Effects of water hyacinth invasion on sustainability of fishing livelihoods along the River Tano and Abby-Tano Lagoon, Ghana

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Abstract: Fishing and fish trading as livelihood activities come under severe threat due to water hyacinth infestation of fresh water bodies. Based on cross-sectional research with 126 fishermen and fish traders who were sampled using the snowballing sampling technique, this study assessed the effects of water hyacinth invasion on fishing and fish trading livelihoods in communities along River Tano and Abby-Tano Lagoon in the Jomoro District, Ghana. Five communities along River Tano and Abby-Tano Lagoon in the district were purposively selected for the study. Questionnaire administration and Focus Group Discussions were employed as data collection methods in the study. We found that water hyacinth infestation had both positive and negative effects on fishing and fish trading. However, while communities along the Abby Lagoon found water hyacinth helpful in their fishing endeavour, those along the River Tano found them disruptive of their fishing activities, making their livelihoods precarious and unsustainable. Among the problems posed by the invasion to fishing and fish trading were: denial of access to fishing grounds, delays in preparatory work for fishing, fishing traps siltation, low fish supply and reduced profit. In a few cases, however, water hyacinth was perceived to have led to increased fish catch and income. To resolve the annual problem of low fish catch...
and difficulties encountered to reach fishing grounds due to the infestation, the study recommends the establishment of fish farms in both water bodies to ensure all year-round production of fish devoid of the water hyacinth menace.

Subjects: Development Studies; Sustainable Development; Rural Development; Economics and Development; Human Geography

Keywords: Water hyacinth infestation; invasion; fishing; fish trading; Jomoro District; Ghana

1. Introduction

Water hyacinth (Eichhornia crassipes) is a highly productive free-floating aquatic plant which has proven to be a serious economic and ecological burden to many subtropical and tropical regions of the world (Jafari, 2010). The dense mats of the weeds disrupt socio-economic and subsistence activities such as boat navigation, fisheries and farming (Honlah, Segbefia, Appiah, & Mensah, 2019a; Ndimele & Jimoh, 2011). Several water bodies on the African continent have been infested with water hyacinth (Borokini & Babalola, 2012; Ndimele & Jimoh, 2011). In Ghana, the River Volta, River Tano and Abby-Tano Lagoon have been affected by water hyacinth (Annan, 2012; Hauser, Wernand, Korangteng, Simpeney, & Sumani, 2014; Honlah, Appiah, & Segbefia, 2019b; Honlah et al., 2019a). In spite of the adverse effects of water hyacinth, studies have shown that it promotes fish diversity, particularly smaller species, and the mechanisms for this include reducing fishing pressure by providing habitat for fish and aquatic invertebrates (Kateregga & Sterner, 2009). Despite their value, water hyacinth presently remains a menace to riparian communities especially in Ghana since there is the lack of technical know-how to duly utilise these weeds for economic benefits (Honlah et al., 2019b).

Studies have been conducted into different aspects of the water hyacinth, including its bioethanol production potential (Ayodele, Oseni, & Uthman, 2015), ecological and socio-economic utilisation (Jafari, 2010), impacts on fishing communities (Waithaka, 2013), effects on fish stocks (Kateregga & Sterner, 2009) and appropriate control measures (Ray & Hill, 2013). In Ghana the effects of water hyacinth invasion on smallholder farming, health and education (Honlah, Appiah, Segbefia, Mensah, & Atakorah, 2019c; Honlah et al., 2019a); the coping strategies to water hyacinth invasion (Honlah et al., 2019b), as well as the utility of water hyacinth (Honlah, Appiah, Segbefia, & Mensah, 2019d) have been studied. Hauser et al. (2014), also studied how water hyacinth could be turned from menace to sustainable opportunity by fostering local entrepreneurship. However, none of the studies in Ghana deals with how water hyacinth invasion affects the activities of fishermen and fish traders, which makes this study relevant. This is because fishing and fish trading are major livelihood activities in communities along River Tano and Abby-Tano Lagoon in the Western region of Ghana. However, the recent spread of water hyacinth impedes fishing and reduces the income of both fishermen and fish traders. The main objective of this paper is to analyse the effects of water hyacinth invasion on the sustainability of fishing and fish trading along River Tano and Abby-Tano Lagoon.

The sustainable livelihood framework (SLF) was used to organise thoughts around the effects of water hyacinth invasion on fishing livelihoods. The framework helps to understand how individuals combine the various assets/capitals (natural, physical, financial, social and human) available to them in engineering their livelihoods, and what factors may influence the viability, security and sustainability of such livelihoods. Natural capital refers to the living and nonliving components of ecosystems—other than people and what they manufacture. It is key to the generation of goods and services of value for people (Guerry, et al., 2015) and includes water, air and aquatic resources (Serrat, 2008). The two water bodies may be considered natural capital, providing fish and sustaining fishing and fish trading livelihoods. Water hyacinth may become a menace, impeding fishing effort and reducing the viability of fishing or it may enhance fishing by providing a hiding
place for fishes. However, water hyacinth on its own could become a natural resource if local residents are able to convert them to useful products.

Physical assets are the facilities that people need to ensure efficient running of their livelihood strategies. They include infrastructure such as transport, tools and technology (Serrat, 2008). The availability of these assets facilitates increased productivity thereby enhancing peoples’ living standard. Vessels such as boats and canoes and working gears like nets and traps are physical capital that make fishing sustainable. However, the blockade by water hyacinth in the two water bodies impedes the use of these assets, thus posing a challenge to the sustainability of the fishing business.

An important component of the fishing and fish trading livelihood is the skills, knowledge, and health of the fishers, which constitute the human capital/asset. It is arguably the most important asset with which the other ones are organised and assembled or combined. Water hyacinth invasion may affect this asset in various ways. They serve as breeding grounds for mosquitoes (malaria) and other diseases-causing vectors such as snails (Schistosomiasis) which can affect the use of this asset (Honlah et al., 2019c; Patel, 2012). When fishermen are infested with malaria and other sicknesses associated with the weeds, their productivity is affected as they are not able to go fishing during periods of illness and recovery.

Fishers rely on financial assets/capitals including cash, savings, and credit (Scoones, 1998; Serrat, 2008) to acquire physical assets to pursue their activities. The water hyacinth infestation reduces the quantity of fish catch as fishermen are denied access to their fishing zones. This affects not only fishermen but fish traders who rely on the fishermen for fish supply. The reduction in productivity reduces the financial asset/capital of the fishers. This, in turn, affects their capacity to acquire the needed physical assets to invest in their livelihoods.

Social asset/capital stands for the ability of actors to secure benefits by virtue of membership in social network or other social structures (Ijaiya et al., 2012). It comprises of family or social relations which people lean upon as tools for pursuing different livelihood strategies which require organised and mutual efforts (Serrat, 2008). Water hyacinth invasion may prevent fishers from commuting between communities located across the sections of the water bodies to interact with their relatives and friends. This impediment may affect their social assets as they may not be able to effectively take advantage of these relationships to acquire other assets like finance to invest in their fishing activities. According to Guerry et al., (2015), the different forms of capital interact to generate goods and services. For fisher folks, the quantity of fish harvested depends on a number of assets/capital including the availability of fish stocks (natural capital), which in turn depends on the quality of habitat (natural capital). Besides, harvesting is also influenced by manufactured and financial resources such as vessels as well as the skills and experience of fishers (human capital), and fisheries governance (social capital). The absence of, or challenges posed to the use of any of these assets impede production.

2. Materials and methods

2.1. Profile of study area
The Jomoro District is found in the Western Region of Ghana. It is located between latitudes 4° 80 ′ N and 5° 21 ′ N and longitudes 2° 35 ′ W and 3° 07 ′ W. It is located in the rainforest zone with a high rainfall and uniform temperatures. The majority of people employed (aged 15 years and above) are engaged in skilled agriculture, including forestry and fisheries (39.0%). However, more males (46.5%) are employed as workers in these sectors (Ghana Statistical Service, 2010). Due to the availability of wetlands and freshwater bodies, these men depend on canoe-fishing as their source of livelihood (Jomoro District Assembly, 2012).

2.2. River Tano and Abby-Tano Lagoon
The Tano River Basin is a principal south-western river basin system in Ghana. It is located between latitudes 5° 00 ′ N and 7°40 ′ N, and longitudes 2° 00 ′ W and 3°15 ′ W (Water Resources Commission,
The River Tano is transboundary since the last 100 km of the downstream course of the river flows across the international boundary between Ghana and La Côte d’Ivoire before finally joining the Abby-Tano-Ehy Lagoon system (Water Resources Commission, 2012). The Abby-Tano Lagoon is also located in the south-western part of the Jomoro District. While the Abby Lagoon is located 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 (Honlah et al., 2019b, 2019c). However, the two water bodies are interconnected with the Ehy Lagoon in La Côte d’Ivoire to form a lagoon complex (Finlayson, Gordon, Ntiamoa-Baidu, Tumbulto, & Storrs, 2000), as shown in Figure 1.

3. Methods

3.1. Research design

The study adopted the cross-sectional study design. In using this approach, the effects of water hyacinth invasion on fishing and fish trading was studied only once in all the selected communities. Besides, data were gathered from a cross-section of the population of each community (Kumar, 2011). The mixed-method, involving the collection of both qualitative and quantitative data from the field was also adopted. The aim of the partly qualitative study was to provide detailed information to augment those obtained from the structured surveys, since the use of only structured surveys could not have contributed to a complete understanding of the problem (Honlah et al., 2019a, 2019c). According to Ganle, Afriye, and Segbefia (2015), a strictly quantitative design such as a survey with a large sample could be used in a study, but such a design offers limited space. Therefore, the use of such a design alone could not have provided the opportunity for a more descriptive and exploratory study of the effects of water hyacinth invasion on fishing and fish trading.

According to Creswell (2010), the use of both quantitative and qualitative data in a study gives a better understanding of a research problem than using only one of them. Quantitative data collected in the study included the effects of water hyacinth invasion on fishing, fish trading and the incomes of both fishermen and fish traders. Qualitative data, on the other hand, included direct quotes from respondents.

3.2. Sampling procedure

The study made use of non-probability sampling procedure in the selection of the study communities and respondents. The process involved a two-stage sampling procedure. In the first stage, five riparian
communities close to the water bodies were purposively selected. According to the distance decay
effect theory, as the distance between two localities increases, the level of interactions between them
decline (Dempsey, 2012). The first law of Geography by Tobler (1970) also states that everything is
related to everything else but near things are more related than distant things. Communities that were
close to the water hyacinth-infested waterbodies were therefore anticipated to suffer more from the
effects of the invasion. While Asukro and Jaway Wharf, were selected along the Abby-Tano lagoon;
Ellenda Wharf, Takinta Wharf and Adusuazo were selected along the River Tano.

In the second stage, snowballing sampling procedure was used to trace fishermen and fish
traders whose livelihood activities had been affected by the invasion for the administration of the
questionnaires. This process followed the introduction of the researcher and his assistant to the
community leaders. The snowballing sampling technique was used because the researcher did not
have at his disposal the records of fishermen and fish traders whose activities had been affected
by the invasion (Honlah et al., 2019a, 2019b).

In all, 210 respondents were selected for the study. To ensure fairness in the selection of
respondents from the communities, the proportionate sampling method was used to calculate
and select 11 respondents from Asukro, 6 from Takinta Wharf, 100 from Jaway Wharf, 7 from
Ellenda Wharf and 86 from Adusuazo; based on their respective population sizes. Out of the 210
samples generated, there were 126 fishermen and 84 fish traders.

3.3. Data collection methods and instruments
In order to reproduce respondents’ views about the effects of water hyacinth invasion on fishing and
fish trading, focus group discussions (FGDs) were employed to collect data. However, structured
instrument was used to collect data to complement those derived from the FGDs. Four FGDs were
organised in two of the selected communities, including Adusuazo along River Tano and Asukro
along the Abby-Tano Lagoon. Participants were grouped based on gender (men and women) and
occupation. The aim of the gender groupings was to make sure respondents from each gender
category freely expressed their views in the discussions without fear of being intimidated by
participants from the other gender identity (Honlah et al., 2019c; Honlah et al., 2019b). The
occupational groupings, on the other hand, were to yield similar and rich information from the
discussants.

Each group had a membership range between eight and twelve. The aim was to use limited
numbers that would lead to proper group management and fruitful discussions (Honlah et al., 2019c;
Mumin, Gyasi, Segbefia, Forkuor, & Ganle, 2018). The discussions were conducted in the local dialect
(Nzema) of the study communities, in order to serve the linguistic needs of the discussants. They
were also conducted in enclosed and serene places to prevent external interferences that could
affect the process. Each discussion lasted for about 60 min. The discussions were facilitated by the
researcher and a research assistant. After obtaining participants’ verbal consents, the interviews
were recorded using an audio recorder (Honlah et al., 2019a, 2019b, 2019d).

Besides the audio recorder, open-ended interview guide was developed for the FGDs. This was
designed after a review of literature on the effects of water hyacinth invasion on fishing activities
in other jurisdictions. Based on the main research question, some of the issues explored include:
how do the water hyacinth affect your livelihood activities; how has the invasion affected your
income from your occupation; and what do you think your future living condition will be in the
presence of the water hyacinth?

Supplementary to the information derived from the interviews and questionnaire administration,
secondary data were collected by consulting other research papers, journal articles, reports from
government departments and e-materials. These secondary data were particularly useful in
providing information about the effects of water hyacinth invasion, especially in other jurisdictions.
Some also contained information relevant to the case study, such as the types of aquatic weeds.
that pose danger to the use of water resources along River Tano and Abby-Tano Lagoon, and the biological method used to control the water hyacinth invasion and other aquatic weeds in the study area. They, therefore, helped to contextualise the data (Bowen, 2009).

3.4. Research instruments
The study made use of two main instruments. While open-ended interview guides were used in the focus group discussions, interviewer-administered questionnaires were used in collecting data from the 210 respondents. However, in order to derive focused information and effectively compare the responses, similar issues were raised in the two sets of instruments. Both close and open questions were raised in the questionnaire. The aim was to give respondents the opportunity to adequately contribute descriptive information to the study, since the close questions might have limited them in their quest to contribute viable information to the study (Honlah et al., 2019a, 2019b).

3.5. Data analysis
Quantitative data collected from the field were analysed using descriptive statistics such as percentages, frequency tables and bar charts in statistical package for social sciences (SPSS, V 16.0) and Microsoft Excel. Besides, some of the responses from the participants were quoted directly in the analyses of qualitative data. Dey’s (1993) three-step process of transcription, classification and interconnecting were used to analyse qualitative data from the interviews. These data were analysed using both inductive and deductive thematic analysis. The audio records taken during the FGDs were first transcribed into English. Following that, the transcript was thoroughly read and information that was related to the objective of the study was extracted.

4. Results and discussion

4.1. Effects of water hyacinth invasion on fishing
Research has shown that water hyacinth invasion has negative consequences on fish and fishing. The negative effects have been highlighted at the international level (Sotolu, 2012). Table 1 presents the effects of water hyacinth invasion on fishing in the study area.

Table 1 shows that 80.3% of the fishermen reported to have had their activities negatively affected by water hyacinth invasion. The following subsections present these negative effects.

4.1.1. Denial of access to fishing grounds
Table 1 indicates that 62.7% of the fishermen reported that water hyacinth invasion posed problems to the use of fishing gears in the River Tano and Abby-Tano lagoon. It was mainly reported at Jaway Wharf and Adusuazo that it became difficult for fishermen to set gears like raffia traps, hook and line, and bamboo traps when water hyacinth covered the fishing zones. This happened until the weeds were drifted away by the waves or rains, affirming the report of Moyo, Segbefia et al., Cogent Food & Agriculture (2019), 5: 1654649 https://doi.org/10.1080/23311932.2019.1654649

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Chapungu, and Mudzengi (2008), that floodwaters contribute to the removal of water hyacinth. There were instances where fishing gears like raffia and bamboo traps, and wire nets were drifted away by floating hyacinths. In some cases, fishermen abandoned their traps after they had been covered by water hyacinth. The effect of the invasion on the use of fishing gears was expressed in the following words by a respondent during a Focus Group Discussion:

“The water hyacinth entangles our nets. When this happens, we do not get adequate fish. It also breaks the net. Money must thus be spent to buy a new one. When the water hyacinth comes, we do not get enough fish because it occupies the space for fishing. In July, we are supposed to retire from fishing, some have left for their homes but many of us are still here due to the hardship posed by the water hyacinth invasion” (A 40-year old man at Asukro; August, 2016).

Because of the challenges posed by the water hyacinth, it was reported that fishing activities especially in the River Tano, came to a halt in the dry season, from December to March. Fishermen mostly waited till the weeds had been moved downstream by the increased volumes of water in the rainy season (Moyo et al., 2008). These findings reflect the observation made by Twongo and Howard (1998) that the presence of water hyacinth blocks fishing grounds for species like tilapia in Lake Victoria, and according to Faton et al. (2015), the weeds cause damage to fishing equipment. The destruction of the gears of fishermen in this study brought about increased cost of production since it reduced the life span of these gears. The high cost of production resulted in a reduction of the net profit generated by fishermen. Kamau, Njogu, Kinyua, and Sessay (2015), have reported that there exists a significant relationship between the proliferation of water hyacinth in the Lake Victoria and the increased cost of fishing. This situation has affected fishermen and fish consumers because reduced quantity of fish catch in the presence of dense mats of water hyacinth means fishermen dig deeper into the pocket to pay for the increased cost of production associated with the destruction of fishing gears. This directly leads to a rise in the price of fish and indirectly influences the behaviour of some community members in their quest to cope with the increasing cost of living. The instances of young women engaging in prostitution with fishermen in exchange of fish to feed their families have been indicated to be on the rise in the Nduga village of the Lake Victorian Basin.

In related studies, Kateregga and Sterner (2009) and Aloo, Ojwang, Omondi, Njiru, and Oyugi (2013), found that fish production in Lake Victoria declined because water hyacinth had blocked many fish landing beaches, sheltered bays which were breeding grounds of fish while in open waters, the mats of the weeds had swept away and entangled fleets of nets. The mats also posed obstruction to fisheries exploitation which led to higher operation costs hence increase in fish prices. Many landing beaches have therefore been abandoned and income-generation from the sale of fish has been negatively affected. Kateregga and Sterner (2009) also reported that although fish stocks in Lake Victoria had fallen since 1990, the decline appeared to have been at least temporarily halted by the declining catchability of fish because of the increasing amount of water hyacinth. Onyango and Ondeng (2015), in their study, reported that fish catch rates on the Kenyan section of Lake Victoria decreased by 45% because water hyacinth mats blocked access to fishing grounds, delayed access to markets and increased costs in terms of effort and materials of fishing. The presence of water hyacinth in River Tano and Abby-Tano Lagoon, therefore, does not only affect the waterways and fishing zones as natural assets, but it also has a ripple effect on the physical (fishing gears) and financial (income) assets of the fishermen. These effects negatively affects the sustainability of fishing livelihood in the study area.

Water hyacinth invasion also contributed to fishermen finding themselves in economic hardship since it reduced their incomes. This problem was mostly reported at Adusuazo. According to these fishermen, the low fish cash recorded during the season of the invasion meant they had relatively low quantity of fish for sale which affected their net profit. This affirmed earlier findings (Aloo et al., 2013; Kamau et al., 2015; Kateregga & Sterner, 2009; Onyango & Ondeng, 2015). It was reported in this study that fishermen sometimes relied on credits to prepare their fishing gears. However, when water hyacinth prevented them from getting enough fish catch to generate the needed income to pay the loan, they had to engage in other livelihood activities to enable them to repay. This brought about economic hardship.
A reduction in their financial asset made it difficult to make the necessary investment in the fishing business. One fisherman explained in the following words during an in-depth interview:

“I could stay in the house for about four days without going to fish” (A 30-year old fisherman from Jaway Wharf; August, 2016).

4.1.2. Delays in preparatory work for fishing

Water hyacinth invasion was reported to bring about delays in the preparatory work done by fishermen. At Adusuazo, it was reported that fishermen prepared for fishing in the swamp across the River Tano in the dry season using a trap known as atele in the local parlance. However, it was in that period that water hyacinth blocked their access routes on the river. This prevented them from crossing to prepare the grounds for fishing to take place during the raining season. By the time the rains removed the water hyacinth to make the swamp accessible, it was too late to work on the gears so as to fish since the fishing zones in the swamp then got flooded. This problem which came up in the FGD with the fishermen was explained by one of them in the following words:

“In the dry season (January to March), when we are supposed to start preparing our fishing gears to be used in the swamp, the water hyacinth prevents us from doing so by blocking our navigational route on the River Tano. By the time the rains move them downstream the fishing grounds are already flooded and so we cannot do efficient work to set adequate traps to get enough fish” (A 40-year old man at Adusuazo; July, 2016).

Studies have shown that the presence of water hyacinth impedes water transportation. The mats of the weeds clog waterways due to their rapid growth and propagation rate (Ndimele & Jimoh, 2011; Patel, 2012). Even boats require extra time to dock in the presence of the dense mats of water hyacinth (Aloo et al., 2013). The reliance of fishermen in this study on dugout canoes for fishing thus worsens their plight because the use of these physical assets is hindered with negative implications on the sustainability of the fishing occupation.

4.1.3. Increased working hours and fishing traps siltation

The coverage of River Tano and Abby-Tano Lagoon by water hyacinth meant fishermen must spend longer period struggling their way through to get access to their fishing grounds and landing beaches. This led to increased number of hours spent on fishing. Majority of fishermen who reported on this problem came from Jaway Wharf. One explained in an in-depth interview:

“In times of excess water hyacinth proliferation, we could go to the lagoon at 5:00 am and come home after 12:00 noon instead of the normal 8:30am. Sometimes we come in the evening” (A 45-year old fisherman at Asukro; August, 2016).

Apart from the blockade by the water hyacinth that caused the delays, fishermen also noted they spent quite a long time disentangling their nets from the leaves and roots of water hyacinth and other debris (Figure 2). In addition, they found it difficult to cart their produce to the market using canoes in the dry season; an observation made by Patel (2012) and Ndimele, Kumolu-Johnson, and Anetakhai (2011).

There were fishermen who also perceived water hyacinth as an agent of siltation to their fish traps. This problem was mainly reported at Adusuazo. It was indicated that in the absence of the weeds, the free-flowing river kept the raffia traps clean to attract fish. However, in their presence, dirt from their roots entered the traps. This prevented the fish from entering leading to low fish catch. This was observed by Jayan and Sathyanathan (2012), that the dense roots of aquatic weeds slowed down the movement of water thereby allowing sediment to settle on the bed of the invaded water body. According to Madsen (2005), aquatic plants in excess can harm a system by reducing water quality, slowing water velocity and facilitating siltation.
4.1.4. Increased fish catch

Contrary to the widespread opinion that water hyacinth invasion impede fish catch, 14.3% of fishermen in this study reported that the presence of the weeds led to increased fish catch. This was because the weeds provided hiding places for the fish. There were fishermen who also thought that despite the challenges posed to the use of fishing gears, the weeds led to increased fish catch. This was highlighted by a fisherman in the following words:

“*When the water hyacinth are few, the fish breed under it. However, when it is in excess, it disturbs a lot. It can even drift the nets away. You hardly get enough catch because you can’t use the gears*” (A 35-year old man at Jaway Wharf; August, 2016).

According to Villamagna and Murphy (2009), the effect of water hyacinth on fish communities depends on a number of factors including the preferred and available fish habitat, physio-chemical conditions and probably, water hyacinth density. These make it difficult to point out specific effects. McVea and Boyd (1975), and Dribble, Killgore, and Harrel (1996) have indicated that intermediate coverage of a water body by water hyacinth yields maximum fish growth and abundance. This is because the fish feed on micro-organisms under the water hyacinth (Bhattacharya, Haldar, & Chatterjee, 2015; Brendonck et al., 2003). Besides, Dugdale, Hunt, and Clements (2013) have reported that aquatic plants are necessary components of freshwater ecosystems and provide a number of advantages such as serving as habitat for fish and aquatic invertebrates. On the other hand, extreme presence of water hyacinth is not only a hindrance to fishing but is also lethal to the fish species (Jayan & Sathyanathan, 2012; Villamagna & Murphy, 2009).

Majority of the fishermen who reported water hyacinth led to increased fish catch came from Jaway Wharf. It was observed that some fishermen in that community used the weeds to provide shades in their fish traps (Figure 3). In this regard, water hyacinth becomes a natural asset that could assist in sustainable fish farming if the practice of sheltering fish in traps is adopted on a large scale. It was also reported that water hyacinth was more favourable to fishing in the Abby Lagoon than in the Tano River. The reason being that the vast nature of the lagoon made it difficult for the water hyacinth to entirely cover its surface and so fishermen could easily manoeuvre through the gaps in the patches of the weeds to access their fishing grounds. This was not so with the River Tano that was narrow and so could easily be covered by the water hyacinth, thereby...
making activities on it almost impossible in the peak season of invasion. Besides, Annang (2012), has indicated that the Tano Basin has the highest amount of water hyacinth in Ghana.

The 5.6% fishermen (Table 2) who reported their activities were not affected by the water hyacinth invasion came from Adusuazo and Jaway Wharf. Those from Adusuazo reported that even though they crossed the River Tano to their fishing grounds in the swamps along the river, they did their fishing work mainly in the rainy season when the rains had washed the water hyacinth downstream (Honlah et al., 2019c). During the peak period of the invasion in the dry season, the swamp from which they fished had almost dried up, hence they stopped fishing. Those from Jaway Wharf, on the other hand, perceived that the hyacinth was only advantageous to fishing as they provided hiding place for fish.

4.2. Effects of water hyacinth invasion on the income of fishermen

The negative effects of water hyacinth invasion on fishing activities had a corresponding effect on the incomes of fishermen. Generally, fishermen perceived that the presence of water hyacinth in the two water bodies negatively affected their incomes. These effects have been presented in Table 2.

Table 2 indicates that majority of the fishermen perceived that the invasion led to decreased incomes. This was mainly due to the challenges the weeds posed to the use of fishing gears and the blockade caused that sometimes brought fishing to a halt, confirming the findings of Kateregga and Sterner (2009), Aloo et al. (2013), and Kamau et al. (2015). This effect of the invasion is a threat to the sustainability of fishing livelihoods in communities along the two

![Figure 3. Water used to provide shade in fish trap on the Abby Lagoon at Jaway Wharf.](image)

| Effects on income | Jaway Wharf (%) | Takinta Wharf (%) | Asukro (%) | Adusuazo (%) | Ellenda Wharf (%) | Total (%) |
|------------------|-----------------|------------------|------------|--------------|------------------|-----------|
| Increases        | 4.0             | –                | –          | 0.8          | –                | 4.8       |
| Decreases        | 42.8            | 3.2              | 5.6        | 37.3         | 3.2              | 92.1      |
| Same             | 0.8             | –                | –          | 2.4          | –                | 3.2       |
| Total            | 47.6            | 3.2              | 5.6        | 40.5         | 3.2              | 100.00    |
water bodies. However, 4.8% of the fishermen reported the presence of the weeds led to an increase in their incomes. This situation was especially reported at Jaway What where some fishermen perceived that the weeds brought about an increase in fish catch and in some cases used them to provide shade in their traps in the Abby Lagoon (Figure 3).

Due to the negative effects of the invasion on the incomes of fishermen, majority predicted that their future living conditions will be worse off as shown in Figure 4. This will occur if the weeds are not controlled to a level where they will cease to highly interfere with fishing activities. These fishermen thought the source of their livelihood will not be sustainable due to the invasion. Relatively, only a smaller percentage of the fishermen perceived that their living conditions will be better off. Among these were those who thought the water hyacinth was advantageous to fishing.

4.3. Effects of water hyacinth invasion on fish trading

Water hyacinth invasion, with its negative effects on the activities of fishermen, indirectly affected the livelihood of fish traders who relied on the affected fishermen for fish supply. Table 3 presents a summary of the effects of the invasion from the perspectives of the fish traders.

Similar to the response of fishermen, majority of the fish traders reported the invasion negatively affected their livelihood. The effects have been presented in the following subsections.

4.3.1. Low fish supply and reduced profit

Table 3 indicates that majority of the fish traders perceived that water hyacinth invasion brought about a reduction in the quantity of fish they bought from fishermen. The reduction meant that fish traders got less fish to trade in for profit. This was because the presence of the weeds prevented the fishermen from fishing regularly, a situation which could render some fish traders temporarily jobless. Water hyacinth invasion of the two water bodies which served as the natural capital of the fish traders, therefore, affected their ability to pursue their livelihood activities leading to poor livelihood outcomes. One fish trader explained in an in-depth interview:

*In the absence of the water hyacinth, I could sell fish worth Gh₵400.00 on one market day but when the water hyacinth comes, I could only get fish worth about Gh₵20.00 for sale. Sometimes I do not get fish at all. When this happens, I do not make money* (A 40-year-old woman from Asukro; August, 2016).

4.3.2. Reduction in fish quality

Water hyacinth invasion was also reported to have an effect on the quality of fish that fish traders bought from the fishermen. The reduction in fish quality occurred when fishermen spent long
hours on the invaded waters before finally getting access to berth on the wharfs. By the time they got access route to the beaches, the fish might have been staled. This affirms Fatou et al. (2015), in their study in Benin that the water hyacinth impedes the movement of canoes leading to subsequent reduction in income.

4.3.3. Increased fish supply
Contrary to the view of the majority of fish traders, 7.1% reported that the presence of the weeds rather led to increased fish supply. This was in spite of the challenges they posed to the use of fishing gears. These fish traders perceived that water hyacinth offered shelter to the fish, hence their invasion promoted fish catch (Bhattacharya et al., 2015; Brendonck et al., 2003; Dugdale et al., 2013). One of them commented in the following words during an in-depth interview:

“The water hyacinth brings the fish so when it later floats away; we get a lot of fish to buy. I could sell fish worth Gh¢600.00 a day when the water hyacinth comes. People who complain do not know that the water hyacinth helps us to get a lot of fish” (A 60-year old woman at Jaway Wharf; August, 2016)

Like their fishing counterparts, fish traders who reported their activities were not affected by the invasion came from Adusuazo and Jaway Wharf. Those from Adusuazo reported that the River Tano was not the major fishing ground for the men who supplied them with fish. Their suppliers fished in the swampy areas across the River Tano in the rainy season, when the rains had moved the water hyacinth downstream. Those from Jaway Wharf only perceived the presence of the weeds to be an advantage to fishing as its presence led to increased fish catch.

4.4. Effects of water hyacinth invasion on the income of fish traders
The study revealed that the effects of the water hyacinth invasion on fishing had a ripple effect on the incomes of fish traders. These effects have been presented in Table 4.

The results displayed in Table 4 indicate that a significant majority of the fish traders reported to have had their incomes decreased due to water hyacinth invasion. Spatially, all respondents from

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**Table 3. Effects of water hyacinth invasion on fish trading in the Jomoro District**

| Effects                                | Jaway Wharf (%) | Takinta Wharf (%) | Asukro (%) | Adusuazo (%) | Ellenda Wharf (%) | Total N = 84 |
|----------------------------------------|-----------------|-------------------|------------|--------------|-------------------|--------------|
| Low fish supply and reduced profit     | 35.7            | 2.4               | 3.6        | 28.6         | 3.6               | 73.8         |
| Increased fish supply                  | 7.1             | -                 | -          | -            | -                 | 7.1          |
| Reduced fish quality                   | 3.6             | -                 | 1.2        | 6.0          | -                 | 10.8         |
| No Effect                              | 1.2             | -                 | -          | 7.1          | -                 | 8.3          |
| **Total**                              | **47.6**        | **2.4**           | **4.8**    | **41.7**     | **3.6**           | **100.00**   |

**Table 4. Effects of water hyacinth invasion on the income of fish traders in the Jomoro District**

| Effects on Income | Jaway Wharf (%) | Takinta Wharf (%) | Asukro (%) | Adusuazo (%) | Ellenda Wharf (%) | Total N = 84 |
|-------------------|-----------------|-------------------|------------|--------------|-------------------|--------------|
| Increases         | 3.6             | -                 | -          | -            | -                 | 3.6          |
| Decreases         | 44.0            | 2.4               | 4.8        | 36.9         | 2.4               | 90.5         |
| Same              | -               | -                 | -          | 4.8          | 1.2               | 6.0          |
| **Total**         | **47.6**        | **2.4**           | **4.8**    | **41.7**     | **3.6**           | **100.0**    |
Takinta Wharf, Asukro and Ellenda Wharf reported that the invasion decreased their incomes due to the numerous challenges it posed to fishing and its related activities. However, 3.6% of the respondents reported the invasion increased their incomes. These included fish traders who perceived that the weeds led to increased fish catch. Others reported their incomes remained unchanged in the face of the invasion. These respondents included those who reported they were not affected (Table 3) by the water hyacinth invasion since they worked mainly in the rainy season.

On the basis of the negative effects of the invasion on their incomes, majority of the traders predicted that their future living conditions will be worse off in the presence of water hyacinth. By implication, the fish trading business was seen not to be sustainable due to water hyacinth invasion. Respondents thought that with the presence of water hyacinth they will continue to face the problems of reduced fish catch which will not permit them to make the necessary returns on their activities.

Figure 5 indicates that 8.3% of the respondents perceived that their future living conditions will be better in the presence of the water hyacinth. Among these were those who reported the invasion increased their incomes since they provided shelter for fish and hence led to increased fish catch. Among the 7.9% respondents who thought their future living conditions will not change were those who reported the weeds had no impact on their activities.

5. Conclusion and recommendations
The study discussed that the effects of water hyacinth invasion mainly manifest itself negatively on the livelihood activities of fishermen and fish traders. The authors found that water hyacinth in the River Tano and Abby-Tano lagoon displaced people from fishing activities in the dry season, when the invasion reached its peak. As the water hyacinth increased in quantities, the level of fishing and fish trading activities reduced. Some of the effects of the invasion on fishing and fish trading included reduced fish catch, difficulty in the use of fishing gears, reduced profit and increased cost of fishing. These effects largely affect the sustainability of fishing and fish trading in the study area. In spite of the widely held perception of the invasion on fishing, a few fishermen and fish traders perceived that the water hyacinth provided shelter for fish. But the majority of the respondents reported that their incomes reduced when the weeds blocked access to fishing grounds. Water hyacinth invasion, therefore, was found to affect the natural, physical and financial assets of the fishermen and fish traders. These have indirect effects on their social and human capitals as well. We recommend that a multidisciplinary research should be carried out to investigate the relationship between water hyacinth and fishing in the Tano River and Abby-Tano Lagoon to help provide further clarification on the effects of the weeds on fish species. In order to resolve the annual problem of low fish catch that results from the blockade, the study recommends that fish farms are established in both water bodies to ensure all year-round production of fish devoid of the water hyacinth menace.
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Cover Image: Samples of traps used by fishermen at Ellenda Wharf
Source: Author.

Competing Interests

The authors declare no competing interests.

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