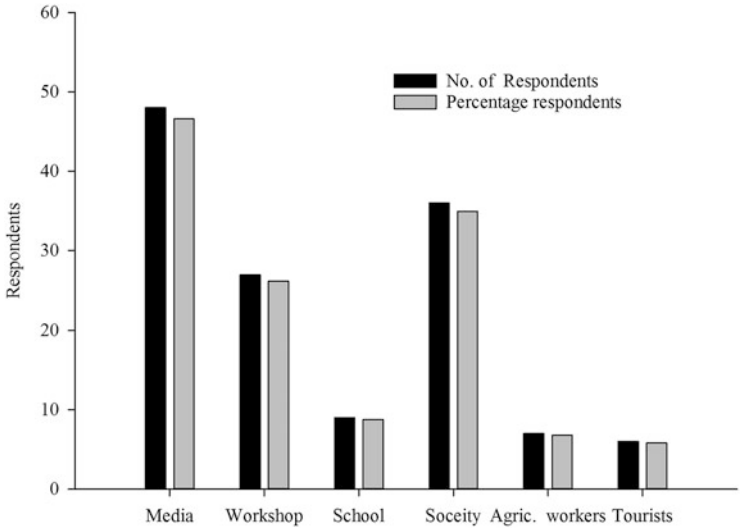

Fig. 16.7 Sources of Climate change information for the socio-economic groups in TWNP

fisher folks 8.18, farmers 7.30, residents 6.63 and the lowest scoring group being the tourism group (5.80) (Fig. 16.8).

In terms of the local adaptation measures/response strategies employed by the socio-economic as coping mechanism to the ecosystem changes in TWNP, a total of 32 different responses were given by the respondents. Most common among these was "nothing", 70 (50.72 %) out of the 138 respondents have no knowledge of

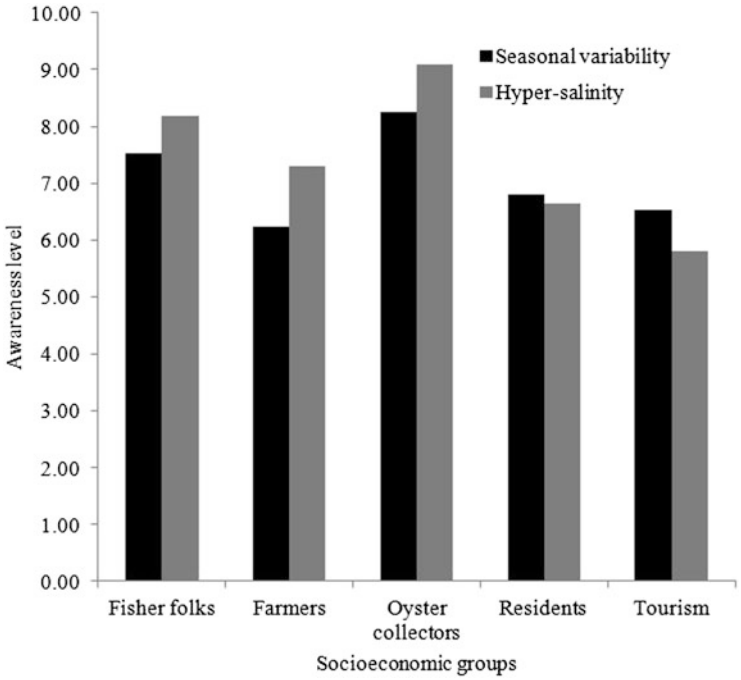

Fig. 16.8 Local understanding of climate-induced ecosystem changes by socio-economic groups in TWNP (score 0–10)

what measures they could take to maximize their daily output and prevent unnecessary economic losses in their place of work. 15 out of the remaining 68 respondents (22.06 %) seasonally shift their attention to exploitation of alternative resources allowing their main species of interest to "fallow" (case in point, oyster collectors who shift to crabbing and lobster fishing during the rainy season, when water quality is very poor in TWNP); 7(10.29 %) practice crop rotation based on observed changes in soil quality due to salt intrusion; while 9(13.24 %) change their usual sowing period in anticipation of late and insufficient rains (i.e. farmers' group). The "less fortunate" groups here 5 (7.35 %) deal with these changes by buying bigger boats (tourism group), while 4 (5.88 %) of all respondents deal with the ecosystem changes by expanding their fishing zones (this is the case of the fisher folks) (Fig. 16.9). Both of these measures in addition to being unsustainable are neither "pocket-friendly" nor "time-friendly", as they require huge financial inputs and longer fishing hours just for meagre catches.

In terms of economic growth, most of the respondents expressed a decline in income. About 65 % of the respondents from the oyster collectors expressed a decline in income over the past three decades, this was followed by the farmers group (61 % of the respondents), the residents (58 % of the respondents) and the

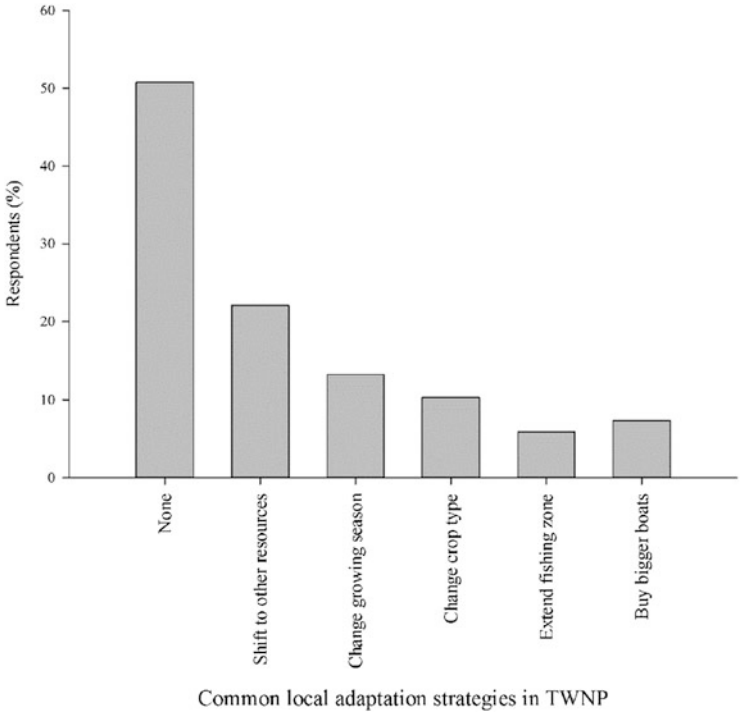

Fig. 16.9 Common local adaptation practices to climate-induced ecosystem changes in TWNP

Fisher folks (42 % of the respondents). About 57 % of the respondents from the tourism group expressed an increase in income (Fig. 16.10).

On average, the socio-economic groups considered here have registered a decline of 46 % in their earnings within the TWNP for the past three decades. The greatest average decline (72.73 %) was recorded among the fisher folks, followed by the oyster collectors (50 %) and the lowest (33.85 %) among the farmers groups' (Fig. 16.11).

Discussion

Mertz et al. (2009) advised for a careful formulation of policies and adaptation strategies to climate change for societies that are poor and vulnerable for a wide range of reasons. Hence, both physical and institutional assets need to be included when formulating adaptation strategies. In TWNP the former has been made available for the groups involved in shellfisheries through provision of canoes, sanitation facilities, oyster smoking pens and alternative livelihoods (setting up an oyster culture program), while the latter is available for groups involved in

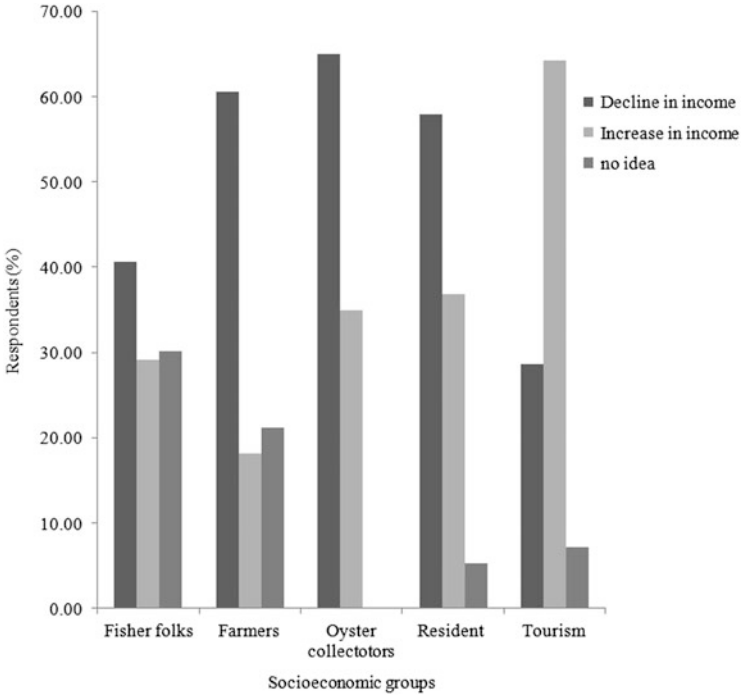

Fig. 16.10 Economic situation of the socio-economic groups in TWNP

agriculture through awareness creation by agricultural extension programs, credit schemes and subsidies for improved seed variety (National Environment Agency 2010).

The latter is also in part available for the fisher folks, through the coastal zone management plan, enforcement of fishing regulations, and guidelines on appropriate net usage within the wetland. While the aforementioned incentives are provided alongside numerous awareness creation campaigns for the socio-economic groups such as the farmers and oyster collectors, awareness levels are is still low for the fisher folks, as evidenced by their poor responses to adaptation mechanisms.

Kelly and Adger (2000) suggested that in cases concerning state-run adaptation programs, it might be necessary to "adapt to the adaptation," as some measures might solve one problem while creating another. As an example, (Barnett and Mahul 2007) suggested that credit schemes and new crops, accompanied by "weather insurance," have been tried experimentally in some developing countries. This approach was applied to a large extent in the agricultural sector, with provision of soft loan credit schemes with flexible payment plans that took account of the possibility of crop failure due to rainfall shortages (Government of The Gambia 2010). A similar approach was also applied for the shell fisheries sector, with the provision of alternative livelihoods through value-adding (packaging) of

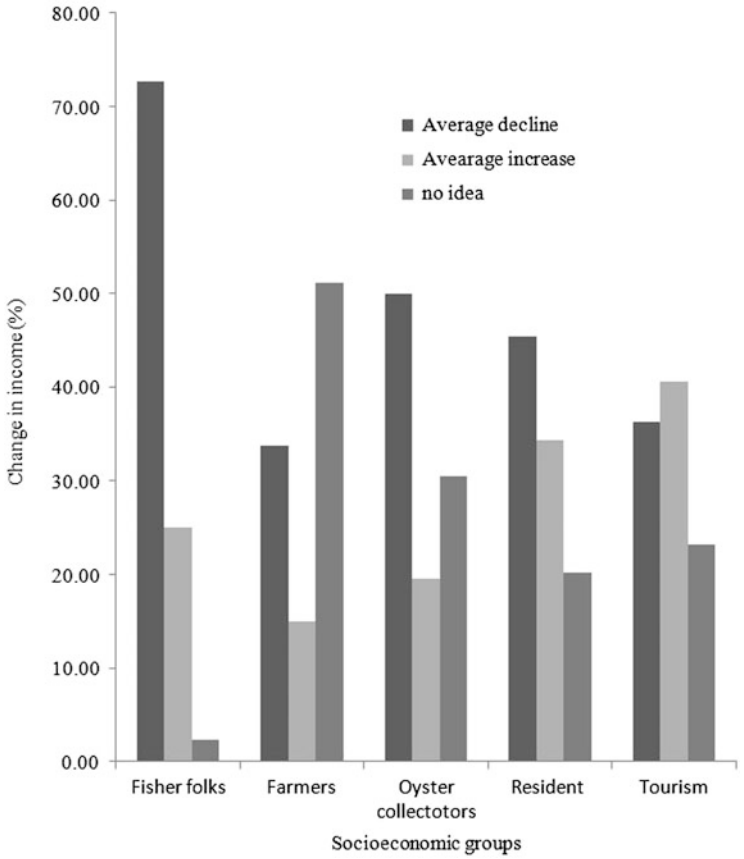

Fig. 16.11 Changes in average income of the socio-economic groups in TWNP

pre-processed oyster meat as well as setting up an oyster culture program (Crow and Carney 2013; USAID-BANAFAA Project 2012).

However, for the fisher folks only institutional assets are available in the form of the enactment of The Gambia's Fisheries Regulations (1995) and Act (2007) (Government of The Gambia 2007), as well as stricter netting regulations for sustainable fisheries in The Gambia allowing for no less than 20 mm mesh sized nets within the estuary of the River Gambia (personal communication, The Gambia Department of Fisheries). This has no doubt helped reduce overfishing, especially within the nursery grounds of the TWNP, but it still did not solve the problem of declining fish catches or the low economic returns as the physical assets needed by the fisher folks are not in place. This move might have also promoted complete colonization of estuary by hardy, but smaller sized fish species such as the native African tilapias (*Sarotherodon melanotheron*), which is known to respond to environmental stress by reducing its growth rate (Panfili et al. 2004).

In the words of Munang et al. (2010) it is necessary for policy makers to recognize the fundamental role of ecosystems as life-supporting systems first for successful implementation of adaptation strategies. In absence of a go-to activity for the fisher folks during times of low catches (as shown in this study), restricting fishing activity only lowers their earning potential without necessarily solving the problem of ecosystem change. This also does little or nothing to alleviate the declining fish catches, because fish species migrate in response to natural deterioration in their environment (Panfili et al. 2004).

Portner and Peck (2010) suggested that the implications of climate change for marine fish species are at four levels: organismal, individual, population and ecosystem level; individual level being the most relevant one when referring to the state of fisheries in TWNP. Over 23 % of the strict estuarine fish species for instance have been reported to seasonally migrate inland as a response to hypersalinity during the peak dry season and then to the creeks during the flood season (Ceesay et al. 2016—article in press). This is now believed to be the reason behind the drastic reduction in daily catches/earnings of the fisher folks interviewed during this research.

Similar findings were reported by Panfili et al. (2004) in a study of the impacts of salinity on the life traits of the native African tilapia (*Sarotheron melanotheron*) in the estuaries of Senegal and The Gambia, where he reported interruptions in fish migration patterns, reproduction timing and spawning success as well as stunting, leading to smaller market sized fish and thus earning lower prices. Such phenomenon was also reported to be the cause for the complete colonization of the inverse estuary of Sine-Saloum delta in Senegal by marine fish species; thus replacing the native estuarine species and causing a decline in fisheries output for over a decade (Dia 2012).

The aforementioned condition is worsened by the synergistic effects of human activities such as overfishing on climate-induced ecosystem changes, as evident in the responses from the fisher folks. In addition, the commonness of the phrase "in God's hands" among the fisher folks as a response to how they locally adapt to climate-induced ecosystem changes indicates their low levels of awareness. Thus leading to the deduction that the fisher folks are the most vulnerable socio-economic group when it comes to climate change adaptation in TWNP. This group has been relatively overlooked and uninvolved when it comes awareness creation campaigns by conservationists as well as in the provision of alternative livelihoods by state institutions.

The case is different for the farmers' group which apart from having its members frequently trained on alternative farming methods and provided with improved seed variety in order to adapt to climate-induced ecosystem changes in TWNP; also has the luxury of having an agricultural extension worker on site to guide them in responding to common farming problems. In comparison, the oyster collectors' group having been provided with suitable alternative livelihood programs such as the state-led oyster culture program. In addition, they were recently given management rights to the TWNP. Meanwhile, the tourism group finds it much easier to cope with the ecosystem changes, for instance by expanding sightseeing zones and

proportionally increasing safari prices, which may not be a realistic approach for the other groups as one is catering to a local market, while the other targets an international market.

Of course, it is noteworthy that this current study also has its own set of limitations. For instance, difficulties in locally translating basic climate concepts to the mostly uneducated respondents might have downplayed their ability to accurately respond to questions about climate-ecosystem changes. The general mistrust between local resource users/end users and state-employed conservationists also played a dampening role in people's willingness to answer the questionnaires. Nonetheless, sufficient information was garnered to portray overall understanding and response mechanisms employed by the locals in order to deal with climate-induced ecosystem changes in the mangrove estuary under study (TWNP), as well as the socio-economic implications of these changes.

Conclusions

Interpretations of the responses gathered from the socio-economic groups during this research work in TWNP indicate the following:

- Even though slow, there has been a progressive increase in general awareness about climate change and how it affects socio-economic activities within the fragile mangrove ecosystems in The Gambia.
- Environmental awareness campaigns have been more successful with the groups involved in oyster collection and farming (who are mostly female), and least so with the groups involved in fishing and tourism (all male); as evident in their responses to observed changes and coping mechanisms. This calls for the need to make gender issues a principal component when designing awareness creation programs.
- Based on findings of this research, the reported decline in fisheries of the TWNP is mostly climate-induced. The reduction of fishing pressure and strict enforcement of Fisheries policies, legislations and net size regulations for sustainable fisheries has been going on for the past couple of decades. Yet, the positive effect of these measures are at best negligible; thus calling for the need to review the guiding fisheries policies, as well as provision of alternative livelihoods for the fisher folks.
- There is also a growing need for more research into the response mechanisms of aquatic species to environmental change and how this affects the lives of the common fisher folks. This will avail The Gambia a possibility of identifying the best modes of intervention needed in terms of sustainable alternative livelihoods for those gainfully employed within TWNP.

References

Albaret J-J, Simier M, Darboe FS, Ecoutin J-M, Raffray J, de Morais LT (2004) Fish diversity and distribution in the Gambia Estuary, West Africa, in relation to environmental variables. Aquat Living Resour 17:35–46. doi:10.1051/alr:2004001

Alongi DM (2008) Mangrove forests: resilience, protection from tsunamis, and responses to global climate change. Estuar Coast Shelf Sci 76(1):1–13. doi:10.1016/j.ecss.2007.08.024

Austin J, Zhang L, Jones RN, Durack P, Dawes W, Hairsine P (2010) Climate change impact on water and salt balances: an assessment of the impact of climate change on catchment salt and water balances in the Murray-Darling Basin, Australia. Clim Change 100:607–631. doi:10.1007/s10584-009-9714-z

Baran E (2000) Biodiversity of estuarine fish faunas in West Africa. Naga ICLARM Q 23:6

Barnett BJ, Mahul O (2007) Weather index insurance for agriculture and rural areas in lower income countries. Mississippi State University, Starkville, MS, 19p

Camara AS (2012) Protected Areas Resilient to Climate Change, PARCC West Africa. National Data Collection Report: UNEP-WCMC, Banjul, The Gambia, 42 p

Ceesay A, Wolff M, Koné T, Njie E, Matthias B (2016) Seasonal changes in water quality and fisheries of Tanbi Wetland National Park. Regional Studies in Marine Science. http://dx.doi.org/10.1016/j.rsma.2016.04.006

Chen CA (2008) Effects of climate change on marine ecosystems. Fisheries for Global Welfare and Environment, 5th World Fisheries Congress, pp 307–316

Church JA, White NJ (2006) A 20th century acceleration in global sea-level rise. Geophys Res Lett 33:94–97. doi:10.1029/2005GL024826

Corcoran E, Ravilious C, Skuja M (2007) Mangroves of western and central Africa. Regional Seas Programme/UNEP-WCMC, Cambridge, UK, 92p

Crow B, Carney J (2013) Commercializing nature: Mangrove conservation and female Oyster Collectors in The Gambia. Antipode 45:275–293. doi:10.1111/j.1467-8330.2012.01015.x

Dai A, Lamb PJ, Trenberth KE, Hulme M, Jones PD, Xie P (2004) The recent Sahel drought is real. Int J Climatol 24(11):1323–1331. doi:10.1002/joc.1083

Darboe FS (2002) Fish species abundance and distribution in the River Gambia Estuary. UNU–Fisheries Training Programme, pp 1–40. http://www.unuftp.is/static/fellows/document/famara2002prf.pdf

Dia MI (2012) Vulnerability assessment of Central Coast Senegal (Saloum) and The Gambia Marine Coast and estuary to climate change induced effects. Coastal Resources Center and WWF-WAMPO, Consolidate report. University of Rhode Island, United States of America, 40p

Government of The Gambia (2007) The Gambia fisheries Act. Supplement "C" to The Gambia Gazette No. 20. Banjul, The Gambia, 54p

IPCC (2007) Climate change: impacts, adaptation and vulnerability. Contribution of the Working group II to the Fourth assessment report of the Intergovernmental panel on climate change IV. In: Parry ML, Canziani OF, Palutikof JP, Van der Linden PJ, Hanson CE (eds) Cambridge University Press, Cambridge, 987p

IUCN (2010) National diagnostic report for The Gambia on climate change vulnerability. International Union for Conservation of Nature (IUCN), Banjul, The Gambia, 132p

Kathiresan K (2002) Why are mangroves degrading? Curr Sci 83(10):1246–1249

Kelly PM, Adger WN (2000) Theory and practice in assessing vulnerability to climate change and facilitating adaptation. Clim Change 47(4):325–352. doi:10.1023/A:1005627828199

Lauer H, Eguavoen I (2016) Mainstreaming climate change adaptation into development in The Gambia—a window of opportunity for transformative processes? In: Filho WL (ed) Handbook of innovation in climate change management. Springer, Switzerland, pp 87–98

Lee V, Tobey J, Castro K, Crawford B, Ibrahima Mat D, Ousman D, Tanvi V (2009) Gambia-Senegal sustainable fisheries project. In: Marine biodiversity assets and threats assessment for WAMER, p 50

Maniatis D (2005) Retrospective study of the Mangroves of the Tanbi Wetland Complex. Master's thesis submitted to the University of Vrije, Bussel, Belgium 129p

Mertz O, Halsnaes K, Olesen JE, Rasmussen K (2009) Adaptation to climate change in developing countries. Environ Manage 43:743–752. doi:10.1007/s00267-008-9259-3

Munang R, Rivington M, Takle ES, Mackey B, Thiaw I, Liu J (2010) Climate information and capacity needs for ecosystem management under a changing climate. Procedia Environ Sci 1(1):206–227. doi:10.1016/j.proenv.2010.09.014

Panfili J, Mbow A, Durand J-D, Diop K, Diouf K, Thior D et al (2004) Influence of salinity on the life-history traits of the West African black-chinned tilapia (Sarotherodon melanotheron): Comparison between the Gambia and Saloum estuaries. Aquat Living Resour 17:65–74. doi:10.1051/alr:2004002

Portner HO, Peck MA (2010) Climate change effects on fishes and fisheries': towards a cause-and-effect understanding, pp 1745–1779. doi:10.1111/j.1095-8649.2010.02783.x

Project U-B (2012) Report on Sanitary Shoreline survey within the Tanbi Wetlands National Park and other shellfish harvesting communities, The Gambia

Satyanarayana B, Bhanderi P, Debry M, Maniatis D, Fore F, Badgie D et al (2012) A socio-ecological assessment aiming at improved forest resource management and sustainable eco-tourism development in the mangroves of Tanbi Wetland National Park, the Gambia, West Africa. Ambio 41:513–526. doi:10.1007/s13280-012-0248-7

Simier M, Laurent C, Ecoutin JM, Albaret JJ (2006) The Gambia River Estuary: a reference point for estuarine fish assemblages studies in West Africa. Estuar Coast Shelf Sci 69:615–628. doi:10.1016/j.ecss.2006.05.028

Spalding M, Blasco F, Field C (eds) (1997) World Mangrove Atlas. The International Society for Mangrove Ecosystems, Okinawa, Japan, 178p

The Gambia Government (2007) Gambia National Plan of Action (NAPA) on Climate Change for The Gambia. GOTG, UNEP and GEF, Banjul, The Gambia, 97p

The Gambia National Environment Agency (2010) The Gambia State of the environment report, 2nd edn. National Environment Agency, Banjul, The Gambia, 263p

The Ramsar Convention on Wetlands (2012) Ramsar sites in order of their addition to the Ramsar list of wetlands of international importance, pp 1–37. http://www.ramsar.org/pdf/sitelist_order.pdf