GEOGRAPHY | RESEARCH ARTICLE

Effects of water hyacinth invasion on the health of the communities, and the education of children along River Tano and Abby-Tano Lagoon in Ghana

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Cogent Social Sciences (2019), 5: 1619652
Effects of water hyacinth invasion on the health of the communities, and the education of children along River Tano and Abby-Tano Lagoon in Ghana

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Abstract: Water hyacinth invasion has been highlighted to be a source of problem to riparian communities. They are known to reduce the velocity of water bodies, thereby serving as suitable breeding grounds for mosquitoes. Their obstruction to water transportation also means students who cross invaded water bodies to school will have their education negatively affected. Based on cross-sectional research with 305 respondents who were sampled using snowballing sampling procedure, this study assesses the effects of water hyacinth invasion on the health of the communities, and the education of children along River Tano and Abby-Tano Lagoon in Ghana. We found that water hyacinth invasion in the two water bodies was associated with malaria infestation. The blockade created also meant students delayed in their quest to access their schools. However, respondents mainly used insecticide-treated nets to cope with the spread of the mosquitoes that bred in the water hyacinth while parents made provision for their wards to stay outside the affected village across the River Tano in order to attend classes in the peak season of the invasion. We recommend that further studies should target only those...
people whose children cross River Tano to attend school in the Adusuaazo community and increase their sample size. This will help gather detailed information on the effects of the invasion on the education of children. We also recommend that further studies should be conducted to provide more concrete data on the categories of respondents whose health are more affected by the invasion and their adaptive strategies.

Subjects: Health & Development; Rural Development; Human Geography

Keywords: water hyacinth; health; education; coping strategies; Jomoro District; Ghana

1. Introduction

Water Hyacinth (Eichhornia crassipes) is a well-known ornamental plant that is found in water gardens and aquariums (Bhattacharya & Kumar, 2010). They are difficult to manage once established (Champion, de Winton, & Clayton, 2014). Their rapid growth and sporadic dispersal have destroyed many ecologically and economically important waterbodies and productive wetlands (Patel, 2012). The weeds tend to endanger biodiversity; serve as microhabitat for disease vectors and shelter pests (Kateregga & Sterner, 2009; Ndimele, Kumolu—Johnson, & Anetakhai, 2011; Patel, 2012; Waithaka, 2013). Children’s education may also be threatened due to the blockade caused by water hyacinth invasion (Ghana News Agency, 2007).

The menace of water hyacinth is reaching alarming proportions in many parts of the world, especially in tropical waterbodies (Aloo, Ojwang, Omondi, Njiru, & Oyugi, 2013). With the lack of naturally occurring “enemies” and predators (Gichuki et al., 2012; Onyango & Ondeng, 2015) such as Warner (Neochetina eichhorniae) and Hustache (Neochetina bruchi) (Wilson, Holst, & Rees, 2005) to feed and destroy the weeds, Africa has particularly been affected by the introduction and spread of water hyacinth. In Ghana, runoff from rainwater that carries nutrients from untreated wastewater, sewage and fertilized fields into waterbodies has led to increased levels of nutrients such as nitrate and phosphate in such waterbodies and that enhances the hyacinth’s growth. In the Volta River Basin, the construction of dams for hydropower, irrigation, water extraction and aquaculture has reduced the flow of the river system, thereby contributing favourable conditions for the hyacinth colonies to flourish (Hauser, Wernand, Korangteng, Simpeney, & Sumani, 2014).

Currently, aquatic weeds that have invaded the Tano River and the Abby-Tano Lagoon include water hyacinth, Kariba weed, water lettuce and hippo grass which inhibit the transportation of goods and people on these waterbodies (De Graft-Johnson, Blay, Nunoo, & Amankwah, 2010). It has been reported by Annang (2012), that the Tano Basin has the highest level of water hyacinth in the country. Children who stay across the River Tano to attend school also have their education threatened as they cannot easily go to school due to the blockade caused by the water hyacinth. Research question intended to be answered by this study was: what are the effects of water hyacinth invasion on the health of the communities, and the education of children along River Tano and Abby-Tano Lagoon in Ghana. Given the importance of health and education to the government and people of Ghana, this question is relevant.

Health and education form important aspects of the human capital base of the riparian communities along River Tano and Abby-Tano Lagoon. Human capital encompasses, among other things, the issues of education and health (Becker, 2007). The primary determinant of a society’s standard of living is highly dependent not only on how well it develops and utilises the skills and knowledge of its people but also how it furthers their health and educates them (Ozturk, 2001). Arimah (2010) has revealed that inter-country differences in poverty levels can be accounted for by variables indicative of the different facets of human development, including public expenditure on education, primary school enrolment, female educational enrolment and expenditure on health. The Sustainable Development Goals adopted in 2015 by member states of the United Nations form an indication of an international consensus regarding the role of health and education in human development: goals 3 and 4 are about health and education.
Human capital theory assumes that formal education is highly instrumental and necessary to improve the productive capacity of a population (Psacharopoulos & Woodhall, 1997). Education plays a key role in rural development by influencing the development of the rural individual, family, community and society, leading to reduced poverty, income equity and controlled unemployment (Chandra, nd; Ozturk, 2001). This helps to upgrade the general standard of living in a society (Almendarez, 2010). In addition to promoting human development, good health, on the other hand, allows people to attend work regularly, to be productive at work, and to work for more years. Robust health can serve as a platform for progress in other areas, given a suitable policy environment (Bloom, nd). According to Bleakley (2010), the productivity associated with improvements in health positively affects people’s income.

Various aspects of water hyacinth invasion have been studied, including the ecological and socio-economic utilisation of water hyacinth (Jafari, 2010), the appropriate control measures of water hyacinth (Julien, 2001; Julien, Griffiths, & Stanley, 2001; Ray & Hill, 2013), the impact of water hyacinth on fish stock (Kateregga & Sterner, 2009), how water hyacinth inhibits the growth of other plant species in the same environment (Shanab et al., 2010), the distribution, socio-economic importance and management of water hyacinth (Firehun, Struik, Lantinga, & Taye, 2014; Jayan & Sathyananathan, 2012) as well as the association of water hyacinth invasion with diseases vectors (Aloo et al., 2013; Feikin, Tabu, & Gichuki, 2010).

In Ghana, a few studies have investigated different aspects of water hyacinth invasion. De Graft Johnson (1995), focused on how the integrated method including the use of chemical, biological and manual methods could be used to control aquatic weeds in waterbodies in Ghana, including the Western Region. Annang (2012) studied the constituents of invasive macrophyte community in the three River Basins in the Okyeman area while Hauser et al. (2014), studied how water hyacinth in the Lower Volta Region could be turned from menace to sustainable opportunity by fostering local entrepreneurship. Besides, Honlah, Segbefia, Appiah, and Mensah (2019a, 2019b) have examined the effects of water hyacinth invasion on the activities of smallholder farmers along River Tano and Abby-Tano Lagoon as well as how the affected people along the two waterbodies cope with the effects of the invasion. However, a review of the existing literature reveals that none of the studies on water hyacinth in Ghana focuses on how water hyacinth invasion affects the health and education of riparian communities. The main objective of this paper is to explain how water hyacinth invasion is perceived to affect health and education as human assets of riparian communities in the Jomoro District, Ghana.

2. Profile of study area
The River Tano and the Abby-Tano Lagoon form two most important drainage systems in the Jomoro District. The Tano Basin lies between latitudes 5°00’ N and 7°40’N, and longitudes 2°00’W and 3°15’W (Water Resources Commission, 2017). It is transboundary, as the last 100 km of the downstream reaches of the river flows through the international boundary between Ghana and La Côte d’Ivoire before entering the Aby-Tano-Ehy lagoon system (Water Resources Commission, 2012). 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 (Finlayson, Gordon, Ntiamoa-Baidu, Tumbulto, & Storrs, 2000). The Abby-Tano Lagoon is transboundary between Ghana and Côte d’Ivoire but most of the lagoon system is located in La Côte d’Ivoire. It discharges into the sea in that country (Water Resources Commission, 2012) at Assinie Manvea.

3. Methodology
3.1. Study design
The study adopted the cross-sectional study design in the collection of data. Information on the effects of water hyacinth invasion on the health and education of communities along River Tano and Abby-Tano Lagoon were collected from cross-sections of people in the selected communities.
Besides, the study was conducted only once in all the study communities (Kumar, 2011). Both quantitative and qualitative data were collected since according to (Creswell, 2010), the use of the mixed method in a study gives a better understanding of a research problem than the use of anyone of them. Quantitative data collected in the study included respondents’ perceptions about the major health problems in their communities before and after the water hyacinth invasion, respondents responses about whether water hyacinth invasion was responsible for the major health problems in their communities, percentage of respondents whose children crossed River Tano to attend school, effects of water hyacinth invasion on children education and the strategies adopted by respondents to cope with the effects of the invasion on their health and the education of children. On the other hand, qualitative data included direct quotes from respondents (Honlah et al., 2019a, 2019b). The partly adoption of qualitative research design made it possible to engage respondents’ experiences about water hyacinth invasion and its effects on health and education in a way which would have not been feasible using only quantitative research approach. The method helps obtain subjective account delivery of original experiences of respondents (Mumin, Gyasi, Segbefia, Forkuor, & Ganle, 2018) and ensures adequate discourse between the interviewer and the respondents which helps to produce meaningful effects (Guba & Lincoln, 1994).

3.2. Sample and data
Five riparian communities along River Tano and Abby-Tano Lagoon were purposively sampled for the study. Their selection was based on their close location to the two waterbodies. Besides, the first law of geography by Tobler (1970), states that everything is related to everything else but near things are more related than distant things. It was, therefore, envisaged that communities close to these water hyacinth-infested waterbodies would experience a greater impact of the invasion. Collecting data on the effects of water hyacinth invasion on the health and education of riparian people from these communities would thus yield rich and detailed information than gathering data from those communities located farther from the two waterbodies. The selected communities were Jaway Wharf and Asukro along the Abby-Tano Lagoon and Ellenda Wharf, Takinta Wharf and Adusuazo along the River Tano.

After introducing the researchers to community leaders, the snowballing sampling technique was adopted in which farmers, fishermen, fish traders, and boat operators who lived and worked in the selected communities were contacted personally for data collection purpose. The application of the snowballing sampling method was due to the unavailability of records on the number of people who have been affected by the invasion of the water hyacinth. In using the snowballing method, networks of fishermen, fish traders, boat operators and farmers who worked along River Tano and Abby-Tano Lagoon were used to contact the targeted respondents. From the onset, a few respondents from these occupational groups in the study communities were sampled for data collection purpose. They then identified and directed the researcher to other respondents in the same occupational groups who were also selected and became a part of the sample. Data was then collected from them and then these respondents were asked to identify other fishermen, fish traders, boat operators, and farmers from whom data was further collected. This process continued until the required sample size was reached (Honlah et al., 2019a; Kumar, 2011).

Of the total population of 6,927 in the five communities (Ghana Statistical Service, 2010), 305 respondents were selected. The proportionate sampling method was used to calculate and select 16 respondents from Asukro, 8 from Takinta Wharf, 140 from Jaway Wharf, 10 from Ellenda Wharf and 131 from Adusuazo. This was based on their respective population sizes. The purpose of the proportionate sampling technique was to make sure samples from the communities were fairly represented. Out of the 305 sample size, there were 126 fishermen, 84 fish traders, 55 farmers and 40 boat operators.

The triangulation approach (Polit & Beck, 2012), was used by gathering data through interviewer-administered partially pre-coded questionnaires and Focus Group Discussions. The open-ended questions in the questionnaires gave respondents the chance to adequately express their opinions as the pre-coded questions might have limited them in their quest to contribute detailed...
information to the study. Eight focus group discussions (FDGs) were also held for two of the sampled communities. Each group had a minimum of eight and a maximum of 12 people. The numbers were limited in order to ensure effective group management. To facilitate rich information sharing and prevent possible external interference, the FGDs were held in enclosed places. The selection of the discussants was based on gender (men and women) and occupation (fishermen, fish traders and farmers). This was done to promote the free flow of information from the discussants as the grouping together of respondents from the two gender classes might have caused intimidation from either of the two gender identities. The essence of the occupational groupings was to obtain information from respondents with similar characteristics.

The FGDs were organised in the local language (Nzema) in order for the discussants to eloquently contribute information to the study. They were held at Adusuazo along the River Tano and Asukro along the Abby-Tano Lagoon. The discussions were facilitated by the researcher and a research assistant. Besides, an interview guide was designed for the FGDs after a review of literature on the social effects of water hyacinth invasion, including its effects on health and education. Based on the research objective and interview guide, respondents, and FGD participants were asked to state the major health problems in their communities before the water hyacinth invasion; the current major health problems in their communities; whether or not respondents agreed the major health problems in their communities were due to the water hyacinth invasion; whether they had children who crossed any of the waterbodies to school; the categories of school their children attended; and in what ways the invasion of water hyacinth had affected the education of their children? Respondents were interviewed at appropriate places including their homes and the wharfs along the two waterbodies. The questionnaire administration was carried out in local languages (Nzema and Twi) to serve the language need of all respondents. In addition to the field notes taken, interviews in the FDGs were recorded with an audio recorder after seeking the consent of the participants. This was to enable the researcher to record participants’ own words and examine them afterwards, and where necessary, play and listen to the discussions several times before drawing any conclusions. To ensure the free-flow of responses from respondents, they were first previewed to the purpose of this study and what was required of them. Besides, they were assured of the confidentiality and anonymity of their responses. No names of the respondents and FGDs participants were therefore collected. Respondents and FGDs participants participated in the study out of their own volition.

3.3. Data analysis
Descriptive statistics using cross-tabulations, percentage frequency tables and bar charts in statistical product for social sciences (SPSS, Version 16.0) and Microsoft Excel, were used in the analyses of quantitative data. Qualitative data, on the other hand, were recorded, transcribed and used to support the quantitative data. These data were used to provide explanations for the quantitative data. In this light, some of the respondents’ responses were quoted directly to add further details to the quantitative data. This helped to describe the dimensions of the health and education effects of water hyacinth invasion from the perspectives of the respondents. The audio records taken during the FGDs were initially translated into English before the qualitative analysis.

4. Results and discussion

4.1. Water hyacinth invasion and health of riparian communities

4.1.2. Perceived major health problems before and after water hyacinth invasion
In order to determine the extent to which respondents associated the major health problems in their communities with the water hyacinth invasion, the study first found out the major health problems before and after water hyacinth introduction into the two waterbodies. Table 1 presents a summary of the findings.
From Table 1, a significant percentage of respondents perceived malaria to be the major health problem before and after the invasion of the water hyacinth, even though the majority could not tell what major diseases existed in their communities before the invasion. This pertained to all the study communities. The responses reflected the contribution made by the District Health Information Officer during a Focus Group Discussion with the District Assembly officials that malaria topped the first 10 most prevalent causes of illness in the Jomoro District. The other health problems outlined by respondents included rheumatism, headaches and hernia.

4.1.3 Water hyacinth invasion and the perception of major health problems in study communities

The results of the study show that a relatively higher percentage of respondents associated the major health problems in their communities with the presence of water hyacinth. The responses from the respondents have been presented in Table 2.

Table 2 shows that 80 of the respondents, representing 26.2% of the total 305 sample size agreed and strongly agreed that the major health problems in their communities were due to the presence of water hyacinth in the two waterbodies. The majority of these respondents largely came from Jaway Wharf and Adusuazo, mainly due to their large sample size. These respondents mainly associated water hyacinth with mosquitoes since they thought mosquitoes bred in the water hyacinth. At Adusuazo for example, it was reported that malaria infections had become common in the community than before the invasion of water hyacinth. Respondents who mainly suffered from the malaria infection were those who spent a greater part of their time staying in villages along

| Problems Before | Jaway Wharf | Takinta Wharf | Asukro | Adusuazo | Ellenda Wharf | Total |
|-----------------|-------------|--------------|--------|----------|---------------|-------|
| Malaria fever   | 58(52.7)    | 1(0.9)       | 4(3.6) | 42(38.2) | 5(4.5)        | 110(100.0%) |
| Cholera         | 1(25.0)     | 1(25.0)      | -      | 1(25.0)  | 1(25.0)       | 4(100.0%)  |
| Other           | 4(50.0)     | -            | -      | 4(50.0)  | -             | 8(100.0%)  |
| Cannot tell     | 77(42.1)    | 6(33.3)      | 12(66) | 84(45.9) | 4(2.2)        | 183(100.0%) |
| Total           | 140         | 8            | 16     | 131      | 10            | 305    |

| Current problems | Jaway Wharf | Takinta Wharf | Asukro | Adusuazo | Ellenda Wharf | Total |
|------------------|-------------|--------------|--------|----------|---------------|-------|
| Malaria fever    | 105(44.1)   | 2(0.8)       | 12(5.0)| 110(46.2)| 9(3.8)        | 238(100.0%) |
| Cholera          | -           | 1(20.0)      | 1(20.0)| 2(40.0)  | 1(20.0)       | 5(100.0%)  |
| Other            | 9(62.2)     | 3(23.1)      | -      | 1(7.7)   | -             | 13(100.0%) |
| Cannot tell      | 26(53.1)    | 2(41.1)      | 3(61)  | 18(36.7) | -             | 49(100.0%)  |
| Total            | 140         | 8            | 16     | 131      | 10            | 305    |

Table 1. Perception of major health problems in the study communities before and after water hyacinth invasion

| Responses | Jaway Wharf | Takinta Wharf | Asukro | Adusuazo | Ellenda Wharf | Total |
|-----------|-------------|--------------|--------|----------|---------------|-------|
| Agree     | 38(47.5)    | 1(1.3)       | 2(2.5) | 38(47.5) | 1(1.3)        | 80(100.0%) |
| Strongly agree | 17(37.0) | -            | 4(8.7) | 20(43.5) | 5(10.9)       | 46(100.0%) |
| Disagree  | 25(48.1)    | 3(5.7)       | 2(3.8) | 19(36.5) | 3(5.7)        | 52(100.0%) |
| Strongly disagree | 6(35.3%) | -            | -      | 10(58.8%)| 1(0.6%)       | 17(100.0%) |
| Cannot tell| 54(49.1)    | 4(3.6)       | 8(7.3) | 44(40.0) | -             | 110(100%)  |
| Total     | 140         | 8            | 16     | 131      | 10            | 305    |
the River Tano, especially during working days. Due to the proximity of their settlements to the river, mosquitoes breeding in the weeds easily moved to these settlements to infest the inhabitants. These people then carried the parasites into the Adusuazo community. Besides, when water hyacinth caused a blockade on the River Tano, respondents like farmers had a difficult time navigating through the weeds to their farms (Honlah et al., 2019a). This exposed them to mosquitoes' bites and subsequent malaria infections. Similarly, fishermen from Jaway Wharf and Asukro who spent part of the night fishing on the Abby-Tano Lagoon were also exposed more to mosquitoes' bites and malaria infections. The following statements illustrate the effects of water hyacinth invasion on health:

In the evening when you are weaving the raffia traps in the village along the Tano, you could be bitten by mosquitoes and get infested with the malaria parasite (A 36-year old fisherman at Adusuazo, July; 2016).

The water hyacinth could accumulate to a depth of 20 inches. There was a time a man from this community was trapped in the hyacinths on the Tano for a whole night since his canoe could not go through the weeds. He was rescued only on the following day and for about two weeks he could not get up due to the mosquitoes bites (A 27-year old fisherman at Adusuazo, July; 2016).

There were respondents who also associated the malaria cases with water hyacinth invasion as well as poor sanitation in the communities. At Adusuazo, respondents reported that in addition to water hyacinth invasion, poor sanitation, and the presence of stagnant water contributed to malaria infections especially in the rainy season, while respondents from Jaway Wharf outlined issues such as the presence of swamp in the community, the dirt and hippo grass at the wharf, open defecation and abandoned wells in the community as other causes of the breeding of mosquitoes and malaria infections. A fish trader explained in the following words:

When the water hyacinth reduces the velocity of the water in the Tano, the mosquitoes easily breed in the water. However, the cocoa pods left on the farms after harvesting also breeds mosquitoes which move to the main community (A 40-year old woman at Ellenda Wharf, July; 2016).

Aloo et al. (2013), in their study of the impacts of invasive aquatic weeds on the biodiversity of Lake Victoria (Kenya), reported that the presence of water hyacinth in the Lake had led to increased water-borne diseases while Jayan and Sathyanaathan (2012), reported that the dense growth of water hyacinth provides an ideal environment for the growth of mosquitoes. According to Mack and Smith (2011), it is the ability of the mass of fibrous, free-floating roots, and semi-submerged leaves and stems of the water hyacinth to decrease water current that increases habitat for anopheline mosquitoes. In the life cycle of mosquitoes, adult females choose locations that will provide suitable conditions for egg laying and larval development (Michigan Mosquito Control Association, 2002). Water velocity is, therefore, one of the most important abiotic factors influencing the survival of aquatic insects such as mosquitoes, in rivers and streams. In turbulent environments, the processes of eggs deposition, eggs hatching and larval development are highly impeded. The unidirectional water flow defining the habitat of aquatic insects and characteristically dividing it into alternating regions of high and low water velocity thus imposes on these insects the necessity to adapt to the continual downstream movement (Mazzuccoa, Nguyenc, Kimc, & Chonc, 2015). Kamau, Njogu, Kinyua, and Sessay (2015), have indicated that the breeding of mosquitoes and other parasites in Lake Victoria due to the presence of water hyacinth impacts negatively on the health of residents of Ndunga Village located near the lake. This has led to increased incidents of malaria and bilharzia diseases recorded in local medical facilities following the invasion of the lake by water hyacinth. The majority of those affected by these parasitic diseases were children, and their families incurred additional costs to access medical treatment. In effect, increased mortality of under 5 years old children from these parasitic diseases has been recorded in the Village.
In addition to anopheles larvae which breed in water hyacinth-covered habitats (Minakawa, Sonye, Dida, Futami, & Kaneko, 2008), snails which serve as vectors for the parasite of Schistosomiasis reside in the tangled weed mat (Masifiwa, Twongo, & Denny, 2001). Varshney and Sushilkumar (2008), found that water hyacinth had increased the instances of filaria in Godavari Delta region in India while Chandra, Ghosh, Biswas, and Chatterjee (2006), in their study of host plant preference of Mansonia mosquitoes found that the Mansonioides mosquitoes which are the vectors of human lymphatic filariasis causing nematode Brugia, bred on the water hyacinth. In addition to those who perceived water hyacinth to breed mosquitoes, other respondents in this study reported the weeds bred insects such as tapeworms and tsetse flies and provided habitat cover to crocodiles and poisonous snakes which attacked people and posed danger to their health, thus affirming the finding of Ndimele and Jimoh (2011) and Patel (2012).

The results displayed in Table 2 indicate that 69 (22.6%) of the 305 respondents disagreed and strongly disagreed that the major health problems in their community were due to water hyacinth invasion. Some respondents in these categories associated the major health problems with poor sanitation in the form of bushy environment and stagnant water. They remarked that malaria had been a general cause of sickness in their communities before the water hyacinth invasion due to the problem of poor sanitation. At Jaway Wharf, for example, it was reported that neglected refuse generated on market days and the surrounding swamps were the major causes of mosquitoes’ breeding and malaria infections. This affirmed the assertion by Tenkorang, Kendie, and Enu-Kwasi (2008), that lack of sanitation and hygiene cause the transmission of many parasitic diseases. In their study on sanitation and stored drinking water quality of households in the Sissala East and Bolgatanga Districts of Ghana, they noted that the distance between refuse dumps and households had health implications for members of the households and the entire communities. The indiscriminate disposal of refuse, therefore, creates breeding grounds for diseases vectors like mosquitoes which transmit and spread pathogens among households.

Other respondents in this study had the perception that the invaded waterbodies were far from the main communities hence the presence of water hyacinth and its associated insects could not lead to the spread of mosquitoes and cause of sickness in the main communities, even though it may have affected those who worked on the water hyacinth-invaded-waters. This was in line with the distance decay effect theory that the interaction between two locales declines as the distance between them increases. One respondent explained in the following words during an in-depth interview:

*The distance from Adusuazo to the Tano River is about 4.6 miles hence mosquitoes breeding in the water hyacinth in the River Tano could not lead to the spread of malaria in the town (A 57-year old fisherman at Adusuazo, July; 2016).*

The lack of medical proof to substantiate the association of water hyacinth invasion with the major health problems like malaria, diarrhoea and headache was a reason why other respondents disagreed. These respondents argued from the perspective of positivism, a system of philosophy based on experience and empirical knowledge of natural phenomena. Hence, since they did not know of any medical proof that associated water hyacinth with poor health, they could not speculate. Other respondents who outlined cholera, stomachache and stress as the major causes of sickness in their communities were also of the view that none of these was related to the presence of water hyacinth. However, Feikin et al. (2010), found that yearly water hyacinth coverage on the Kenyan section of the Lake Victoria was positively associated with the number of cholera cases reported in the Nyanza Province. This was because water hyacinth provided habitat for the causative agent of cholera.

Another dimension of the health challenges posed by water hyacinth invasion was the difficulty with which people in communities like Atchimanou (Figure 1) across the River Tano crossed the river to access health centres in the presence of the weeds. This was in connection
with the findings of Mironga, Mathooko, and Onywere (2012), in their study of the effect of water hyacinth infestation of Lake Naivasha that water hyacinth invasion poses obstacles to people in their quest to assess health facilities. Besides, it was reported in this study that people who had their boats and canoes capsized in the presence of water hyacinth could easily lose their lives since the weeds made it difficult for such victims to swim to the shores. Water hyacinth invasion, therefore, negatively affects rural development since rural people who have their health as human asset negatively affected will not be able to increase their productivity and incomes when sick. When this situation persists with the seasonal invasion, the ability of these people to contribute to the development of their communities will be impeded.

4.2. The effects of water hyacinth invasion on children’s education along River Tano

Water hyacinth invasion of River Tano was reported to have negatively impacted on the human assets of some of the respondents, by affecting the education of pupils. However, out of the five study communities, that problem was only reported at Adusuazo.

The results presented in Table 3 indicate that only 20 of the respondents, representing 6.6% of the total 305 sample size, had children who crossed the River Tano to attend school. These respondents only came from Adusuazo. They reported that their children stayed at Atchimanous (Figure 1) across River Tano to attend basic school at Adusuazo. Others attended Senior High School at Half-Assini, the district capital. That situation was not recorded in the other four communities. For example, even though Asukro, one of the study communities, was located close to both the Abby-Tano Lagoon and the Tano River, students walked to Half-Assini to attend school rather than crossing any of these waterbodies to school. In the case of Jaway Wharf, students attended school in the community. Besides crossing the lagoon means one head towards La Cote d’ Ivoire; hence, that situation did not exist.
4.2.1. Effects of water hyacinth invasion on children’s education at Adusuazo

The study revealed that when water hyacinth invaded River Tano, students found it difficult to cross to school. The effects of the blockade on children’s education have been presented in Figure 2.

Out of the 20 respondents at Adusuazo who reported their children crossed the River Tano to school, 17 (85%) reported about reduced frequency of school attendance as an effect of water hyacinth invasion. They reported their children could stay in the house for weeks or months depending on the span of the invasion period until the rains washed the weeds downstream or communal labour was organised to remove them from the designated routes. The following words illustrate the effects of water hyacinth invasion on children’s education:

In the peak season of the invasion, my children could stay in the house for more than a week without going to school. Those at each side of our hut impound the water hyacinth and when that happens it blocks the section of the Tano where we are hence my children can’t go to school (A 45 year old fish trader at Adusuazo; July, 2016).

There was a time two students fell in the River Tano. The girl was fortunate to have had her clothing hooked around a thorny plant and so she was rescued after shouting for help. For the boy, the coverage of the river by the water hyacinth prevented him from swimming out even though he knew how to swim, so he died. (A 30 year old fisherman at Ellenda Wharf; July, 2016).

Three (3) (15%) of the 20 respondents from Adusuazo, on the other hand, reported that water hyacinth invasion brought about students lateness to school. This occurred when they had to use their hands to remove and pave way through the weeds that had blocked their access routes, thus slowing down their movement on the river to school. Commenting on another dimension of the problem, a Senior High School student who does fishing with his father at Asukro reported in a Focus Group Discussion about the effect of the invasion in the following words:

When the water hyacinths settle on our nets, we take a long time to remove them before going to school and that poses challenges to our education (A 19-year old boy at Asukro; July 2016).

Table 3. Percentage of respondents whose children crossed River Tano at Adusuazo to attend school

| Responses | Jaway Wharf | Takinta Wharf | Asukro | Adusuazo | Ellenda Wharf | Total       |
|-----------|-------------|---------------|--------|----------|---------------|-------------|
| Yes       | -           | -             | -      | 20 (100) | -             | 20 (100.0%) |
| No        | 140 (49.1%) | 8 (2.8%)      | 16 (5.6%) | 111 (38.9%) | 10 (3.5%)    | 285 (100.0%) |
| Total     | 140         | 8             | 16     | 131      | 10            | 305         |

Figure 2. Effects of water hyacinth invasion on children’s education at Adusuazo.
The reduced frequency of school attendance and lateness were reported by parents to have affected the academic performance of children. Water hyacinth invasion therefore affects not only the fiscal assets of the people but also their human assets, producing poor outcomes in the form of poor academic performance. These negative effects of the invasion on the human capital of the affected communities stifle the potential of the pupils from fully developing themselves to contribute to the development of their communities in the long-run. The findings affirmed a study by Faton et al. (2015), in which students reported that the presence of water hyacinth on the So River made it difficult for them to access their homes.

4.3. Coping Strategies for the effects of water hyacinth invasion on the health of the communities, and the education of children

4.3.1 Coping Strategies for the effects of water hyacinth invasion on health

In dealing with the health problems which arose from the presence of water hyacinth in the two waterbodies, the 126 respondents who reported the water hyacinth was responsible for the major health problems in their communities adopted a number of coping strategies. Table 4 depicts the various strategies adopted to deal with the effects of water hyacinth invasion on health.

Table 4 indicates that 71 (56.3%) of the 126 respondents (Table 2) who associated water hyacinth invasion with the breeding of mosquitoes, and malaria infections resorted to the use of insecticide-treated nets as a coping mechanism. It was revealed in the study that the use of the strategy was common especially among respondents who stayed along the waterbodies to work. For example, even though the Adusuazo community was not located as close to the waterbodies as the others, respondents from the community adopted the use of the treated nets to cope with the malaria infections. This was because some of these respondents stayed in villages along the river where they did their fishing work and returned to the main community during weekends. In such villages, mosquitoes were prevalent due to their proximity to the river. Similarly, the other four communities, by virtue of their proximity to the waterbodies made the inhabitants susceptible to mosquito bites and malaria infections (Kamau et al., 2015). The use of the net was therefore prevalent in all the study communities. Respondents in this study who were allergic to the use of mosquito coil also preferred the insecticide-treated nets.

Studies have shown that the use of insecticide-treated nets (ITNs) has proven to be one of the most cost-effective components of malaria prevention through vector control approach (Gakpey, Baffoe-Wilmot, Malm, Dadzie, & Bart-Plange, 2016; Manu et al., 2017). In Ghana, the Ministry of Health (MOH) and Ghana Health Service (GHS) have promoted the use of Long-lasting Insecticidal nets (LLINs) as a proven malaria vector control intervention. The country has used different channels for the distribution of the nets, including distribution through Maternal and Child Health Promotion campaigns, voucher schemes and highly subsidized sale of the nets at health facilities (Gakpey et al., 2016). In

| Responses                     | Jaway Wharf | Takinta Wharf | Asukro | Adusuazo | Ellenda Wharf | Total   |
|-------------------------------|-------------|---------------|--------|----------|---------------|---------|
| Treated nets                  | 28(39.4)    | 1(1.4)        | 3(4.2) | 36(50.7) | 3(4.2)        | 71(100.0%)|
| Medication                    | 9(52.9)     | 2(11.8)       | 6(35.3)| 4(36.4)  | 1(9.1)        | 17(100.0%)|
| Protective Clothing           | 12(100)     | –             | –      | –        | –             | 12(100.0%)|
| Treated nets and mosquito coil| 6(54.5)     | –             | –      | 4(36.4)  | 1(9.1)        | 11(100.0%)|
| Mosquito coil                 | –           | –             | –      | 9(90)    | 1(10)         | 10(7.9%) |
| Use of insecticides           | –           | 1(50)         | 1(50)  | –        | –             | 2(100%)  |
| No measures                   | –           | –             | 2(66.7)| 1(33.3)  | –             | 3(100%)  |
| Total                         | 55          | 1             | 6      | 58       | 6             | 126      |
effect, report from the Ministry of Health (2013) indicates that good progress has been made in the
country in reducing malaria case fatality in children under five, deaths attributable to malaria in health
facilities, and deaths among pregnant women. According to the WHO (2007), the effort to promote the
use of Long-lasting Insecticidal nets (LLIN) has shifted from a focus on vulnerable populations like
pregnant women and children to a broader aim of universal coverage. In this light, all members of
households are targeted in the distribution and use of the nets. This is irrespective of age and gender,
a move that is accounting for the increasing use of the net among the populace. Thus, Larson et al.
(2014) has pointed out that insecticide-treated nets (ITNs) have proven instrumental in the successful
reduction of malaria incidence in holoendemic regions during the past decade, and remain
a cornerstone of global malaria control (Mathanga et al., 2015).

Table 4 indicates that 10 (7.9%) of the 126 respondents (Table 2) used the mosquito coil in their rooms
to control mosquitoes. Among them were respondents who reported they felt suffocated when sleeping
under insecticide-treated nets. However, 11 (8.7%) of the affected respondents combined the use of
both treated nets and mosquito coils. The following statement illustrates the use of both mechanisms to
control malaria infections:

At 6:00 pm, we ask the children to sleep under the treated net while we the men use the coil
as we weave the traps in the village (A 30year old fisherman at Adusuazo; July, 2016).

According to Hogarh, Antwi-Agyei, and Obiri-Danso (2016), mosquito coils are widely used in
countries that record high levels of malaria infections even though the practice is not a recommended preventive measure for avoiding mosquitoes. This is irrespective of the potential environmental health risks that may be associated with emissions from the
smoke of the coil (Hogarh et al., 2018). The coils contain insecticides which vaporise slowly
once the coil is lit to protect users against mosquitoes. However, the smoke of the coil is
a potential source of indoor air pollution with implication for acute respiratory infection
(Hogarh et al., 2016).

The results presented in Table 4 show that 17 (13.5%) of the affected respondents resorted to
medication by either visiting chemical stores in their communities or travelling to nearby hospitals
and clinics in communities like Half-Assini for treatment. However, 12 (9.5%) of the respondents,
mainly fishermen from Jaway Wharf, reported they wore long and heavy clothes to protect
themselves from mosquito bites on the lagoon.

Other respondents sprayed insecticides in their rooms to control mosquitoes. Livingston (2013)
has indicated that insecticides spraying have been shown to reduce the transmission of diseases
from mosquitoes. The spraying occurs at night when most people are indoors. Even though there
are concerns about the impact of these insecticides on the health of users and the environment
(Lorono-Pino et al., 2014; Nalwanga & Ssempebwa, 2011), some of the diseases like West Nile virus
from mosquitoes can be very serious; therefore, the very small risk of being in a spray area is
outweighed by the benefits of significantly lowering the risk of these diseases. Besides, the droplets
of spray have enough insecticide to kill mosquitoes but not enough to cause significant harm to
the environment or human health. The presence of enzymes in humans also breaks down the
chemicals used in these sprays (Livingston, 2013).

4.3.2. Coping Strategies for the effects of water hyacinth invasion on the education of children
In order to reduce the effects of water hyacinth invasion on the education of children, the affected
parents at Adusuazo had put in place measures to assist their children during the peak season of
the invasion. These strategies have been presented in Figure 3.

Seventeen (85%) of the 20 respondents who reported they had children who crossed the River
Tano to attend school at Adusuazo had provided accommodation for their children in that commu-
nity. There were respondents among this group who reported their children stayed in the community
till the water hyacinth had been removed by the rains (Moyo et al., 2008) before they joined their parents at Atchimanous (Figure 1) across the River Tano. Some stayed for months as they waited for the rains to move the weeds downstream. Others joined their families on Fridays and returned to Adusuazo on Sundays to attend school the following days.

The other three respondents used any of the following strategies: assisted their children to cross the Tano River, educated their children to pave way using their hands, asked them to go through the fragmented water hyacinth or impounded the water hyacinth on both sides to create a route on the river. It was also reported that when the water hyacinth invaded the river, children below the age of 10 did not attend classes since they continued to be under the care of their parents at Atchimanous. Thus, water hyacinth invasion of River Tano posed a threat to the development of the human resource base of Adusuazo and the villages across the River Tano.

5. Summary, conclusion and recommendations
This paper has contributed to knowledge by exploring the impact of water hyacinth invasion first, on the health of the communities and second, on the education of pupils/students living along River Tano and Abby-Tano Lagoon in Ghana. Results of the study indicate that during the short dry season when the currents of River Tano and Abby-Tano Lagoon are slow, and the level of water is low, water hyacinth grows profusely over the two waterbodies, and consequently impedes navigation.

The abundant water hyacinth serves as a habitat for disease-carrying insects such as mosquitoes that cause malaria in the study communities. Respondents therefore perceived their health to have been affected negatively by the water hyacinth invasion. Even though many respondents perceived malaria infection to have been the major cause of illness in their communities prior to the introduction of water hyacinth in the waterbodies, the current predominance of the disease in the study communities is highly perceived to have been mainly caused by the presence of the weeds.

Besides, the presence of water hyacinth in the River Tano was reported to impede the movement of students to school. In the dry season, students who crossed the river to the other shores for classes stayed away from the endemic areas and received private tuition at home until such periods that the weeds were swept downstream by the river; and this occurred during rainfall season when the volume of the river was augmented, and the currents strengthened.

In order to cope with the health problems associated with water hyacinth invasion, respondents mainly resorted to the use of insecticide-treated nets. Other strategies adopted included the use of medication, protective clothing and mosquito coils. The use of multiple strategies such as treated nets and mosquito coils was also reported by some respondents. In coping with the effects of the invasion on children’s education, majority of the respondents’ whose children were affected made

![Figure 3. Coping strategies for school attendance at Adusuazo.](https://doi.org/10.1080/23311886.2019.1619652)
provision for their wards to stay in the community where they schooled to have their routine classes. These pupils rejoined their parents in the communities across the River Tano either on weekends or when the water hyacinth had been moved downstream in the rainy season. Water hyacinth invasion of River Tano and Abby-Tano Lagoon was therefore reported to have negatively affected the human resource base of the riparian people.

On the basis of the challenges posed by water hyacinth invasion to the health and education of the people, we recommend that the Jomoro District Assembly in collaboration with the traditional rulers, and rural development agencies should find a permanent solution to the invasion. Until a sustainable solution is found, the Ghana government effort to ensure a universal distribution and usage of the insecticide-treated nets should be strengthened, especially in riparian communities. This will help curb the level of mosquito bites and malaria upsurge. Besides, this study did not involve stakeholders like medical professionals and class teachers in examining the effects of water hyacinth invasion on the health and education of the selected communities. Further studies will therefore be needed to include these professionals so as to provide detailed information on the study. Moreover, since this study aimed at examining the effects of water hyacinth invasion on health and education from the perspectives of fishermen, fish traders, boat operators and farmers generally, another study may target only those people whose children cross River Tano to attend school in the Adusuazo community and increase their sample size for a more detailed information on the effects of the invasion on the education of children.

We also recommend that further studies should be conducted to provide more concrete data on the categories of respondents whose health are more affected by water hyacinth invasion as well as those who resort to the different types of adaptive strategies. Such a study could examine causal relationships to arrive at more concrete recommendations.

Acknowledgements
We wish to express our appreciation to the DANIDA Fellowship Centre for providing the funds for the field work under the project “Biofuel production from lignocellulosic materials” with grant number 2GBIONRG.

Funding
This work was supported by Danida Fellowship Centre [grant number 2GBIONRG].

Competing interests
The authors declare no conflict of interest.

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Citation information
Cite this article as: Effects of water hyacinth invasion on the health of the communities, and the education of children along River Tano and Abby-Tano Lagoon in Ghana, Emmanuel Honlah, Alexander Yao Segbefia, Divine Odame Appiah, Moses Mensah & Peter Ofori Atakora, Cogent Social Sciences (2019), 5: 1619652.

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