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Original Article

Floating gardening in coastal Bangladesh: Evidence of sustainable farming for food security under climate change

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A B S T R A C T

Around a quarter part of Bangladesh is flooded for several months a year, affecting agriculture in particular - this has far-reaching consequences for the lives of the rural population. Especially during the monsoon season, many people in water-rich areas suffer from food shortages and nutrient deficiencies, mainly due to crop failures and lower incomes. Through the use of floating gardens, smallholder farmers can use flooded areas that would otherwise be unmanageable for months. Due to the growing population pressure and the potential impact of climate change in Bangladesh, available agricultural land may decrease, making such innovative cultivation methods more important. Coastal people of Bangladesh have practiced this farming method to grow vegetables and seedlings on floating beds and thereby secure food production and farmers' income with adverse climatic shocks. The main purpose of this study is to investigate the overall methods of floating gardening, and how it contributes to food security at the households' level. The findings of the study are based on nine qualitative interviews with the local farmers and key informant interviews (KII). The study shows floating gardening is a sustainable farming method and income strategy for rural households in coastal flood-prone regions of Bangladesh. Floating gardens contribute to food security by nutrient intake growing vegetables. Areas that cannot be cultivated are made usable, and the achievable income ensures the security and variety of food in the season of the floating gardens.

Introduction

Climate changes are growing vulnerability of natural resource dependent livelihood practices of large community in Bangladesh. Climatic extreme events such as cyclones and storm surges, flood, river erosion and salinity stress have been severely affecting agriculture, fishing or fish cultivation and livestock rearing. Communities remain extremely fragile to disasters that impeded the key livelihoods in the coastal areas than any other place (Braun & Shoeb, 2008; Cook & Lane, 2010). The traditional agriculture cropping is decreasing in coastal areas due to variation of fresh water and salinity level and increasing abrupt weather events, tidal inundation and water logging. Simultaneously, the population is growing by 1.6% annually (as of 2015), which means Bangladesh must provide food for an additional 2.25 million people each year (Abedin *et al*., 2015). Agriculture plays a crucial role in this, and is also one of the country's most important economic sectors. The current share of agriculture in the national gross domestic product (GDP) is around 15% of the total GDP and employs around 48% of the population (Abedin *et al*., 2015). Many of these people live as smallholders in marginalised and ecologically sensitive areas in the coastal area of the country (Food Security Information Network, 2018). They have difficult access to means of transport and roads and thus to markets for the sale of their goods. They also have limited access to advisory services, credit or insurance systems and relatively low levels of formal education (Braun & Shoeb, 2008). They

often lack stable income strategies that could secure the family's financial situation. These marginalized groups also lack secure access to agricultural land and there is a high risk that the harvest will be destroyed by flooding, cyclone and storm surges. Several studies notes that, after the floods and storm surges, the land cannot be cultivated for some time due to the weak drainage capacity of land (Abedin *et al*., 2015; Hasan *et al*., 2017). The lack of resources makes it even more difficult for farmers to compensate crop losses and to recover from them. Food security is directly affected by this (Ziervogel & Ericksen, 2010). Despite the economic successes and the increase in agricultural productivity, 25% of Bangladesh's population is still considered food insecure. (Mishra & Khanal, 2017).

National progress in food production of Bangladesh has been promoted through the use of high-yielding varieties, fertilizers, irrigation systems and pesticides (Abedin *et al*., 2015). Priority was given to strengthen the supply side of food security in order to improve food availability deficits. This is linked to food shortages and high food prices (Grebmer *et al*., 2018). Since 2000, the country has achieved self-sufficiency in food. The average per capita energy supply has increased from 1,800 kcal in the 1970s to 3,055 kcal in 2009 (Abedin *et al*., 2015). Afterwards, the focus shifted to the demand side of food security, so that access to food came to the fore. The focus is now on the individual and household level, rather than on the global and national level (Mishra & Khanal, 2017).

In this context, strengthening local income strategies through local innovation is becoming increasingly important. Appropriate adaptation strategies and indigenous knowledge about how to deal with natural hazards and adverse climatic shocks may help to improve the livelihoods of affected people and reduce poverty and hunger (Anik & Khan, 2012). By promoting traditional and sustainable strategies based on people's own skills and knowledge, local vulnerable groups can strengthen their income strategies and resilience through their own innovation skills and experiences (Daskon, 2010). Often, these traditional systems are adapted to the prevailing conditions, available resources and human needs and are therefore very effective. Floating gardens are such an innovation and adaptation strategy based on indigenous knowledge. Floating beds built from aquatic plants are used to grow food and seedlings for vegetables on flooded areas.

Around a quarter part of Bangladesh is flooded for several months a year, affecting agriculture in particular - this has far-reaching consequences for the lives of the rural population. Especially during the monsoon season, many people in water-rich areas suffer from food shortages and nutrient deficiencies, mainly due to crop failures and lower incomes. Thus, how this large size of coastal wet land can be cultivated is a key concern for the local and national policy makers. Through the use of floating gardens, smallholder farmers can use water logged areas that would otherwise be unmanageable for months. Due to the growing population pressure and the potential impact of climate change in Bangladesh, available agricultural land may decrease, making such innovative cultivation methods more important. Numerous studies have been conducted on community-based innovations to tackle climate change particularly coastal agriculture and farming, however, limited investigation found on agriculture practices in wetland through floating gardening (Abedin, 2015; Al-Maruf *et al*., 2020). This article explores how floating gardens can contribute to food security as a sustainable farming method under climate change. This study also investigates the cultivation methods of floating gardening in wetland areas.

The interaction between the floating gardens and different types of capital (natural, financial, human, social and physical capital) will be examined in light of the sustainable livelihood framework. Furthermore, the extent to which floating gardens contribute to food security in the study area will be investigated. The four dimensions of food security are used to answer this question and the extent to which floating gardens influence them is examined. The dimensions are the availability, usability, stability of and access to food (FAO, 2009). The dimensions show that food security consists of different components, relates to food needs and preferences and is influenced by social, physical and economic factors. "Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (Briones *et al*., 2018).

2. Methodology

This study essentially used qualitative data through direct interviews with different level of respondents. Interviews with local farmers of floating gardens were conducted to collect data to address the research question. The interviews were conducted in the Barisal district, which is located in the south of Bangladesh (Figure 1). Within the two sub-districts (Upazila) of Banaripara and Wazirpur, interviews were conducted in three villages. In Banaripara the interviews were conducted in the Union Bisharkandi in the village Umarerpar, Ward 7 and in the Union Iluhar in the village Peseim Maluhar in Ward 9. In Wazirpur the interviews were conducted in the Union Shatla in the village Shibpur in Ward 3.

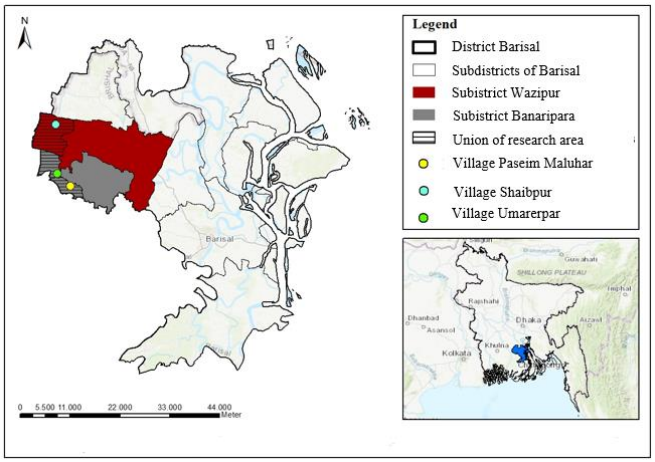

Figure 1. Map of the study sites (Prepared by author, 2019)

Long-lasting floods make it routinely difficult to use agricultural land in this district. The study area was selected because the cultivation method is not to be found in every district of Bangladesh (Alam & Chowdhury, 2018) and contacts exist that made this research feasible. The selection of the specific villages was made in the field and dependent on the availability of farmers in the region. Individual and group interviews were conducted. A total of nine interviews were carried out with farmers. All main contacts for the interviews were male. Women were also present in the group interviews, some of them participated in the discussion to provide additional information regarding households.

To structure the qualitative interview, a questionnaire was developed. The questionnaires contained ten thematic blocks: (1) personal data, (2) general information on floating gardens, (3) general information on the study area, (4) floating gardens and changing environmental conditions, (5) government support, (6) floating gardens as a sustainable income strategy, (7) floating gardens and food security, (8) crop calendar, (9) floating gardens and their limitations, (10) the implementation of floating gardens in other regions. Most interviews lasted 50 minutes, some 90-100 minutes.

In addition to the interviews with the farmers, we interviewed expert observers: the chief agricultural officer of Wazirpur sub-district; a professor of agriculture and climate change at a regional university (climate change and local farming) and two representatives of the non-governmental organization (NGO) Care Bangladesh. The interview situation was recorded on audio carriers that were transcribed, allowing an authentic presentation of the conversations. Each transcribed interview was then checked with the translator to clarify any discrepancies and to allow any lost information to flow back into the translation from Bengali into English. The interviews were then analysed using Mayring's qualitative content analysis and evaluated using MAXQDA computer software.

3. Results

3.1 Description of the study area and the target group

In order to allow a differentiated consideration of the floods on site, the terms "increased water level", "normal flooding" and "abnormal flooding" were used in the interviews. In the study area an increased water level can be observed from June/July to November/December. Two of the respondents reported a rising water level already in May (Interview 8: 62-66; Interview 7: 52-53). During this period, fields are under water and not available for cultivation. Between July and November, "normal flooding" occurs two to four times a year, which floods 30 - 50 % of the villages and also stays in the house for three to ten days (Interview 4: 41-46, Interview 6: 89-92). One of the interviewees reported that the water is in his house for two months a year (Interview 2: 72-79). Only every few years the "abnormal flood" occurs, flooding about 100% of the villages and destroying buildings and roads. Almost all houses in the study area are Kaccha houses with clay floors and walls of thin wooden planks, jute bars or bamboo and roofs of straw or sheet metal. Most houses in the study area are now built on socles to reduce flooding vulnerability.

All but one of the interviewed farmers was running floating gardens at the time of the interview. The exception (#5) is a farmer who once used floating gardens but stopped three years ago. Almost all the farmers surveyed have no or too little land of their own to use for agriculture (Interview 1: 74-75, KII-1). Therefore, fields are rented seasonally (Interview 1: 70-73). This does not apply to interview partner #3, who has sufficient land of his own. None of the fields or floating beds are owned or shared by a commune (Interview 2: 55, KII-3). The areas used for rice cultivation in winter are later used for floating gardens when the fields are flooded (Interview 1: 90, KII-2).

None of the respondents could answer where the practice of floating gardens comes from (Interview 1: 35). The literature shows that this is a traditional practice that is used in different ways in Asia at Inle Lake in Myanmar, at Tonle Sap in Cambodia, in Kashmir in India and in some parts of Bangladesh (Saha, 2010). Almost all farmers have learned from their parents and grandparents to operate floating gardens and are in contact with the practice as far as they can remember (Interview 2: 14). Where the grandparents learned the practice could not be answered either (Interview 2: 22-24).

3.2 Growing season of floating gardening in the study area

All farmers interviewed use two growing seasons per year (Interview 1: 392-337). Rice cultivation takes place from late December/early January to April. In December, soil preparation for sowing begins and harvesting takes place in April. From mid-May/July, depending on the water level in the region, the season for the floating gardens begins. This season ends in November/December, when the high water level has decreased. Vegetable growing takes place in both seasons parallel to rice growing and floating gardens.

Most crops are cultivated during winter (mid-December to mid-February) and spring (mid-February to mid-April). Figure 2 shows the crops of all respondents except the products produced on floating gardens. It can be clearly seen that from the beginning of the Bangladeshi summer in mid-April until the end of the rainy season in mid-October there is hardly any normal agricultural activity. The products grown in floating gardens therefore enhance food production during the monsoon season.

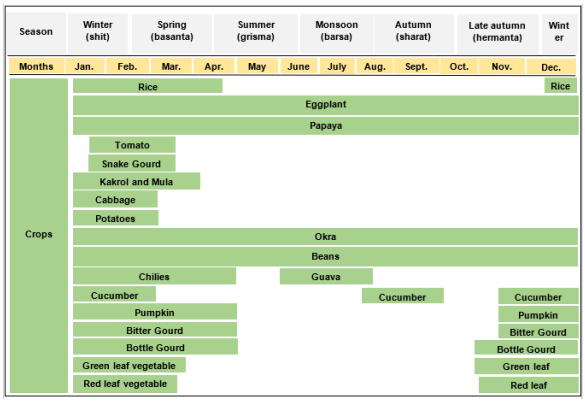

Figure 1. Crop calendar based on the farmers interviewed with exception of the products of the floating gardens

3.3 Construction method and materials

The construction of the beds varies from village to village. All respondents use a variety of water hyacinth (Latin: Eichhornia crassipes, Bengali: Kuchuri Pana) as the main component of the bed (El-Morsy *et al.*, 2006). Some of the respondents also use the aquatic plants Shola (Latin and English name unknown), Shellflower (Latin: Pistia stratiotes, Bengali: Fenna) and Dhundalebon (Latin and English name unknown) (Interview 4: 24-26). A bamboo scaffold initially serves some respondents as a frame for the aquatic plants. However, not all respondents use this tool, since the aquatic plants combine with each other without tools (Interview 4: 24-26). The aquatic plants are layered on top of each other to a height of around three feet (Interview 10: 77). Farmers then densify the plants by stamping them or tapping them with sticks (Interview 8: 60). When the water hyacinth starts to decompose in the water, nutrients are released, making it a biological fertilizer (Interview 11: 55). Therefore the addition of soil is not necessary. The grated outer shell of coconuts is spread on the bed after it has been built (Interview 1: 61).

3.4 Procurement of materials

The aquatic plants from which the floating gardens are built are procured in different ways by the farmers. In Shibpur, there are naturally enough aquatic plants due to newly accredited soil by river, so there is no need to purchase additional plants on the market (Interview 6: 67-71, Interview 8: 55-56). Sometimes the quantity is insufficient and additional plants are purchased, as in the village of Umarerpar, where the villagers collect a part of the plant material themselves and purchase the rest (Interview 1: 106-107; Interview 4: 71-72; Interview 7: 72, KII-4). The plants are available on the market (Interview 3 2019: 40) and in other villages, where plants grow naturally in abundance or are cultivated (Interview 2: 29-31). Not every village has enough space to cultivate the plants (Interview 1: 112-113). In the village Paseim Maluhar, almost all aquatic plants are bought by the respondents on the market (Interview 2: 101-102; Interview 3: 40), but some water hyacinth is cultivated for 30 days to use it for the beds (Interview 2: 37). To make a bed of 100 feet, about 500 feet of water hyacinth are needed (Interview 10: 133). The third farmer interviewed reports that he sometimes buys already finished swimming beds on the market (Interview 3: 42).

Seeds are purchased by each respondent (Interview 1: 244-248). Seeds from hybrid breeds are partly used, especially for rice cultivation, but also for vegetables on floating gardens: "He always uses hybrid seeds" (Interview 3: 138-145, KII-5). It should be noted that these seeds are more expensive to buy, but more productive. However, new seeds must be purchased for each season.

Figure 3. Floating gardens in Barisal (Photo: Pyka: 2019)

Figure 4. Floating gardens in Barisal (Photo: Pyka, 2019)

All farmers reported various pests that could affect the floating gardens. Therefore, almost all farmers buy pesticides in addition to some chemical fertilizer. Chemical products are mainly used, some of which are combined with natural ones (Interview 8: 40-42). The opinion seems to be that the chemical products work better than the natural ones: "The natural fertilizer does not work properly" (Interview 7: 39-40, KII-7). Interview partner six is the only interviewee who does not use any chemical input. He says that the aquatic plants Fenna and Kuchuri Pana act as natural pesticides and fertilizer (Interview 6: 78). Those farmers, who only grow seedlings on the beds, spray pesticides and fertilizers directly on the bed. All seedling farmers reported that the chemicals flow into the water and negatively affect the number of fish (Interview 1: 127, KII-6). Farmers who grow vegetables do not spray the beds, but the plants on them. As a result, less chemicals enter the water. Fish stocks around the floating gardens were reported to be higher among all farmers growing only vegetables. Additionally "When the Kuchuri Pana rots then the fish eat it. That's why there is more fish" (Interview 6: 176-178). The floating gardens can thus represent an improvement for the ecosystem or the natural capital by creating new habitats for fish, but at the same time they can have disadvantages if farmers misuse pesticides. In the right application of pesticides "There is a huge lacking. The more they use the better it is. That's the common sense" (Interview 12: 53, KII-8).

3.5 Different uses of the cultivation method

Floating gardens are composed of individual beds. The size of the beds varies from family to family from 20 to 300 feet (Interview 2: 25-28). As with the land use system, there are no communal floating gardens. Each family has several beds (Interview 1: 98-99), with the number of floating beds depending on the family's financial capabilities (Interview 9: 33). All the farmers interviewed cultivate a number of five to twenty beds, with the exception of three interview partners, who cultivate 50-60 beds in one season.

Two different uses of floating gardens were found in the study area as you can see in figures 3, 4 and 5. Floating gardens are used for the cultivation of seedlings, as well as for vegetables. Sometimes the different uses are combined with each other. Seedlings are cultivated on the beds several times during a season. Vegetables are harvested only once. Some of the respondents use the floating gardens not only for one season, but for several years (Interview 8: 49-50). The beds remain on the edge of the field when it is dry (Interview 8: 60). It was reported that the beds can be used between ten and twenty years with good maintenance (Interview 8: 146-148). However, each season the old bed must be repaired and equipped with new water hyacinths (Interview 8: 55-56, Interview 6: 28-31). If the bed is not used several times, it is left on the field as a natural fertilizer for the following rice season (Interview 2: 65).

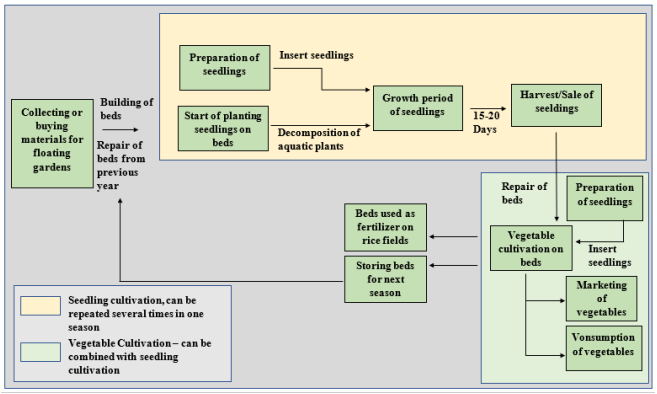

Figure 2. Cycle of activities within a season of floating gardens based on the farmers interviews

3.6 Workers involved

The entire family is involved in the preparation of the floating gardens for all respondents (Interview 6: 137-138), with the exception of interview partner number three

(Interview 3: 88-89). Women, children and older people prepare the seedlings for the floating gardens and collect aquatic plants (Interview 1: 212-215) (Figure 5 & 6). Thus the human capital of the family is strengthened, since the ability to work within the household has increased, as well as the financial capital through lower costs for wage labourer.

Figure 6. Collection of aquatic plants for building floating beds by housholds (Photo: Pyka, 2019)

Figure 7. Seeding by female household members (Photo: Pyka, 2019)

All interviewees employ additional wage labourer during the time of the floating gardens. The wage labourer learn from their families to build floating gardens (Interview 3: 90-91), but do not own their own floating gardens (Interview 8: 100-105). Some wage labourer do not know how floating gardens are made and get it taught by the farmer who hires them. The wage earners are employed mainly for the construction of the beds (Interview 6: 139-142), but also later for irrigation (Interview 1: 189). To employ a labourer costs a farmer 500 Taka (Apx. USD 6) per day as well as a lunch and a dinner (Interview 2: 96-98). In one day one worker manages to produce about 20 feet of a bed (Interview 6: 139-142, KII-9). Even if the employment of wage labourer reduces the families' financial capital, an income strategy is created for the wage labourer, who can thereby upgrade his financial capital. In addition, he learns the technique of floating gardens, which also enhances his human capital.

3.7 Investment costs

Floating gardens represent a very profitable source of income for all farmers surveyed. "He says it is very profitable" (Interview 6: 146). "Through the floating gardens they have enough money" (Interview 6: 224). Furthermore, according to all farmers, the family income is increased by the floating gardens and thus the financial capital is strengthened (Interview 6: 147-148). The ninth interviewee was the only one to earn more from rice production than from floating gardens (Interview 7: 90-91). The other farmers state that they earn the most income from floating gardens, which in some cases is up to four times higher than that from the rice harvest (Interview 7: 121-122, KII-3).

Even if the beds provide a good income, the investment costs of around 20,000 Taka per bed (Apx. USD 240) represent a high financial burden for the farmers (Interview 1: 324). Of the 20,000 Taka, water plants, fertilizer, seeds, pesticides and wage earners are paid. Also included are the necessary costs for the repair of the bed with water hyacinth after each seedling harvest, which amount to about 2,000 Taka.

To cover the investment costs, all respondents take out a loan from local non-governmental organizations (NGOs) for floating gardens at the beginning of the season. Only one loan can be taken out at a time from an NGO, which is why the interviewees are in contact with several NGOs. There is therefore a linking network (Al-Maruf, 2017), meaning a networking between people and organizations (e.g. NGOs) outside the usual local environment, which strengthens the social capital of the interviewees. Depending on the respondent, up to four loans are taken out each year (Interview 2: 146). After the season for the floating gardens, the loan is repaid to the organization. Almost all respondents report a high interest rate on loans from NGOs. Three of the respondents paid an interest rate of 12-20% (Interview 6: 184; Interview 7: 100, KII 5). One of the farmers reported an interest rate of only 3%. Islam (2016) confirms that some NGOs in Bangladesh are more profit-oriented than charitable. They demand loans with high interest rates that can drive the poor into a debt cycle. None of the respondents reported from NGO's offering or supporting training for the technology of floating gardens.

3.8 Food insecurity and food quality

Food insecurity is a common problem in the study area (Interview 1: 284-285), (Interview 7: 108), (Interview 2: 116-117). It should be noted that the staple foods rice and wheat are always available (Interview 12: 31) and families can afford them (Interview 12: 31). However, there is a lack of protein and vitamin supply, which results from the fact that people cannot always afford enough vegetables, fruits, milk, fish and meat (Interview 1: 284-285). “If we have money we can get all things. But money limitation is a big limitation”(Interview 2: 128). Accordingly, the challenge to food security in the investigated area is less hunger and more malnutrition (Interview 12: 31). All respondents, with the exception of the third farmer, are confronted with food shortages. He has enough income to afford food. However, he observes the malnutrition of his neighbours (Interview 3: 129). The farmers interviewed do not cultivate a sufficient variety of crops to meet the vegetables needs of the household. Food shortages have the same cause "No work, no agriculture, no vegetables for selling" among all respondents (Interview 5: 68). As a result, the farmers' income is so low that they cannot afford enough food (figure 3). The hungary season usually lasts two to three months, in some cases longer (Interview 8: 132).

In the months from January to April, food shortages may occur because rice is in the growth period and therefore there is little work and income (Interview 7: 108) (Figure 6). After the rice harvest until the beginning of the season for the floating gardens, as already explained, there is hardly any agricultural activity. Therefore, not enough food is produced, but much more serious is that there is no or little income at this time. As a result, families can afford less food. Interview partner five (the farmer who used to do floating gardening in

the past) reports food insecurity during the months of March to April. He lives from the sale of vegetables and seedlings, he has no income during this time, as hardly any vegetables are produced (Interview 5: 63). Another period of food insecurity can occur during the months of June and July, when the high investment costs of floating gardens must be met (Interview 5: 54). Additionally it takes several weeks for the beds to be prepared, and for the first harvest being ready for sale. The food shortage is particularly drastic if a natural disaster destroys the harvest on the floating gardens (Interview 2: 116-117) or if the harvest takes place later than planned due to unfavourable environmental conditions (Interview 4: 102).

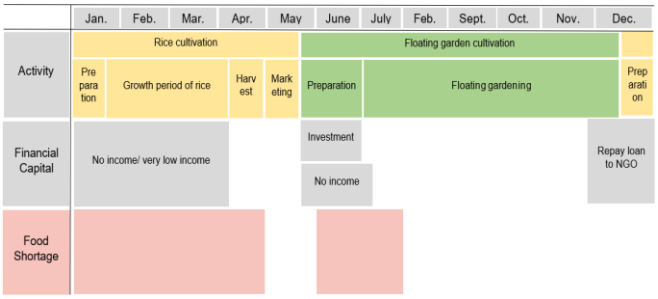

Figure 8. Relationship between agricultural activities, income and food shortages based on the farmers interviews

Towards the end of the season the loan has to be repaid to the NGO's, which is a big burden due to the already mentioned high interest rates (Interview 2: 128) that reduces the financial reserves of the family. During the period of floating gardens, all interviewees report that they have sufficient money and sufficient food (Figure 8). An advantage for farmers growing vegetables on the floating beds is that they can obtain a good price for vegetables in the rainy season because less vegetables are produced in the area (Interview 6: 60). In times of severe natural disasters such as cyclones or severe flooding, staple foods such as rice may not be available because they have been destroyed, markets do not take place or people have no money to buy something. "Actually, when there is a disaster like flood [...] all food is lacking" (Interview 1: 278-282).

In times of food shortages, rice is eaten daily but less vegetables, meat and fish are eaten. Vegetables are rarely bought on the market and, if they are, they are very low-priced vegetables. It is mainly eaten green and red leaf vegetables (similar to spinach). Water lilies are also collected because their stems can be cooked as vegetables (Interview 9: 109). Wild fruits such as jackfruit and coconuts are also used during this period (Interview 5: 76). Some fish and meat are not consumed during the entire period of food shortage (Interview 8: 108-113). Others reduce fish consumption to about once a week to every two weeks and meat consumption to about once a month (Interview 7: 108). This is in stark contrast to the diet during the season of the floating gardens. In this case, each household eats fish almost daily and meat three to four times a month. The variety of vegetables is also much greater (Interview 8: 129). It has to be said that Barisal is a fishing area and therefore there is a lot of fish to buy. In other regions of Bangladesh, food security may appear differently (Interview 12: 72). When meat is eaten, it is usually chicken, rarely beef (Interview 5: 56). One interviewee from the first group interview reports that the situation has improved compared to the food situation 30 years ago. On the one hand agricultural production has improved, on the other hand floating gardens have contributed their part since they are used in the village. "Yes, floating gardens changed a lot" (Interview 1: 309-312). Access to markets plays an important role in the supply of food and the sale of crops. All farmers surveyed have stable access to local markets (Interview 1: 316). The interviews showed that almost all farmers use a floating market that takes place in the region. This is mostly used because the seedlings harvested by boat can be transported directly to the market. In addition, middlemen on boats come to the farmers of the floating gardens, buy seedlings and then transport them to the floating market (Interview 4: 73-74). This market is also the place where merchants who come from Dhaka on large ships buy seedlings. Food is also bought at markets that do not take place on the water (Interview 8: 139). Apart from access to local markets, farmers do not have access to national markets. In most cases, the market is controlled by intermediaries. In order to give farmers stable access to markets, it is important to involve intermediaries. "We need to ensure [...] that they are playing the right role. Like Fairtrade" (Interview 12: 62).

Hasan *et al.* (2017) noted in view of the importance of floating agriculture, the Bangladeshi government has launched a project in 42 sub-districts of the south-central districts through the agricultural offices in order to strengthen farmers' capacities and transfer technology to similar areas of the country. In 2018, the government launched a project to promote floating gardens in the Wazirpur sub-district. Floating gardens are seen as an effective means of raising people's standard of living (Interview 10: 63). One-day training sessions are designed to teach selected farmers about the cultivation method and the use of floating gardens. In addition, selected farmers are to be accompanied for four months in the cultivation of floating gardens, paying attention to the proper and effective use of pesticides (Interview 10: 109-112). The interviewee did not know that the materials could be bought on the market and he was of the opinion that only farmers with direct access to the plants could operate floating gardens (Interview 10: 134-135, KII-9). Five of the farmers interviewed took part in the training sessions or exchanged experiences with neighbours who were there. Almost all interviewees would like more support from the government. This support should take the form of seeds, pesticides, trainings, financial support and cheap loans (Interview 2: 90-94; Interview 6: 135-136). Interview partner two explained that local representatives promise a training, but that it does not take place (Interview 2: 203-206).

4. Discussion

Floating gardens are according to the definition by Chambers and Conway (1992) a sustainable livelihood. Floating gardens provide a solution to cope with the stress of regular and prolonged flooding, recover from it and maintain or improve assets (Scoones, 2009). The natural resource base is not undermined, as the cultivation method is resource-saving and based on natural, locally available materials. They also offer a sustainable income strategy for the next generation, who are handed on the method by their parents. Floating gardens contribute to other income strategies on the local market as there are different job opportunities around the floating gardens (Krantz, 2011). Not only the farmers benefit from the floating gardens, but also middlemen who buy and sell the seedlings, as well as villagers selling the aquatic

plants and the wage earners who build the beds. The floating gardens represent an income strategy that influences and strengthens the assets of a household. Most of all, the financial capital is upgraded by the cultivation method. Although the high investment costs represent a burden for the households, the profit that can be generated by the cultivation method is much higher. Investment costs could be reduced by dispensing with chemical fertilizers and pesticides, as confirmed by other studies on floating gardens Islam & Atkins, 2007; Irfanullah *et al*., 2009). According to Irfanullah *et al*. (2009) the use of pesticides on floating gardens has increased dramatically to make vegetables and seedlings look particularly fresh and good for the market to achieve a better price. This also shows that farmers are dependent on markets that have become increasingly competitive (Irfanullah *et al*., 2009). The use of less chemicals would protect the environment, strengthen natural capital and thus make the cultivation method even more sustainable.

The use of locally available natural resources strengthens natural capital in different ways. On the one hand, as already mentioned, new habitats are being created for organisms living in water. At the same time, it counteracts the spread of invasive water hyacinths (Irfanullah *et al*., 2009), which can lower the oxygen content of water and thus influence fish stocks (Aneja *et al*., 2014). It must also be taken into account that the beds are used as natural fertilisers on dry fields, which reduces the exposure to chemical fertilisers. But probably the most decisive contribution of floating gardens to natural capital is the gain of agricultural land from flooded areas which leads to a significantly improved access to land for marginalised groups.

Farmers need further training to transition from the current production method to a completely biological method and to learn new or more cost-effective techniques. The government is already supporting some households with training, but there is a greater demand than can currently be met by the government. It was also observed that the government employee in charge has little experience with floating gardens, which can affect the quality of training. The social capital of the farmers is strengthened by the presence of NGOs and their microcredit. These organizations support the floating gardens by giving loans for investment costs but, as in many other fields, interest rates are often high and burdens some of the farmers. Stricter laws and stronger controls by the government can help to tackle this problem. No particular impact of floating gardens on physical capital could be found in this work.

Floating gardens make a significant contribution to food security, especially by making it easier to finance food through increased financial capital. Access to food is thus improved by the floating gardens. Physical access to food via markets is a challenge in the study area only in a few exceptional cases during periods of extreme heavy rainfall for short periods. Food is available in the market but is not always affordable. The stability of the food is improved by the floating gardens, although not fully established, as food insecurities still occur. These are strongly linked to financial capital and can be reduced by lowering investment costs and loans with lower interest rates. This can increase families' reserves and create opportunities to ensure food stability even at times of low income. The use of food could not be sufficiently highlighted in the surveys. There is a clear difference in the quality and diversity of food during the season of the floating gardens compared to the dry winter season, suggesting that people have a basic knowledge of the correct use of food. However, it is unclear to what extent nutrient deficiencies are compensated in times of food insecurity, or whether there is an awareness of the consequences of malnutrition.

5. Conclusion

Floating gardens represent a sustainable and lucrative income strategy for rural households in flood-prone regions of Bangladesh, which is also recognized by the country's government. Areas that cannot be cultivated are made usable, and the achievable income ensures the security and variety of food in the season of the floating gardens for almost all respondents. Food insecurity is strongly linked to the financial affordability of food and less to the availability of food. The repayment at the end of the season of the loans at high interest rates taken out to cover the investment costs of the beds will put a strain on the family's financial reserves. This increases the risk of food insecurity in low-income months. Loans at lower interest rates can help to improve the situation of farmers. In addition, further training by the government and NGOs can help to teach the technology more effectively and sustainably to the farmers. This would also help farmers to network with each other in order to exchange knowledge and support each other, even beyond village borders. The income strategy opens up further directly connected fields of activity in addition to the cultivation of the beds and thus has a large sphere of influence from which many people benefit. The use of natural resources does not damage the environment, as is often the case with conventional agriculture. Further studies may show whether the addition of chemical pesticides and fertilizers is necessary or whether they can be replaced by natural ones. This will protect the environment and reduce investment costs for farmers.

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References

Abedin, M.A., Habiba, U., Hassan, A.W.R., Shaw, R. (Eds.) (2015). Food security and risk reduction in Bangladesh. Springer, Tokyo.

Alam, K., Chowdhury, M.A.T (2018). Floating Vegetable Gardening (FVG) as a Sustainable Agricultural System in Bangladesh: Prospects for Kaptai Lake, Rangamati, Chittagong Hill-Tracts. International Journal of Sustainable Development, 11(3), 43–58.

Al-Maruf, A (2017). Enhancing Disaster Resilience through Human Capital: Prospects for Adaptation to Cyclones in Coastal Bangladesh, Universität zu Köln, Köln. Available at: https://kups.ub.uni-koeln.de/7605/1/PhD_thesis_Al-Maruf.pdf

Al-Maruf, A., Jenkins, C., Islam, A., Sarmin, S. (2020). Coastal Zone of Bangladesh: A Tale of Pessimism and Optimism. In Hossain, M., Kholikuzzaman, B., Islam, C (Eds), Climate adaptation for a sustainable economy: lessons from Bangladesh, an emerging tiger of Asia. NY, Nova Publishing, 27-44.

Aneja, K.R., Kumar, P., Sharma, C (2014). A new strain of Alternaria alternata (AL-14) on water hyacinth from India. Journal of Innovative Biology, 1 (2), 117–121.

Anik, S.I., Khan, M (2012). Climate change adaptation through local knowledge in the north eastern region of Bangladesh. Mitigation and Adaptation Strategies for Global Change, 17, 879–896.

Bernzen, A., Jenkins, C., Braun, B (2019). Climate Change-Induced Migration in Coastal Bangladesh? A Critical Assessment of Migration Drivers in Rural Households under Economic and Environmental Stress. Geosciences, 9 (51), 1–21.

Braun, B., Shoeb, A.Z.M (2008). Naturrisiken und Sozialkatastrophen in Bangladesch - Wirbelstürme und Überschwemmungen. In: Felgentreff, C., Glade, T. (Eds.), Naturrisiken und Sozialkatastrophen. Spektrum, Heidelberg, 381–393.

Briones Alonso, E., Cockx, L., Swinnen, J (2018). Culture and food security. Global Food Security, 17, 113–127.

Chambers, R. and Conway, G. (1992) Sustainable Rural Livelihoods: Practical Concepts for the 21st Century, IDS Discussion Paper 296, Brighton: IDS.

Cook, B.R., Lane, S.N (2010). Communities of knowledge: Science and flood management in Bangladesh. Environmental Hazards, 9, 8–25.

Daskon, C.D (2010). Cultural Resilience –The Roles of Cultural Traditions in Sustaining Rural Livelihoods: A Case Study from Rural Kandyan Villages in Central Sri Lanka. Sustainability, 2, 1080–1100.

FAO (2009). World Summit on Food Security, Rom. http://www.fao.org/fileadmin/templates/wsfs/Summit/Docs/Declaration/WSFS09_Draft_Declaration.pdf. Accessed 11 August 2019.

Food Security Information Network 2018. Global Report on Food Crises (2018). https://docs.wfp.org/api/documents/WFP-0000069227/download/?_ga=2.104090566.770162101.1564565007-245890337.1564565007. Accessed 31 July 2019.

Grebmer, K. von, Bernstein, J., Patterson, F., Sonntag, A., Klaus, L.M., Fahlbusch, J., Towey, O., Foley, C., Gitter, S., Ekstrom, K., Fritsche, H (2018). Welthunger Index 2018: Flucht, Vertreibung und Hunger. Deutsche Welthungerhilfe e.V; Concern Worldwide, Dublin.

Hasan, S.S., Mohammad, A., Kumar Ghosh, M., Khalil, M.I (2017). Assessing of Farmers' Opinion towards Floating Agriculture as a Means of Cleaner Production: A Case of Barisal District, Bangladesh. British Journal of Applied Science & Technology, 20 (6), 1-14.

Irfanullah, H.M., Azad, M.A.K., Kamruzzaman, M., Wahed, M.A (2011). Floating Gardening in Bangladesh: a means to rebuild lives after devasting flood. Indian Journal of Traditional Knowledge, 10 (1), 31–38.

Irnfanullah, H.M (2009). Floating gardening in Bangladesh: Already affected by climate variability? In: IUCN Bangladesh, UNEP, United Nations University (Eds.), Biodiversity conservation and response to climate variability at community level, 7–14.

Islam, M.S (2016). The NGOs sector in Bangladesh: emergence, contribution and current debate. Advances in Asian Social Science, 7 (2), 1182–1188.

Islam, T., Atkins, P (2007). Indigenous floating cultivation: a sustainable agricultural practice in the wetlands of Bangladesh. Development in Practice, 17 (1), 130–136.

Krantz, L. (2011). The Sustainable Livelihood Approach to Poverty Reduction: An Introduction, 1st ed. Swedish International Development Cooperation Agency.

Mishra, A.K., Khanal, A.R (2017). Assessing Food Security in Rural Bangladesh: The Role of a Nonfarm Economy. Frontiers of Economics and Globalization (17), 241–257.

Saha, S.K (2010). Soilless Cultivation for Landless People: An Alternative Livelihood Practice through Indigenous Hydroponic Agriculture in Flood-prone Bangladesh.

Scoones, I (2009). Livelihoods perspectives and rural development. The Journal of Peasant Studies, 36 2009, 171–196.

Shamsuzzoha, M., Al-Maruf, A. (2011). Post SIDR life strategy: Adaptation scenario of settlements of the south. Journal of the IBS (Institute of Bangladesh Studies, University of Rajshahi), 19, 207-222

Ziervogel, G., Ericksen, P.J (2010). Adaptation to climate change to sustain food security. WIREs Climate Change, 1, 525–540.