American Journal of Environment and Sustainable Development
Vol. 4, No. 1, 2019, pp. 12-25
http://www.aiscience.org/journal/ajesd

Coping Strategies to Water Hyacinth Invasion Among Riparian Communities in Ghana

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Abstract

Riparian communities are beset with a number of risks associated with water hyacinth invasion. An understanding of how they cope with these shocks is important in the formulation of policies. The aim of this study is to assess the coping mechanisms adopted by communities affected by water hyacinth invasion. The method used involved a cross-sectional research design with 305 fishermen, fish traders, farmers and boat operators who were sampled using the snowballing sampling technique in Ghana. Our results indicated that people whose livelihood activities had been affected by water hyacinth invasion relied on reactive coping mechanisms like manual removal and withdrawal from work; and recovery coping mechanisms like farming and trading to withstand the effects. These strategies, however, varied among respondents based on their location, level of education, sex and ethnicity. The study concludes that the recovery coping strategies were more beneficial to the respondents than the reactive strategies. However, we recommend that further studies are needed for effective comparisons of the results of the two categories of coping strategies to know which one yields better results for the affected people to aid in the formulations of necessary policies.

Keywords

Water Hyacinth, Coping Strategies, Riparian Communities, Jomoro District, Ghana

Received: January 5, 2019 / Accepted: February 18, 2019 / Published online: March 19, 2019

1. Introduction

Water Hyacinth (*Eichhornia crassipes*) is a monocotyledonous freshwater aquatic plant that is related to the lily family (*Liliaceae*) and found in water gardens and aquariums. It has proven to be both a significant economic and ecological burden to many subtropical and tropical regions of the world [1] and is notoriously difficult to manage once established [2]. Water hyacinth negatively impacts aquatic ecosystems, agriculture, fisheries, production of electricity from hydropower plants, transportation, living conditions and social structures [3]. It also affects aquaculture by obstructing fishing, leading to reduction in fish catch and income [4-6].

Mechanical control of water hyacinth is expensive and difficult in some terrains; chemical control is also expensive, requires constant application and often has negative environmental implications, while biological control, which involves the use of natural "enemies" like insects, is mixed with failures and successes [7]. It has been noted that Africa in particular has been affected by the invasion of water hyacinth, partly due to a lack of naturally occurring 'enemies' and predators [8, 9] to control the weeds. Rivers like the Zambezi (Zambia), Congo and Nile (Egypt), have all been infested with water hyacinth [4, 10] and poverty-stricken rural populations, whose livelihoods depend on access to clean freshwaterways, are the most negatively impacted [11].

In Ghana, surface run-off carrying nutrients such as nitrate

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and phosphate from untreated wastewater, sewage, fertilized fields and decayed plants and animal materials into water bodies has facilitated the growth of the water hyacinth [12]. In spite of their adverse effects, studies have shown that water hyacinth could be used for the production of paper, biogas, ethanol, methane, fertilizer, fish feed, human food, animal feed, and in the clean–up of polluted aquatic environment [5, 13, 3]. These benefits notwithstanding, some communities in Ghana affected by water hyacinth infestation don't know what to do with the weeds.

Invasive species presently infesting the River Tano and the Abby-Tano Lagoon include water hyacinth, Kariba weed, water lettuce and hippo grass which pose hindrance to transportation, fishing and farming along these water bodies [14]. It has been reported by Annang [15], that the Tano Basin has the highest level of water hyacinth in the country. A report by the Ghana News Agency [16] indicates that movement of people on the Abby-Tano Lagoon and the River Tano in the peak season of the water hyacinth invasion to conduct economic and social businesses becomes almost impossible.

Coping strategies are defined as conscious, rational ways for dealing with the anxieties of life [17]. Danso and Addo [18], have identified three types of coping strategies, namely; reactive, preventive and recovery strategies. Reactive strategies are the immediate responsive measures used by individuals affected by a negative externality like a disaster. Recovery strategies reclaim destroyed properties and assets, while preventive strategies are employed to avoid the recurrence of negative externalities.

Livelihood diversification is one of the recovery coping strategies through which people cope with negative externalities. It is an attempt by individuals and households to find new ways to raise incomes and reduce environmental risk [19, 20]. Migration is another common livelihood strategy [21] and forms a central component of livelihood diversification [19]. It may be voluntary or involuntary movement to achieve different effects [22]. Social networks are part of the social asset base of people and their maintenance is an important risk management strategy. It includes 'formal' networks such as voluntary organisations and associations, and 'informal' networks including family, friends and work-related ties [23]. The strategy creates opportunities for people to share resources which otherwise could not have been obtained at the individual level [23-25].

2. Significance of Research

Various studies have been conducted into different aspects of the water hyacinth, including its ecological and socio-economic utilisation [1], as well as its proliferation in water bodies [26-28]. Further, the appropriate control and managerial measures of water hyacinth [11, 4, 29, 30], and its impacts on fish stock and fishing communities have also been explored [31, 6]. In Ghana in general and in the study area in particular, few studies have investigated into different aspects of water hyacinth invasion and how affected riparian communities have responded to the issue [32, 14, 16, 12, 15]. Despite the availability of some studies on the subject matter, there seems to be a general absence of researches focusing on how communities affected by water hyacinth invasion cope with the effects, and the types of coping strategies adopted. This study therefore seeks to fill this knowledge gap by assessing the coping and adaptive measures used by water hyacinth affected communities in the River Tano and Abby-Tano Lagoon riparian fringes.

3. Profile of Study Area

3.1. The Jomoro District

The Jomoro District covers an area of 1,344 km^2, which is about 5.6% of the total area of the western region of Ghana and is located between latitude 04°55′–05°15′N and longitude 02°15′ – 02°45′W. It has an extensive rainforest and receives high rainfall which falls in two wet seasons, and uniformly high temperature [33]. Fishermen in the district depend on canoe-fishing in the open seas, as well as from the district's natural network of wetlands and fresh water bodies as their sources of livelihood [34].

3.2. River Tano and Abby-Tano Lagoon

The Tano Basin is one of the principal south-western river basin systems of Ghana and lies between latitudes 5°00′N and 7°40′ N, and longitudes 2°00′W and 3°15′ W [35]. It is a transboundary basin, as the last 100km of the downstream flows across the international boundary between Ghana and La Côte d'Ivoire before entering the Abby-Tano-Ehy Lagoon system [36].

The Abby-Tano Lagoon, on the other hand, lies in the south-western part of the Jomoro District. While the Abby Lagoon lies approximately between latitude 05°05′18.1″ N and longitude 002°56′42.8″ W, the Tano Lagoon lies approximately between latitude 05°05′38.1″N and longitude 002°05′30.9″W but both are interconnected to form a lagoon complex with the Ehy Lagoon in La Cote d' Ivoire [37]. The Abby-Tano Lagoon is transboundary between Ghana and La Côte d'Ivoire but a larger part of it is located in La Côte d'Ivoire and discharges into the sea in that country [36] at AssinieManvea (Figure 1).

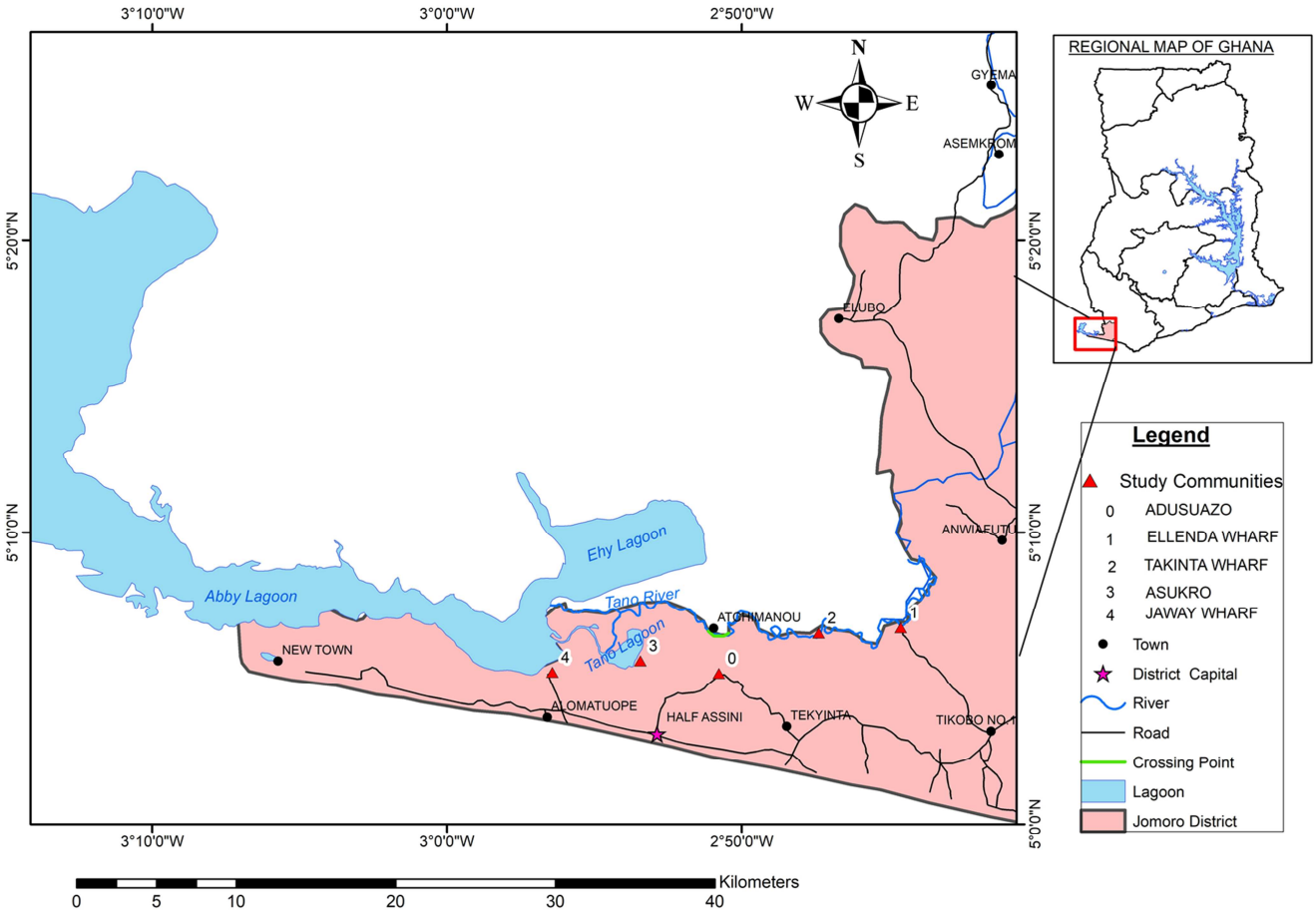

Figure 1. Map of Jomoro District Showing the Study Areas and Water Bodies.

4. Materials and Methods

4.1. Study Design

A cross-sectional study design, which finds out the prevalence of a problem among a cross-section of a population [38], was adopted in the study. Information on how people affected by water hyacinth in the River Tano and Abby-Tano Lagoon coped with the effects were gathered from cross-sections of people in the selected communities. Besides, a mixed method, involving the use of both quantitative and qualitative data, was also adopted since this gives a better understanding of a research problem than the use of one aspect on its own [39]. Quantitative data collected using questionnaire, included gender, level of education, ethnicity and marital status of respondents.

Some of the responses from respondents were quoted directly in the analyses of qualitative data. The qualitative aspect of the research design was appropriate because it made it possible for the researcher to engage respondents' experiences and reactions to the water hyacinth invasion in a way which would not have been feasible using only a quantitative research approach. It also ensured adequate discourse between the interviewer and the respondents in the production of a meaningful effect [40].

4.2. Sampling Procedure

Five riparian communities close to Tano River and Abby-Tano Lagoon were selected for the study. The selection was based on the proximity of these communities to the two water bodies, in line with the first law of geography by Tobler [41], which states that everything is related to everything else but near things are more related than distant things. Hence, the closer a community is to a water hyacinth infested water body, the more likely will be the impact. The selected communities were Jaway Wharf and Asukro along the Abby-Tano Lagoon and Ellenda Wharf, Takinta Wharf and Adusuazo along the River Tano (Figure 1).

A total of 305 respondents, shown in Table 1, were proportionally selected from the populations of the communities for the study. Since there was lack of data on the population of people who had been affected by water hyacinth invasion in each community, 5% (0.05) of the population of each community was selected and distributed among the various categories of respondents, with the exception of Jaway Wharf where following the method would have made the sample too large. Therefore, a sample of 140 respondents was selected for that community.

Table 1. Population and Sample Characteristics of the Selected Communities.

Community,	Population, 2010.	Sample Selected from the Community
Asukro	314	16
TakintaWharf	163	8
Jaway Wharf	3,626	140
Ellenda Wharf	197	10
Adusuazo	2, 627	131
Total	6, 927	305

Source: GSS [42].

Out of the 305 sample generated, there were 126 fishermen, 84 fish traders, 55 farmers and 40 boat operators. Respondents from these samples were people whose livelihood activities had been affected by the water hyacinth invasion and were to represent fishermen, fish traders, farmers and boat operators whose livelihoods had been affected in the five study communities by presenting information on how they coped with the invasion.

With the introduction of the researchers to community leaders, respondents were contacted personally through the application of the snowballing sampling technique [38], in which only the affected people were traced for data collection purpose. The snowballing sampling method was used due to unavailability of records on the number of people in the various occupation categories who had been affected by water hyacinth invasion.

4.3. Data Collection Methods and Tools

Method triangulation approach [43], involving the use of partially pre-coded questionnaires and Focus Group Discussions, was employed. The use of the partially pre-coded questionnaires was to give respondents the chance to adequately express their opinions in the open questions since the pre-coded questions might have limited them in their ability to contribute vital information to the study. Respondents were interviewed in their homes and at the landing beaches along the selected water bodies. The interviews were conducted in two local languages (Nzema and Twi). This was to serve the language need of all participants, including migrants who mainly resided at Jaway Wharf. All respondents were initially briefed on the purpose of this study and what was required of them. Participation in the study was voluntary. Respondents were assured of confidentiality and anonymity of the responses they provided. To achieve these, no names or other identifying features of the respondents were collected.

Eight focus group discussions (FDGs) were held for two of the selected communities, with a minimum of eight and maximum of twelve people in each group. These numbers were limited to allow for proper group management and rich information sharing. The discussions were conducted in enclosed places to prevent possible interruptions from potential third parties [44]. Individuals were selected and grouped based on gender (men and women) and occupation (fishermen, fish traders and farmers). This was to ensure the free flow of responses in the discussions and to allow each gender category to relate their experiences without intimidation.

In order to serve individual linguistic needs, the FGDs were carried out in the local dialect (Nzema). This made it possible for respondents to eloquently contribute to the discussions. Each group discussion lasted for about 60 minutes. The selected communities for the FDGs were; Adusuazo along the River Tano and Asukro along the Abby-Tano Lagoon. The discussions were facilitated by the researcher and a research assistant, aided by a recorder. An interview guide was developed and used as a checklist during the discussions. The guide was designed after a critical review of literature on coping strategies. Besides the taking of field notes, interviews in the FDGs were audio recorded after seeking the informed consent of participants. The aim was to provide the researcher with the opportunity to capture participants' own words and examine them afterwards, to avoid the loss of useful information during the note taking. On the basis of the main research question and interview guide, both the 305 respondents and FGD participants were asked to highlight the measures they adopted to cope with the effects of water hyacinth invasion on their livelihood activities, the outcomes of the strategies, and whether or not they were satisfied with the outcomes.

4.4. Data Analysis

Quantitative data collected were analysed through descriptive statistics using cross-tabulations, percentage frequency tables, pie charts and stacked bar charts embedded in the statistical package for social sciences (SPSS, Version 16.0) and Microsoft Excel. In order to ascertain the association between the level of education, marital status, sex and ethnicity of respondents and the various coping strategies, a Chi-square test of independence was performed for these demographic variables and the coping strategies. The aim was to examine how the various coping strategies varied among respondents according to their level of education, marital status, sex and ethnicity. Qualitative data, collected in this study were recorded, transcribed and analysed using both inductive and deductive thematic analysis. The audio records taken in the local language during the FGDs were transcribed into English. Through multiple reading of the transcripts, a proper understanding of emerging patterns in the data was developed, with the accounts relating to the objective of the study extracted.

5. Results and Discussions

5.1. Demographic Characteristics of Respondents

Respondents' demographic characteristics such as age and sex highly impact on their capacity to exercise choices and to access opportunities that build their asset base and livelihood strategies in coping with the effects of water hyacinth invasion. In this study, 41.0% of the respondents were fishermen, followed by fish traders (27.5%). Greater percentages of respondents from these occupations were interviewed because their livelihood activities were directly affected by water hyacinth invasion.

More than 62.6% of the respondents were Nzemas, followed by Fantes (21.3%). People from other ethnic groups such as Kusasi and Nyinda constituted only 3.6%. Nzemas were the most represented due to the location of the study area. This study revealed that 28.5% of the respondents were between the ages of 28 and 37, followed by 25.3% who fell within the age group between 38 and 47. The labour force among respondents was therefore mostly found in those two age groups. Furthermore, 66.6% of those interviewed were males. This was mainly because the study largely focused on occupations such as fishing and farming in which the up-stream activities were male dominated. Also no female was found to be engaging in boat operation which was one of the occupations in the study.

5.2. Reactive and Recovery Coping Strategies for the Effects of Water Hyacinth Invasion on Livelihood Activities in the Jomoro District

Coping strategies vary in many respects, both within and between households [45]. Different coping mechanisms are adopted by people at different poverty levels in accordance with varying degrees of wealth among households [46]. The findings of this study shown in Table 2 indicate that riparian people whose livelihood activities had been negatively affected by water hyacinth invasion relied on various strategies to enable them cope. Even though these strategies might have been instigated by other factors, respondents relied on them in times of water hyacinth invasion to bear the effects. While some of the coping strategies employed could be categorized as reactive, others could be classified as recovery strategies [18]. The results show that the most adopted recovery coping strategies were farming and trading, while physical removal and withdrawal from work was mostly adopted as a reactive coping strategy.

Table 2. Reactive and Recovery Coping Strategies of Respondents in the Jomoro District.

Respondents' Coping Strategy	Jaway Wharf	Takinta Wharf	Asukro	Adusuazo	Ellenda Wharf	Total
Reactive strategies						
Physical removal and withdrawal from work	41(13.4%)	-	-	8(2.6%)	2(0.6%)	51(13.4%)
Extension of Business Grounds	15(4.9%)	-	1(0.3%)	3(1.0%)	-	19(6.2%)
Relocation of Business Ground	-	-	3(1.0%)	-	-	3(1.0%)
Recoverystrategies						
Farming	11(3.6%)	5(1.6%)	8(2.6%)	59(19.3%)	4(1.3%)	87(28.4%)
Trading/Coconut Business	21(6.9%)	1(0.3%)	-	31(10.2%)	-	53(17.4%)
Artisanship	9(3.0%)	-	-	2(0.6%)	-	11(3.6%)
Social network	8(2.6%)	-	-	2(0.6%)	2(0.6%)	12(3.8%)
Fishing	5(1.6%)	1(0.3%)	-	9(3.0%)	-	15(4.9%)
Others strategies	22(7.2%)	1(0.3%)	4(1.3%)	8(2.6%)	1(0.3%)	36(11.8%)
None	8(2.6%)	-	-	9(3.0%)	1(0.3%)	18(5.9%)
Total	140(45.9%)	8(2.6%)	16(5.2%)	131(42.9%)	10(3.2%)	305(100.00)

5.2.1. Reactive Coping Strategies Adopted in the Jomoro District

The reactive strategies could be defined as the immediate responsive measures put in place to reduce the effects of water hyacinth invasion. They included actions that stemmed directly from the presence of the water hyacinth.

(i) Physical removal and withdrawal from work

Physical removal and withdrawal from work, as a reactive strategy, was adopted by 13.4% of the respondents. These respondents used the manual method to remove water hyacinth from the water bodies in order to get space for their activities. According to Cilliers et al., [47], manual removal of the weed is invariably the first control option practised in most countries where water hyacinth occurs. The method is mostly adopted at sections of water bodies known to be shallow for people to walk and remove the weeds [48] After failing to control the weeds, respondents withdrew from work by halting activities like fishing and boat operation until the waves or rains had removed them. They relied on earnings previously saved when they could not go to work due to the blockade by the water hyacinth. This implied reduced savings and investment. This observation was made by Mailu [49], in communities around Lake Victoria, Kenya,

where there was loss of earning opportunities when fishermen could not access fishing and fish landing sites, and when the water hyacinth interfered with fishing gears. However, some fishermen in this study reported that the withdrawal helped them by preventing the destruction of fishing gears like nets, while reducing the cost of maintaining them.

In the Lake Victorian Basin however, Kamau et al., [50], reported that some fishermen who were rendered jobless by water hyacinth invasion in the Ndunga community engaged in crimes such as robbery to make a living. Others also engaged in the use of illicit brews and related substance abuse when they became vulnerable and idle due to water hyacinth invasion. The following comments illustrate how respondents in this study adopted the manual method:

I manually remove the water hyacinth with the help of my wife and children. They use their hands while I use the paddle to remove the weeds. In the absence of my children, I hire someone to help remove the weeds. That is the only alternative I have to get access to my cocoa farm (A 40-year old farmer at Ellenda Wharf during an in-depth interview; July, 2016).

(ii) Extension and Relocation of Business Grounds

The water hyacinth invasion and its effects on people's livelihood no doubt motivated people to change the locations of their livelihood activities. Extension refers to a situation where people added new locations to their existing business grounds, while relocation occurred when people moved their businesses to new locations on a long term basis. The extension or relocation of business grounds helped people to ensure the continuity of their livelihood activities. Table 2 shows that a total of 7.2% respondents adopted these strategies. The study revealed that fishermen who fished from the River Tano relocated to the swampy areas along the river when water hyacinth covered the fishing zones. Moreover, there were fish traders who bought fish from the sea when there was low fish catch from the River Tano or Abby-Tano Lagoon. Likewise, there were fishermen who relied on fishing from the sea to make a living when things went bad especially along the lagoon. But there were substantial socio-economic problems associated with this strategy when fishermen also recorded low fish catch from the sea. Although no fisherman along the River Tano fished from the sea, the situation was common among those from Jaway Wharf because of their proximity to the sea.

At Asukro, three respondents had changed their farming locations because of water hyacinth invasion of the Tano Lagoon. After abandoning their initial locations, they farmed in the surrounding areas of the community where they did not need to cross any of the two water bodies before accessing their new farms. One explained in the following words during a Focus Group Discussion:

My wife and I used to have a coconut farm at Tweabo. By the time the coconuts were ready for harvesting in each year, the water hyacinth had blocked the Tano Lagoon. Besides, we had vegetables farm with okra, eggplants, etc. We abandoned the vegetables farm because anytime the produce was ready for harvest; the water hyacinth blocked our access route leading to their destruction. That is why we left the place. The water hyacinth has really affected our finances. We could not recover the money invested in our vegetables farm (A 50-year old farmer from Asukro; August, 2016).

5.2.2. Recovery Coping Strategies Adopted in the Jomoro District

The recovery strategies included measures meant to regain incomes lost through water hyacinth invasion, including the adoption of other livelihood activities.

(i) Farming

The most adopted coping strategy among respondents was farming. The findings presented in Table 2 reveal that it was practised among 28.4% of respondents, especially fishermen and fish traders. The high level of its adoption was due to the location of the district in the rainforest where people took advantage of the relatively high rainfall and temperature to farm. In comparison with strategies like physical removal and withdrawal from work, and extension of business grounds; farming was the main adopted strategy in the four communities along the River Tano and Tano Lagoon. This was because of the presence of the rain forest that favoured farming, unlike Jaway Wharf that is located close to the coast.

Furthermore, majority of respondents interviewed in these communities were Nzemas and hence because they were natives, access to land for agriculture was not really a problem. The findings of Oladehinde et al., [51], in rural border settlements of Ogun State (Nigeria) showed that natives had easy access to land. High cost of land was the major constraint to land accessibility by migrants. Besides, migrants in rural areas often struggled to get access to land since the rights to lands were owned by families which passed on such rights to younger generations. Lands are thus shared among family members leading to land fragmentation and consequent reduction in land availability for migrants.

Cassava farming was the most commonin the study area while vegetables like pepper, eggplant, okra, tomatoes, and cash crops like cocoa and coconut were also grown. Respondents did the farming work to diversify their sources of income and to spread risk [52]. Also, while some farmed to feed their families, others saw crops like cocoa, rubber and

coconut as sources of future security to make themselves economically resilient [20, 53].

While the study confirmed the assertion of Hussein and Nelson [19] that livelihood diversification is normal for most people in the majority of rural areas of developing countries in both Africa and Asia, it revealed a contrary view to their assertion that non-agricultural activities are critical components of the diversification process. This was because respondents in the study communities, by virtue of their location, were highly involved in agricultural activities as recovery coping strategies.

(ii) Trading and Coconut Business

Table 2 indicates that 17.4% of the respondents engaged in trading and coconut business as a recovery coping strategy. Apart from fish trading, some women engaged in trading in commodities such as vegetables, fruits and pomades while others engaged in the production and selling of local dishes to diversify their sources of income. Like their male counterparts, some women engaged in coconut oil processing to raise additional income. In their study among female agro-pastoralists in Ogun State, Nigeria, Ashimolowo and Ayodapo [54], reported that majority of the poor in both rural and urban areas had survival strategies through which they were employed and the coping strategies adopted by female agro-pastoralists included petty trading. This is likely because in most cases agriculture alone cannot provide sufficient livelihood opportunities in most rural areas [55] and thus rural non-farm employment plays a potentially significant role in reducing rural poverty.

In their study on explaining poverty and income source inequality in Rural Nigeria, Adigun et al., [55], also noted that many small and landless farmers undertook non-farm work such as food processing and weaving of apparel in the slack season. The incomes generated from these sources complemented those from farming. This study found that among the five communities, trading was predominant at Jaway Wharf which was an important commercial centre in the district [34] and Adusuazo, where people took advantage of the abundance of coconut farms to engage in coconut trading business.

(iii) Fishing, Artisanship and Social Networking

Fishing, social networking and artisanship were among the recovery strategies adopted by respondents to cope with the effects of water hyacinth invasion. Fishing was particularly prominent at Adusuazo where farmers rotated between farming and fishing as their sources of income. In the peak season of the water hyacinth invasion when these farmers could not access their farms because of the blockade, they strived to fish from sections of the River Tano where the fishing zones had not been completely covered by the infestation. At Jaway Wharf, there were boat operators who supplemented their activity with fishing to raise additional income. At Adusuazo and Jaway Wharf, some respondents engaged in artisanship, including sowing and carpentry, as recovery coping strategies. This affirmed the report of Rantšo [56], that although farming was still the most adopted strategy, more and more people were turning to non-farm activities as a means of making a living due to the decline in agricultural productivity caused by unfavourable agro-climatic conditions.

Meanwhile, this study revealed that social networking was mainly used by fish traders who relied on their family members, especially husbands, for support in the peak season of the water hyacinth invasion when they did not get adequate fish for sale. According to Afridi [23], social networking forms an important component of people's asset base, as it creates opportunity to share resources. The following comments illustrate the use of social networking as a coping strategy:

'I stay in the village with my husband. Even if he does not get enough fish, I stay there with him. He supports me' (A 25-year old fish trader at Adusuazo during an in-depth interview; July, 2016).

The other coping strategies adopted by 11.8% respondents included charcoal production, truck pushing, hunting, farm labour and palm wine tapping. Respondents used these activities to raise additional incomes to supplement those raised from their main livelihood activities. In the study of Ogulande [57], in riverine areas in Ondo State, Nigeria, more than 55% of the respondents reported that water hyacinth invasion had compelled them to adopt other livelihood activities such as lumbering and palm wine tapping to enable them cope with the effects. Respondents in this study who adopted no coping strategies were those who either perceived the water hyacinth invasion to have no direct effects on their livelihood activities or saw the invasion as only advantageous to their work. At Jaway Wharf, for example, some fishermen used the water hyacinth to provide shade in their fish traps while others perceived the presence of the water hyacinth in the lagoon to have increased fish catch.

5.3. Respondents' Outcome and Satisfaction with Coping Strategies

On the basis of the diverse coping strategies adopted which aimed at minimizing the effects of water hyacinth invasion and raising additional income, various outcomes were reported, as displayed in Figure 2.

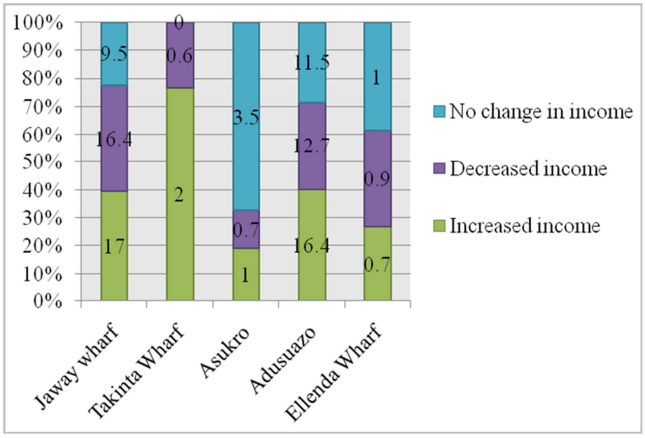

Figure 2. Outcome of Coping Strategies Adopted in the Jomoro District.

After adopting the various coping strategies, 37.1% of respondents reported they experienced an increase in income, 31.3% reported a decreased income, while 25.5%reported they had no change in income. The increased incomes were due to the yield respondents derived from those recovery coping strategies, some of which were reported to have produced better outputs than the occupations directly affected by the invasion.

A number of factors accounted for the decrease in incomes reported, including the multiple effects of water hyacinth invasion on the sources of incomes of respondents. This applied to people who focused on two or more livelihood activities which had all been affected by the invasion. It was typically applicable to respondents who fished in the River Tano and farmed across it as well; hence as the water hyacinth impeded their fishing activities, the blockade caused the destruction of their farm produce as well. A similar situation also affected respondents who were fishermen as well as boat operators. Besides, it was reported that even though some respondents had invested in coconut and cocoa farming because of the invasion, they had not started deriving the benefits because the farms were new.

For respondents who relied on withdrawal from work as a coping strategy, earnings previously saved were spent in the waiting period. Also, when there was low fish catch from the sea, demand and price for fish increased. Therefore, fish traders who relied on fish catch from the sea as a coping strategy also had their incomes reduced since they could not get adequate fish to sell to make profit. Thus overall, the reactive coping mechanisms negatively affected the incomes of respondents who adopted them; suggesting that the recovery strategies were better in the short and long term.

Among the reasons given for the no change in incomes recorded by 25.5% of the respondents was the subsistence nature of their coping strategies. For example, the identified farming work was mainly on a subsistence basis and so generated little income. At Asukro for example, the observations made indicated that respondents largely did their cassava farming in the coconut plantations instead of forests which resulted in lower yields. In the light of the challenges outlined, majority of the respondents reported they were not satisfied with the outcomes of their coping strategies, as shown in Figure 3. This reaffirms the findings that even the advantages that come with non-farm activities do not necessarily mean that rural people benefit from such activities [57, 58].

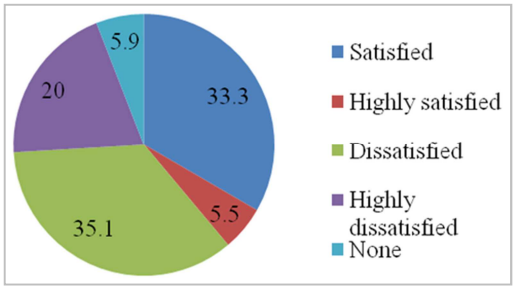

Figure 3. Respondents' Satisfaction with Coping Strategies in the Jomoro District.

5.4. Factors Influencing the Coping Strategies of Respondents

Gender, marital status and educational level are among the important determinants of empowerment at both communal and individual levels [60, 61]. For example, rural people who are better-educated have better access to any non-farm employment on offer, and are also more likely to establish their own non-farm businesses [62].

5.4.1. Relationship Between Level of Education of Respondents and Coping Strategies

In this study, the education levels of respondents were found to influence their coping strategies. The results shown in Table 3 indicate that while farming as a recovery strategy was mainly adopted by primary school leavers, physical removal and withdrawal from work as a reactive strategy was mainly adopted by respondents with no formal education. There was significant relationship between the two categorical variables (education and reactive or recovery strategies). At $\alpha_{.05}$ significant level, the Chi-Square value was χ^2=81.106 at a degree of freedom *df*=36. The probability value of establishing the association, *p-value* was p=0.00. This asserts Gordon and Craig [61], that peoples' level of education influence their access to economic activities. A Cramer's *V* test of strength of the association, however, revealed a weak link between the variables with a value of *V*= .258. This was an indication that the coping strategies adopted by respondents partially depended on their levels of education. If any given respondent was randomly selected

out of the sample, there would be the likelihood that the person would adopt any of the coping strategies irrespective of his/her level of education.

Table 3. Level of Education and Coping Strategies in the Jomoro District.

Coping Strategies	Primary school	Junior High School	Form four/Senior High School/Technical School	Tertiary	No formal education	Total
Farming	34(39.1%)	16(18.4%)	22(25.3%)	1(1.1%)	14(16.1%)	87(100%)
Extension of Business Grounds	5(26.3%)	3(15.8%)	2(10.5%)	-	9(47.4%)	19(100%)
Trading/Coconut Business	14(26.4%)	15(28.3%)	9(17%)	-	15(28.3%)	53(100%)
Artisanship	-	3(27.3%)	3(27.3%)	1(9.1%)	4(36.4%)	11(100%)
Social network	6(50%)	2(16.7%)	3(25.0%)	-	1(8.3%)	12(100%)
Fishing	5(33.3%)	4(26.7%)	5(33.3%)	-	1(6.7%)	15(100%)
Physical removal/withdrawal from work	9(17.6%)	13(25.5%)	12(23.5%)	-	17(33.3%)	51(100%)
Relocation of Business Ground	-	1(33.3%)	-	1(33.3%)	1(33.3%)	3(100%)
Other Strategies	12(33.3%)	16(44.4%)	2(5.6%)	-	6(16.7%)	36(100%)
None	4(22.2%)	5(27.8%)	3(16.7%)	-	6(33.3%)	18(100%)
Total	89(29.2%)	78(25.6%)	61(20.0%)	3(1.0%)	74(24.3%)	305(100%)

5.4.2. Relationship Between Marital Status of Respondents and Coping Strategies

The result of the chi square test of independence, indicated in Table 4, revealed that the various coping strategies were adopted based on respondents' marital status. It showed that married respondents dominated in the adoption of both reactive and recovery strategies, mainly because of their numbers in the sample. The result indicated that there was a significant relationship between marital status of respondents and coping strategies. At $\alpha_{.05}$ significant level, the Chi-Square value was χ^2= 51.890 at a degree of freedom *df*=36. The probability value of establishing the association, *p-value* was p=.042. According to Sadiq and Ishaq [63], marital status is an effective factor influencing the decision making of investors. For example, a positive correlation exists between marital status and financial risk tolerance. A Cramer's *V* test of strength of the association, however, revealed a weak correlation between the variables with a value of *V*= .206. This showed that even though there was a significant difference between respondents' marital status and coping strategies, the difference was not large. The coping strategies adopted by respondents only partially depended on their marital status. If any given respondent was randomly selected from the sample, there would be the likelihood that the person would adopt any of the coping strategies irrespective of his/her marital status.

Table 4. Marital Status of Respondents and Coping Strategies in the Jomoro District.

Respondents' Coping Strategy	Married	Single	Divorced	Widowed	Consensual Union	Total
Farming	69(79.3%)	7(8.0%)	4(4.6%)	1(1.1%)	6(6.9%)	87(100%)
Extension of Business Grounds	12(63.2%)	2(10.5%)	3(15.8%)	2(10.5%)	-	19(100%)
Trading/Coconut Business	38(71.7%)	7(13.2%)	-	2(3.8%)	6(11.3%)	53(100%)
Artisanship	7(63.6%)	3(27.3%)	-	-	1(9.1%)	11(100%)
Social network	8(66.7%)	1(8.3%)	-	-	3(25%)	12(100%)
Fishing	13(86.7%)	1(6.7%)	-	-	1(6.7%)	15(100%)
Physical removal/withdrawal from work	42(82.4%)	6(11.8%)	2(4.0%)	-	1(2.0%)	51(100%)
Relocation of Business Ground	3(100%)	-	-	-	-	3(100%)
Other	20(55.6%)	9(25.0%)	1(2.8%)	1(2.8%)	5(13.9%)	36(100%)
None	15(83.3%)	2(11.1%)	-	1(5.6%)	-	18(100%)
Total	227(74.4%)	38(12.5%)	10(3.3%)	7(2.3%)	23(7.5%)	305(100%)

5.4.3. Relationship Between Sex of Respondents and Coping Strategies

Factors that influenced coping strategies among respondents in the study included sex. The results from the chi square test of independence, shown in Table 5, indicated a significant relationship between sex of respondents and the coping strategies. At $\alpha_{.05}$ significant level, the Chi-Square value was χ2= 84.634 at a degree of freedom df=9. The probability value of establishing the association, p-value was p=0.00. A Cramer's V test of strength of the association also showed a moderately strong correlation between the variables with a value of V= .527. For example, the adoption of reactive measures like physical removal and withdrawal from work was dominated by males. The communal labour which was organised to remove water hyacinth from the two water bodies was mainly undertaken by men. On the other hand, recovery strategies such as trading and social networking were female dominated.

Table 5. Sex of Respondents and their Coping Strategies in the Jomoro Districts.

Respondents' Coping Strategies	Male	Female	Total
Farming	56(64.4%)	31(35.6%)	87(100%)
Extension of Business Grounds	8(42.1%)	11(57.9%)	19(100%)
Trading/Coconut Business	19(35.8%)	34(64.2%)	53(100%)
Artisanship	11(100.0%)	-	11(100%)
Social network	3(25.0%)	9(75.0%)	12(100%)
Fishing	15(100.0%)	-	15(100%)
Physical removal/withdrawal from work	49(96.1%)	2(3.9%)	51(100%)
Relocation of Business Ground	2(66.7%)	1(33.3%)	3(100%)
Other strategies	31(86.1%)	5(13.9%)	36(100%)
None	11(61.1%)	7(38.9%)	18(100%)
Total	203(66.6%)	102(33.4%)	305(100%)

5.4.4. Relationship Between Ethnicity of Respondents and Coping Strategies

The chi square test of independence ran (Table 6) indicated that the coping strategies of respondents varied according to their ethnical background. The results showed a significant relationship between the two variables. A significant majority of Nzemas adopted farming and trading as recovery coping strategies. Migrants, on the other hand, dominated in the adoption of the extension of business grounds as a reactive coping strategy. At $\alpha_{.05}$ significant level, the Chi-Square value was χ^2=1.159E2 at a degree of freedom *df*=36. The probability value of establishing the association, *p-value* was p=.000. A Cramer's *V* test of strength of the association, however, revealed a weak link between the variables with a value of *V*= .308. This indicated that despite the significant relationship between respondents' ethnicity and coping strategies, the coping strategies did not entirely depend on ethnicity. If any given respondent was randomly selected from the sample, there would be the probability that the person would adopt any of the coping strategies in spite of his/her ethnical background.

Table 6. Ethnicity of Respondents and Coping Strategies in the Jomoro District.

Coping Strategies	Nzema	Fante	Ewe	Asante	Others	Total
Farming	79(91%)	1(1.1%)	3(3.4%)	2(2.2%)	2(2.2%)	87(100%)
Extension of Business Grounds	6(35.3%)	9(52.9%)	4(23.5%)	-	-	19(100%)
Trading/Coconut Business	38(71.7%)	8(15.1%)	5(9.4%)	-	2(3.8%)	53(100%)
Artisanship	4(36.4%)	6(5.5%)	1(9.1%)	-	-	11(100%)
Social network	3(27.3%)	4(33.3%)	2(18.2%)	1(9.1%)	2(18.2%)	12(100%)
Fishing	10(66.7%)	1(6.7%)	2(13.3%)	1(6.7%)	1(6.7%)	15(100%)
Physical removal/withdrawal from work	14(27.5%)	22(43.1%)	14(27.5%)	-	1(2.0%)	51(100%)
Relocation ofBusiness Ground	3(100%)	-	-	-	-	3(100%)
Other	21(54.4%)	9(27.3%)	3(9.1%)	-	3(9.1%)	36(100%)
None	12(66.7%)	5(27.8%)	1(5.6%)	-	-	18(100%)
Total	190(62.6%)	65(21.3%)	35(11.5%)	4(1.3%)	11(3.6%)	305(100%)

6. Summary, Conclusion and Recommendations

Water hyacinth invasion compels people to adopt various strategies to cope with the effects. Our aim in this paper was to contribute to knowledge on the water hyacinth discourse by focusing on the coping strategies adopted by people in the face of the invasion. Findings show that both recovery and reactive measures are adopted to help reduce the effects of water hyacinth invasion. The recovery strategies include both farm and non-farm income generating activities. There are riparian people who either change occupations or switch from one activity to another within the same occupation. Others resort to reactive measures like physical removal, relocation or extension of business grounds in order to cope with the effects of the invasion.

Our findings revealed that the most predominant coping strategy adopted to cope with water hyacinth invasion was farming. However, other respondents mainly relied on trading, and physical removal and extension of business grounds as coping strategies. Our findings further suggest that the location, level of education, marital status, sex and ethnicity of people influence the strategies adopted to cope with water hyacinth invasion. In this study for example, while farming as a recovery coping strategy was mainly adopted in communities along the River Tano, physical removal and withdrawal from work was mainly adopted by respondents along the Abby-Tano Lagoon. In relation to their levels of education, farming was mainly adopted by primary school leavers; while physical removal and withdrawal from

work as a reactive strategy was mainly adopted by respondents with no formal education. The study also found that married respondents dominated in the adoption of all the coping strategies. However, with respect to the sex of respondents, males mainly adopted physical removal and withdrawal from work as a coping strategy while trading and social networking were mainly adopted by females. In addition while Nzemas were found to be mainly adopting farming as a strategy, respondents from other ethnical backgrounds adopted the extension of business grounds.

Our findings showed that farming was the most adopted coping strategy in the study area hence respondents who adopted it should be aided to access credit to enable them secure adequate inputs to enhance their farming activities. Although such interventions might already exist in rural areas, there is a need to increase their extent of coverage to help reduce the effects of negative externalities on the livelihood activities of people. We also recommend that since the study categorised the coping strategies of all the 305 respondents into two, namely reactive and recovery strategies, further studies are needed that will focus on the reactive coping strategies that are adopted by all the affected people as well as the recovery coping strategies adopted by all of them for effective comparisons of the results of such strategies. This will help provide a better picture of which set of strategies produce better outcomes. In the long term, developing measures that will address both the reactive and recovery strategies will help reduce, if not completely eradicate, the effects of water hyacinth invasion.

Funding

This work was funded by the DANIDA Fellowship Centre [grant number 2GBIONRG] under the project "Biofuel production from lignocellulosic materials". We express our appreciation to the coordinator, Dr. Moses Mensah at the Department of Chemical Engineering (KNUST), for making funds available for the fieldwork.

Declaration of Interest

All the authors do not have any possible conflicts of interest.

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