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Original Research Article

Effects of land-use changes pattern on tree plantation: Evidence from gher land in Bangladesh

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The southwestern part of Bangladesh is extremely vulnerable to climate change due to its geographical settings. The adverse effects of climate change force people to convert cultivable lands into gher practice for improving livelihood. Therefore, the study aims to explore how land use pattern influences tree plantation in gher land in Bangladesh. A quantitative dominant qualitative mixed method has been used, and data have been collected from 78 respondents comprising farmers practicing tree plantation and those without tree plantation. This study reveals that the ownership of gher has a significant impact on planting trees on gher dike. On the other hand, the farmers with larger gher were more willing to have trees on their gher dike, whereas dike width more than 6ft is feasible to establish a plantation. 69% of the farmer has opined that they practice semi-extensive production systems of gher management (without trees) followed by 44% of gher management (with trees). Further, 79% of farmers of gher with trees are well aware of the benefits of planting trees in gher dike, and they want to plant trees on gher dike willingly. In gher with trees, 62% of respondents were the owner and are willing to plant trees on their gher dike. On the other hand, there was a 56% respondent in favor of gher without trees among whose 54% gher width is 6ft or more. The findings will help local farmers for developing awareness on the benefits of planting trees on gher dike to increase gher land productivity and maintain sustainable ecological balance.

Keywords: Dike width, Gher land, gher size, land use pattern, livelihood pattern, ownership, tree plantation.

INTRODUCTION

Bangladesh is one of the most vulnerable countries (MVC) in the world due to climate-induced natural disaster, and the impact of disaster resulting from ecological destruction cause a severe hazard to livelihoods and the economic development of the country (Hossain et al., 2015; Sarker et al., 2019). It is situated the country in the low-lying Ganges-Brahmaputra river delta, which are fertile plains in the world. Concurrently, it is most vulnerable to river erosion, floods, and cyclones (Islam, 2012; Hossain et al., 2016; Sadekin et al. 2018a;). The southwestern part of Bangladesh is extremely vulnerable to climate change because of riverbank erosion, recurring floods, cyclone, salinity intrusion, and tidal surge (Hossain et al., 2016; Hossain et al., 2019). These natural hazards adversely affect the whole ecosystem, and also lead to loss of human life and shelters, or the resources essential for their livelihoods (Ahamed et al., 2012; Sadekin et al., 2018b; Sarker et al., 2020b). According to the IPCC report (2007), agriculture is a dominant sector of Bangladesh's economy, and the southwestern part of the country is very fertile for growing

rice, which supports most livelihoods. Due to the recurring coastal flood, water and soil are converted into gher land (shrimp cultivation) (Ahmed, 2013). For example, in both Khulna and Satkhira districts,50% of cultivable agricultural land has been shifted into shrimp farming to resume livelihoods (IPCC, 2007). Zarin (2015) found that shrimp farming (gher) upsets the female labor livelihoods and affect their income and occupation, food consumption and also lead to the hazardous working environment. Hoque et al. (2018) reported that the rapid rise of the aquaculture industry (shrimp gher) due to social-ecological changes and climate change has significantly affected the livelihoods of coastal communities in the southwestern region of Khulna, Bangladesh. Rahman et al. (2013), investigated the constant and unregulated growth of shrimp farm (gher) has immense impacts on human health, environment, and sustainability.

Over time, the land use pattern in Bangladesh has been transforming. Although Bangladesh is considered a land-scarce country and per capita cultivated land is only 12.5 decimals (Rahman et al., 2014; Al-Amin, 2018).The per capita cultivable land is decreasing as the total population continues to increase (Islam et al., 2019).To meet the basic demand for overpopulation, exploitation of natural resources, and environmental degradation has appeared (Hossain, 2001). The land productivity of Bangladesh is comparatively low compared to other countries around the world (Mondal, 2008; Kibria and Jashimuddin, 2012), and to maximize the land productivity, the farmers use the existing farmland in the diverse way (Nicholls et al., 2018). Khulna is located in the southwestern part of Bangladesh, where cultivable land use pattern has been changing in the last few decades drastically (Mondal, 2008; Sadekin et al., 2018c). This change has been occurring mainly to expand the shrimp culture. Majority of the cultivable agriculture land has been converted into aquaculture practice due to a handsome amount of profits(Wilson et al., 2017). This aquaculture practice converts cultivable lands into gher practice for bringing change in farmers livelihoods pattern, affecting the socio-economic condition and ecosystem of the area (Rahman et al., 2013; Ahmed, 2013).

In contrast, the monoculture is gradually replacing with a mixed culture, which ultimately leads to reducing crop diversification (Sarker et al., 2020c). As a result, the area has become treeless gradually, which also affects local and regional climatic conditions. These changes in land use patterns are immensely pressure on ecosystem services and livelihoods (Sarker et al., 2020a). The benefits of tree products are extensive, like wood, fibres, food, poisons, and other chemicals due to the direct interactions of trees plantations on aquaculture (Swapan and Gavin, 2011; Ahmed, 2013). The ecological interactions between trees and aquaculture are evident, on both micro and macro scales (Islam et al., 2019). Trees play a vital environmental function, physical structure, shade, reducing soil erosion, ameliorating soil chemical and increasing water infiltration, and flood limitation that impacts directly, or indirectly, on water quality and quantity (Nicholls et al., 2018; Huang et al., 2018). Thus, tree plantation will affect local and regional water bodies and subsequent aquaculture activities (Potapov et al., 2017). The southwestern coastal region of Bangladesh has the cultivable mixed farmland that has been changed gradually into gher land with no tress plantation on dike. Besides, a number of gher land farmers have no interest in planting trees on their gher dike because of the negative perception of co-management of trees fish and crop cultivation. The factors like dike width, ownership of the gher land, gher management, and gher size are responsible for the interest in planting trees on gher dike (Rahman et al., 2013).

MATERIALS AND METHODS

Study area

The present study was carried out at Moikhali village under Dumuria Upazila of Khulna district, Bangladesh, which is bordered in the north by Manirampur, Abhaynagar and Phultala Upazilas, on the south by Batiaghata and Paikgachha Upazilas, in the east by Khan Jahan Ali, khalishpur and Sonadanga than as, in the west by Batiaghata, Tala and Keshabpur Upazilas. The Dhumuria Upazila is located between 22°39' and 22°56' N and 89°15' and 89°32' E (Figure 1) with a total area of 454.23 km^2 and about 25 km southwest of the Khulna district, headquarters of the southwestern part of Bangladesh. The climatic condition of the study area comprises an annual average maximum temperature and the minimum temperature to be 35.5°C (95.9°F), and 12.5°C (54.5°F). The annual average rainfall is 1710 mm, and the soil condition is alluvial floodplain. The four main seasons are pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November), and the dry winter season (December-February). The highest and lowest potential evapotranspiration is 128.98 mm and 65.17 mm (Banglapedia, 2015). Argo-ecologically, the study village is located in the Ganges tidal floodplain (Rahman et al., 2014).

Data collection methods and analysis

The study was conducted using both primary and secondary data. Primary data were gathered through various techniques such as site observation, questionnaire survey, focus group discussion (FGD) with gher farmers and local communities, and key informant interview (KII). The data were collected of gher land morphology, benefits of tree, perception on the influence of trees with fish production, the response of planting trees, dike stability, gher management strategies, the sustainability of gher practices and ownership of the gher land using a semi-structured questionnaire. A total of 35 questions have designed and were asked to farmers, labours, gher management staff, and business persons through face-to-face interviews for qualitative information. The survey was administered to 78 gher land farmers (30% of

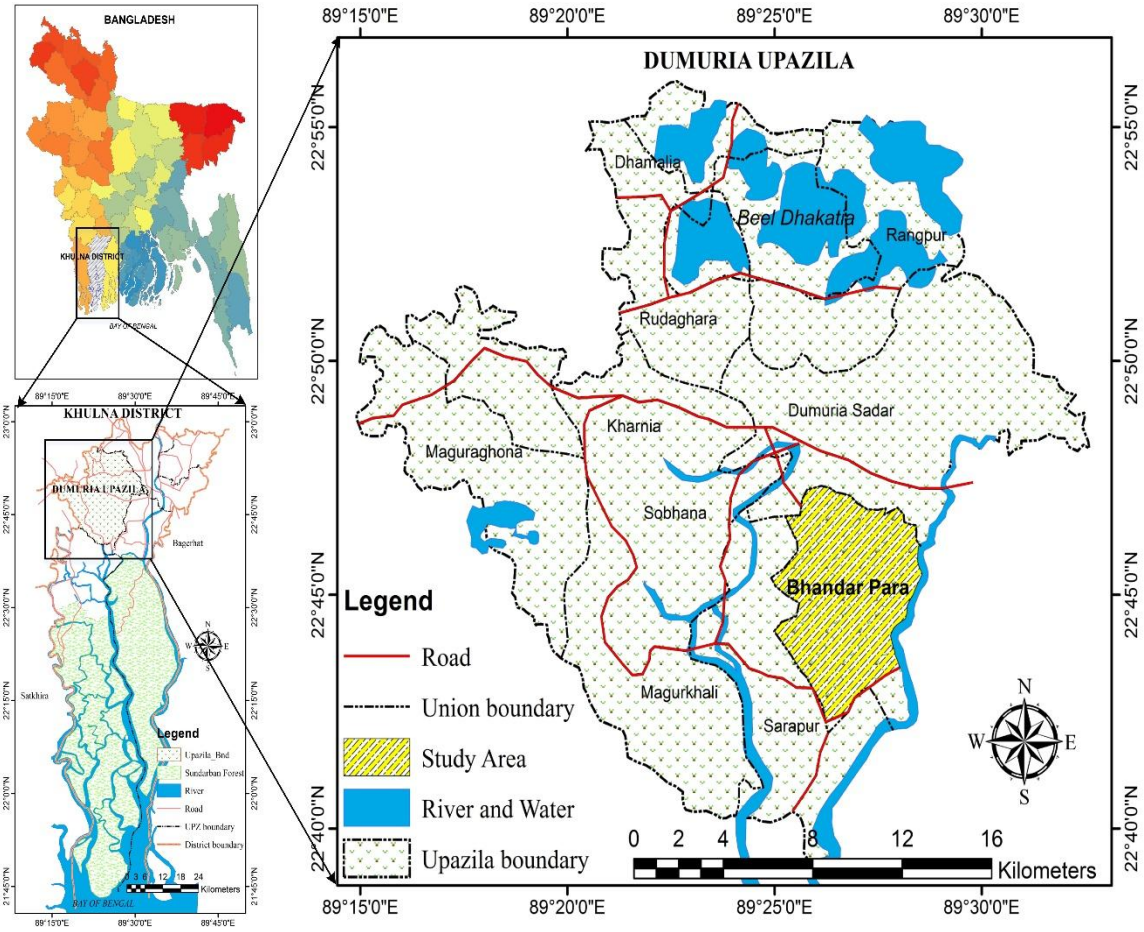

Figure 1: Location of the study area (Dumuria Upazila in Khulna district)

approximately 260 gher land farmer) in the study village, selected through a random route sampling method. There were two groups (39 respondents have gher lands with trees, and 39 respondents have gher without trees) were chose to interview for gathering data. The questionnaire survey, face-to-face interviews, and eyesight observation were accomplished from March 2012 to February 2013.

Moreover, eight Focus Group Discussion (FGD) sessions were conducted among farmers, daily labourers, fishers, and female groups at the Moikhali village, where 32 participants actively attended. During the FGD session, key questions were asked regarding on the objectives of the study, such as gher management practices, the impact of land tenure system on tree plantation in gher embankments, willingness to plant tree seedlings in their gher dike, and influence of tree or annual crops on fish production and their livelihoods. Besides, 4 Key informant interviews (KII) were conducted with various sectoral specialists, leaders, and professionals for obtaining the exact information about the influence of planting trees on gher dike on land productivity. Secondary information including journals, books, government documents, newspaper articles and websites, has been considered as the source of data in this study. The collected Gher related all morphological data like dike width, gher management type, dike stability, interest to change dike, ownership, gher size were edited and coded in a database for further analysis. The data from the survey has rigorously checked for consistency and then analyzed using MS Excel 2016 and SPSS software.

Data on land-use change pattern

In Bangladesh, the land-use pattern has been changing rapidly since 1971. For future sustainable development, it is essential to measure this land-use change pattern and determine its impact on tree plantation on gher land and livelihoods (Hassan, 2017; Hoque et al., 2018). Over time, land use pattern changes are connected with land tenure, labor availability, and proximity to the farmstead and learning opportunities (Mondal, 2008; Yesmin et al., 2014). For the present study, we compared the current agricultural land use and gehr land purpose with the previous condition and determined its influence on tree plantation. For this purpose, we took an attempt to analyze The pattern of land-use changes in the Dumuria Upazila

Figure 2: Types of gher based on management

during the study period (1980-2011). Data on different categories of land use patterns were collected from the Bangladesh Bureau of Statistics. The land use is categorized into five including agriculture area, settlement area, gher (pond, fisheries, and agri-fisheries) area, commercial and institution area.

RESULTS

Type of gher management

In the study area, there are four types of gher management practices in existence (Figure 2). Among gher management practice, the majority of the gher farmer practices semi-extensive types of gher management. In gher without tree, 69% of farmers are practising semi-extensive gher management whereas in gher with trees 44% of farmers practice semi-extensive gher management. The semi-extensive management practice has been reducing 69% to 44% because the farmers with gher management practice (without trees) are aware to improve this management practice. Only 3% of farmers of gher without trees among the respondent practice improved extensive farming methods, whereas the lowest percentages of farmers (15%) of gher with trees are using extensive methods. In both categories, farmers have the massive opportunity of applying intensive gher management practice of approximately 80% as they are practising nearly 20% intensive gher management for maximizing productivity.

Willingness to widen gher dike

In both areas, most farmers cultivate fish in association with crops and trees. Therefore, it is necessary to increase the width of gher dike for the proper management of gher (Dhar et al., 2020). As displayed in Figure 3, 56% of people in gher land without trees do not want to increase dike width for planting trees as they assume that trees have adverse effects on fish production and crops in gher. However, 79% of farmers in gher with trees want to increase the width of gher dike because of the benefits of planting trees.

Gher management in relation to the ownership

Gher land ownership is an essential factor in influencing land management and biodiversity(Morshed et al., 2020). As the farmers get lease gher land from the owner and want to get higher production by intensive management (Figure 4). The study revealed that 37% of farmers intensively cultivate their gher land for production, whereas only 3% use their rented property as an extensive culture. However, 65% of gher owner follows the semi-extensive technology

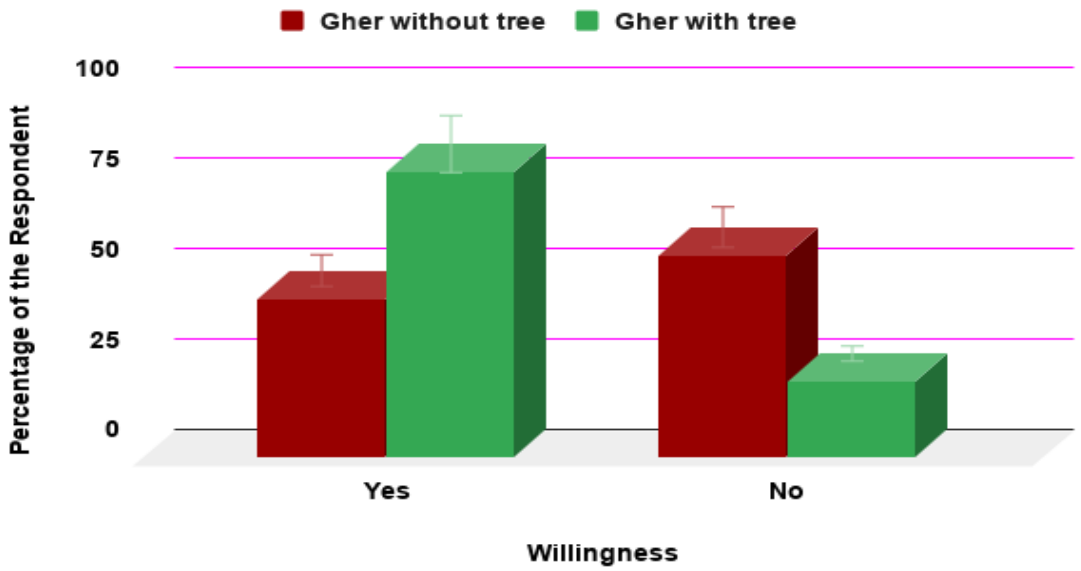

Figure 3: Willingness to widen gher dike

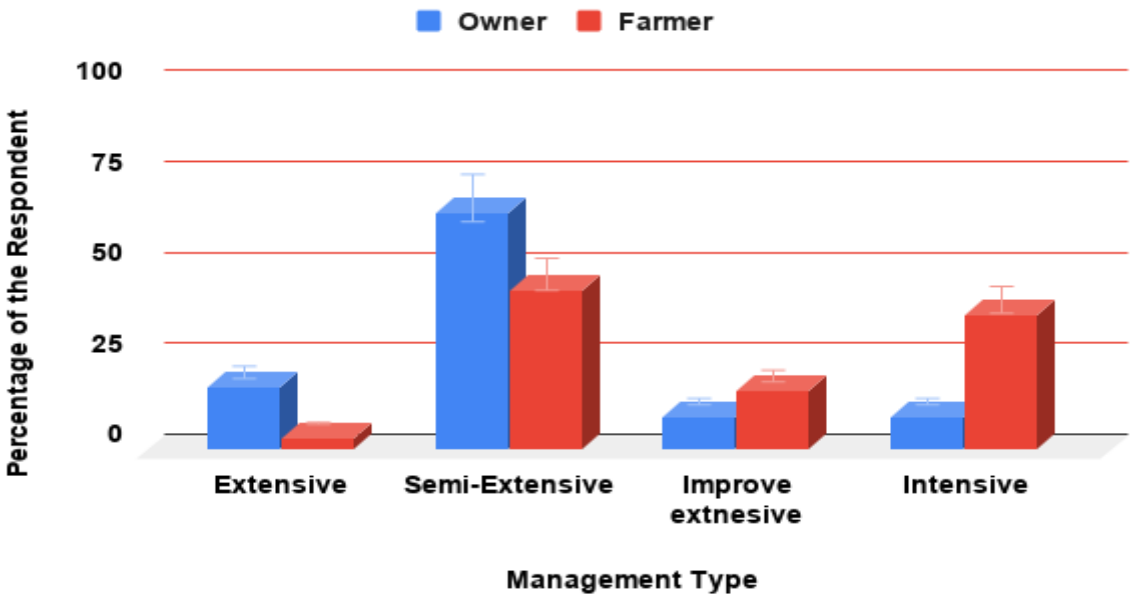

Figure 4: Gher management concerning the ownership

of gher farming, while 9% owner practice improved extensive and intensive agriculture, respectively.

Gher management in relation to the size of gher

The analysis indicates that the semi-extensive management technique is widely practised in both areas (without tress and with trees) of all sizes of gher (Table 1). According to the analysis, 53% of farmers of gher without trees follow a semi-extensive management practice that belongs to less than 6 bighas. In comparison, only 3% of gher are cultured through improving the extensive way. At a maximum 18% of farmers of gher management (with trees) follow the semi-extensive method of cultivation whereas extensive and improve extensive techniques are not being followed by any farmers of gher without trees. Here only 8% of farmers of gher with trees follow the semi-extensive method of farming while extensive improve the extensive

Table 1. Gher management relation with the gher size

Management	Extensive (%)		Semi-Extensive (%)		Improve extensive (%)		Intensive (%)	
Ghersize (Bigha)	Without Trees	With Trees	Without Trees	With Trees	Without Trees	With Trees	Without Trees	With Trees
less than 6	5	0	53	7	3	8	15	13
6-10	0	3	8	18	0	5	5	5
11-15	3	10	5	10	0	3	0	0
above 15	0	3	3	8	0	4	0	3
Total	8	16	69	43	3	20	20	21

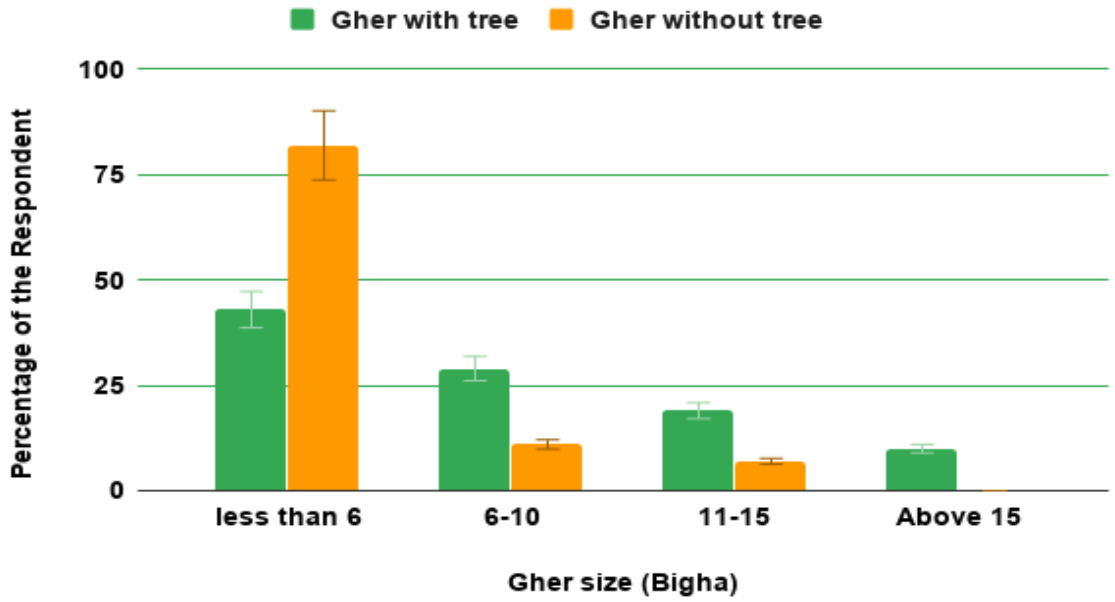

Figure 5: Gher size and effect on fish production

and intensive method of cultivations not followed by any farmers without trees gher.

Effect of trees on fish production about gher size

The perception of farmers on the effect of trees on fish production for both cases is showing a downward trend with the increase of gher size. 82% of farmers who belong to less than 0.96 ha land thought tree can hamper fish production of gher management without trees, whereas no farmers have found above 2.4 ha gher land of that Management (Figure 5). However, gher with trees has only 43% of farmers with less than 0.96 ha land who think that trees can reduce fish production.

Gher dike width

Without a surface cover of vegetation, any earth embankment will be severely eroded within a few years because of the high monsoon rainfall intensities(Ali, 2006). For this reason alone, embankments must have a full cover of vegetation (Islam et al., 2019). Dike width is important for cultivating crops and for planting trees. This study exposed that 51% of farmers opined that their gher dike width is above 6 ft in gher without tree and 44%of farmers of both areas mentioned that their dike width is 4-5ft (Figure 6).

Width of gher dike and ownership

The gher dike width is depending on the ownership of gher land. It is assumed that the borrowed gher farmers usually reduce their gher dike width for getting more benefits from aquaculture production. So, 50% of gher owner opined that their earth dike is 6ft or more while leased gher farmer' s makes for 26% (Table 2). Having a tree on gher dike also depends on the ownership of gher land. Among all respondents of gher with trees, 62% of respondents were gher owner while 56% for gher without trees. For getting long-term benefits, a continuous supply of fruits, fodder,

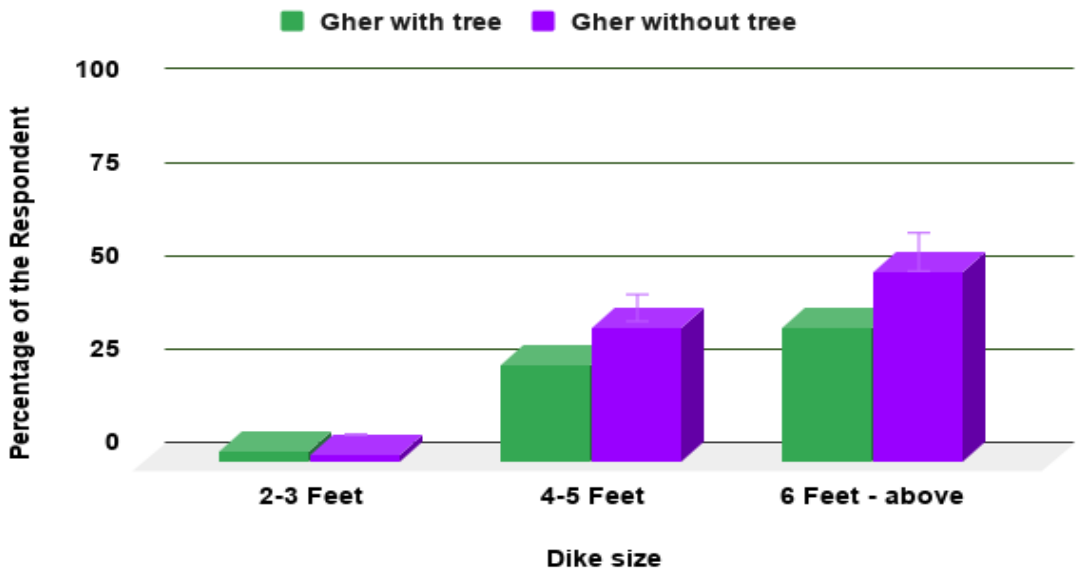

Figure 6: Width of the gher dike

Table 2. Influence of ownership on dike width of gher land

	Gher with tree		Gher without tree	
Dike width	**Owner**	**Farmer**	**Owner**	**Farmer**
2-3 Feet	5	34	0	12
4-5 Feet	45	40	46	42
6 Feet - above	50	26	54	46
Total	100	100	100	100

and fuelwood etc. gher owner is mostly planting trees on their gher dike. For gher management (without trees) 54% respondents (owner) said that their dike width was 6ft or more.

Dike stability with the width

The stability of gher dike depends on the width of the dike to some extent and trees on gher dike. Both categories of gher (gher with trees and without trees) land stability with dike width are shown in Figure 7. The study found that, with the increase of gher dike width, the stability of gher dike is also increased. The study found that, with the increase of gher dike width, the stability of gher dike is also increased. The dike stability (gher without trees) is the highest 51% when dike width is 2-3ft, followed by 36% and 2% for a dike width are 4-5ft and 6ft-above. In contrast, dike stability is 36% and 26% when dike width are 4-5ft and 6ft-above.

Effects of the tree on dike stability

The farmers and owners of the study areas are concerned about the stability of the dikes of their ghers. According to the survey, it was found that Gher dike is stable in the areas of gher without a tree (90%) but dikes were less stable (64%) in the areas of gher with the tree because of dike width variation (Figure 8). 92% of respondents answered yes based on their experience with gher management (with the tree) while 82% were farmers in gher without trees. So, dike stability can be increase dowing to limiting soil erosion by planting trees.

Land-use change pattern

In the study area, over time, land use pattern changes are connected with land tenure, recurrent natural hazards, labour availability, and proximity to the farmstead and learning opportunities (Mondal, 2008). According to the data from Table 3, the area under the settlement, Gher (pond, fisheries, and agri-fisheries), business, and institution areas has been increasing. The agricultural (crop) area has been decreasing within the same period. The influence of rural to urban migration, natural disasters, local politics, and land ownership has caused a decreasing agricultural area. The study reveals that the agricultural

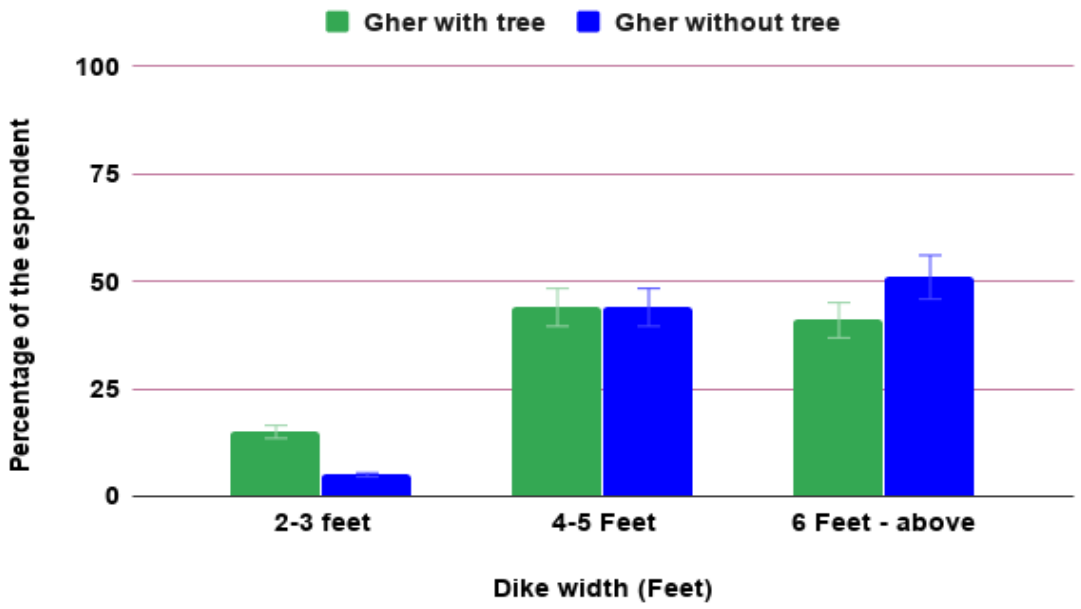

Figure 7: Gher width and dike stability

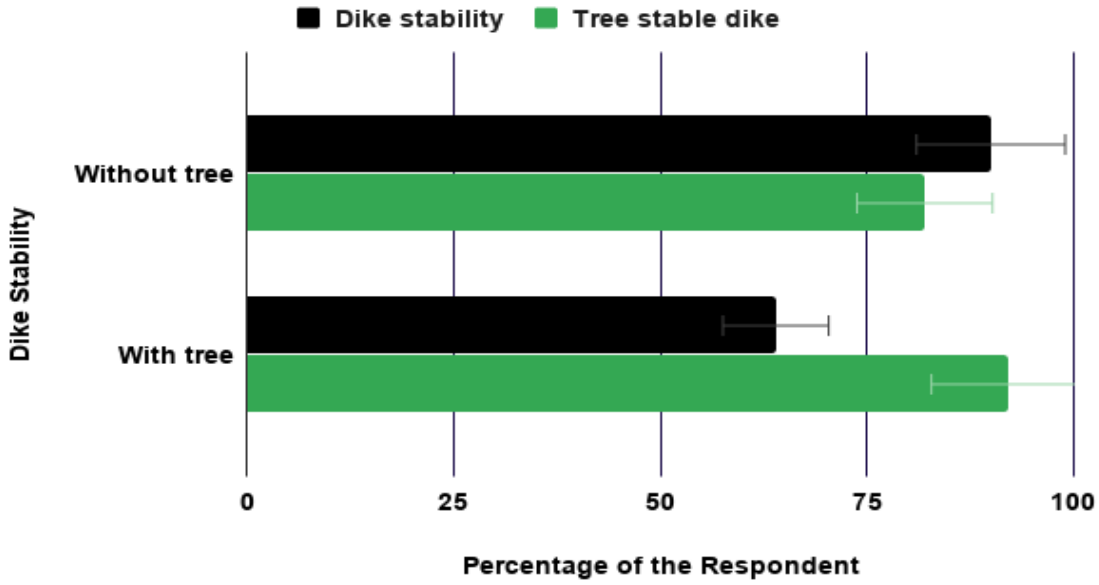

Figure 8: Dike stability

area is decreased by 208.39 acres from 1981 to 2011. In contrast, the gher area, including the pond, fisheries, and agri-fisheries are increased at 271.36 acres from 2011 to 1981. It might be responsible population explosion, recurrent natural hazards, the influence of a local leader on gher land leasing systems for change land use pattern other than the influence of planting trees on gher dike.

DISCUSSIONS

In gher land with trees, most of the gher (72%) are larger than 6 bighas (Table 2). Hence, people think that trees have little influence on fish production by providing shade, leaf, and litter. Even though there is a little reduction of fish production, the supplementary economic benefit would

Table 3. Land-use change scenarios of the study area in 1981, 1991, 2001 and 2011 (unit in acres)

Land use category	1981	1991	2001	2011
Agricultural area	266.54	236.41	89.11	58.15
Settlement area	26.10	38.42	54.2	61.52
Gher area (Including pond, fisheries, and agri-fisheries)	38.08	74.02	202.52	309.44
Commercial area	8.23	9.11	10.56	14.26
Institution area	2.1	3.22	6.38	8.18
Total	341.05	702.23	362.77	451.55

Source: BBS (1981, 1991, 2001,2011)

come from trees through fruits, fuelwood, and fodder (Kibria and Jashimuddin, 2012). The farmers are planting the eco and aquaculture friendly trees on the gher dike such as Coconut, Guava, Safeda, Amra, Neem, Arjun, Mahagony, Chambul. Thus Mahagony, Neem and Arjun purify the water to some extend in the environment (Afroz and Alam, 2013; Islam et al., 2017). To reduce the negative influence of trees such as shade, leaf, branches on fish production in gher can be selected for planting trees on gher dike as with the increase of gher size effect of trees on fish production has been reduced according to Figure 5. The shade is sometimes needed for fish production as a shelter for fish (Morshed et al., 2020). According to the analysis, 69% of farmers opined that they practiced semi-extensive production systems for gher management (without trees) followed by 44% of farmer's are from gher (with trees) (Figure 2). They simultaneously produce paddy, vegetables, and fruits in association with fish cultivation at the same gher land (Hasan et al., 2020). In gher management without tree, most of the farmers would not like to plant trees willingly. They assume the tree harms agricultural crop production and fish cultivation (Hoque et al., 2018). However, 79% of farmers of gher with trees are well aware of the benefits of planting trees in gher dike, and they willingly want to plant trees on gher dike (Figure 3). Farmers can get more benefits from diversified production systems because it can incorporate the trees with the production system, which leads to semi-extensive to the intensive production system(Rahman et al., 2015). In gher with the tree, 62% of respondents are the owner and willing to plant trees on their gher dike. There was 56% owner respondent in gher without trees among whose 54% gher, 6ft or more (Table 2).For this reason, gher owner can be the primary target to increase tree cover on the dike of gher land in the study area. We frequently use trees for stabilizing land and bunds traditionally. Farmers find trees as an important component in stabilizing dikes of gher land (Afroz and Alam, 2013). Therefore, this information could provide important insight into the use of trees in dike management (Alam, 2014). In gher with the trees, a dike was less stable for smaller dike width but after planting trees on gher dike, it has increased stability to some extent (Figure 8). Thus, trees can be planted on the gher dike for increasing the dike stability. In addition, intensive vegetation management on dikes can be ecologically and socially beneficial (Talukder et al., 2016).

Conclusion

Width of the dike is an important criterion for planting trees on gher dike in gher management. Gher dikes of 6ft or above are suitable for tree plantation and annual crop cultivation. Ownership and gher size are also an important factor for planting trees on gher dike. Furthermore, gher owners feel much interest to plant trees on their gher dike than least gher farmers because of long-term benefits like the continuous supply of fuelwood, fodder, wood, fruits, etc. Therefore, larger ghers are suitable for practising agroforestry in the gher land-use system because of less effect of trees on crop production and fish cultivation. Besides, trees on gher dike increases the stability of dike.

Competing interest

There is no potential conflict of interest among the authors concerning this study.

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REFERENCE

Afroz T, Alam S (2013). Sustainable shrimp farming in Bangladesh: A quest for an Integrated Coastal Zone Management. Ocean Coast Manag 71:275–283.

Ahamed S, Rahman MM, Faisal MA (2012). Reducing Cyclone Impacts in the Coastal Areas of Bangladesh: A Case Study of Kalapara Upazila. J Bangladesh Inst Planners 5:185–197

Ahmed N (2013). Linking prawn and shrimp farming

towards a green economy in Bangladesh: Confronting climate change. Ocean Coast Manag 75:33–42.

Alam J (2014). Determinants of Land Use Change in South-West Region of Bangladesh. SSRN Electron J.

Al-Amin M (2018). Impact of Land Use Change on Ecosystem Services in Barisal. Institute of Water and Flood Management, Bangladesh University of Engineering and Technology, Dhaka, Bangladesh

Ali AMS (2006). Rice to shrimp: Land use/land cover changes and soil degradation in Southwestern Bangladesh. Land use policy 23:421–435.

Banglapedia (2015). The national encyclopedia of Bangladesh. Retrieved from http://en.banglapedia.org/index.php on April 5, 2020.

BBS (1981, 1991, 2001, 2011). Statistical Pocketbook(1981, 1991, 2001, 2011). BBS, Dhaka, Bangladesh

Dhar AR, Uddin MT, Roy MK (2020). Assessment of organic shrimp farming sustainability from economic and environmental viewpoints in Bangladesh. Environ Res 180:108879.

Hasan NA, Haque MM, Hinchliffe SJ, Guilder J (2020). A sequential assessment of WSD risk factors of shrimp farming in Bangladesh: Looking for a sustainable farming system. Aquaculture 526:735348.

Hassan MM (2017). Monitoring land use/land cover change, urban growth dynamics and landscape pattern analysis in five fastest urbanized cities in Bangladesh. Remote Sens Appl Soc Environ 7:69–83.

Hoque SF, Quinn C, Sallu S (2018). Differential livelihood adaptation to social-ecological change in coastal Bangladesh. Reg Environ Chang 18:451–463.

Hossain MN, Rahman M, Islam K (2016). Vulnerability of Agricultural Production due to Natural Disaster at Mongla Upazila (Sub District) in Bangladesh. Br. J. Appl. Sci. Technol 16:1–13.

Hossain MN, Saifullah A, Bhuiyan SH, Uddin N (2019). Effects of Climate Change on Rice Production at Khulna district, Bangladesh. Environ Earth Ecol 3:42–54.

Hossain MN, Uddin M, Rokanuzzaman M, Miah MA (2015). Effects of Flooding on Socio-Economic Status of Two Integrated Char Lands of Jamuna River, Bangladesh. J Environ Sci Nat Resour 6:37–41.

Huang X, Li H, Zhang X, Zhang X (2018). Land use policy as an instrument of rural resilience – The case of land withdrawal mechanism for rural homesteads in China. Ecol Indic 87:47–55.

IPCC (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Cambridge University Press, New York, NY 10013-2473, USA

Islam MK, Jashimuddin M, Hossain MN (2017). Tree Diversity and Management of Village Common Forests in Bandarban. Environ Earth Ecol 2:39–51.

Islam MN (2012). Flood Risks for the Char Community on the Ganges-Padma Floodplain in Bangladesh. Int J Environ 2:106–116

Islam S, Zhang M, Yang H, Ma M (2019). Assessing inconsistency in global land cover products and synthesis of studies on land use and land cover dynamics during 2001 to 2017 in the southeastern region of Bangladesh. J Appl Remote Sens 13:1.

Kibria ASMG, Jashimuddin M (2012). Economic efficiency of land-use systems in the seasonally flooded areas of Comilla, Bangladesh. J Land Use Sci 7:349–363.

Mondal G (2008). Effects of land use changes on livelihood pattern of small farmers. A case study of Madertala village under Dumuria upazila in Khulna District. BRAC Univ J V:93–99

Morshed M, Islam S, Lohano H Das, Shyamsundar P (2020). Production externalities of shrimp aquaculture on paddy farming in coastal Bangladesh. Agric Water Manag 238:106213.

Nicholls RJ, Hutton CW, Adger WN, SE Hanson, Rahman MM, Salehin M (2018). Ecosystem Services for Well-Being in Deltas. Springer International Publishing, Cham

Potapov V, Siddiqui BN, Iqbal V, Aziz T, Zzaman B, Islam A, Pickens A, Talero Y, Tyukavina A, Turubanova S, Hansen MC (2017). Comprehensive monitoring of Bangladesh tree cover inside and outside of forests, 2000–2014. Environ Res Lett 12:104015.

Rahman MATMT, Islam S, Rahman SH (2015). Coping with flood and riverbank erosion caused by climate change using livelihood resources: a case study of Bangladesh. Clim Dev 7:185–191.

Rahman MM, Giedraitis VR, Lieberman LS, Akhtar T, Taminskienė V (2013). Shrimp Cultivation with Water Salinity in Bangladesh: The Implications of an Ecological Model. Univers J Public Heal 1:131–142.

Rahman MR, Ando K, Takeda S (2014). Development of shrimp-based cropping systems in the coastal area of Bangladesh: A village-level study in Satkhira district. J Land Use Sci 9:195–210.

Sadekin MN, Ali J, Islam R (2018a). Livelihood vulnerability index: an application to assess the climatic vulnerability status of inland small-scale fishing livelihood. Int. J. Sustainable Development 21(1-4): 75-101.

Sadekin MN, Ali J, Islam R (2018b). The livelihood strategies and food management of the small-scale fishing communities: A case study from inland open water area of Bangladesh. J. Economics and Sustainable Development 9(22): 8-10.

Sadekin MN, Ali J, Islam R (2018c). The socio demographic status of small-scale fishers of inland open water area: A case study from Chalan Beelarea of Bangladesh. International J. Engineering and Technology 7: 305-311.

Sarker MNI, Wu M, Alam GM, Shouse RC (2019). Livelihood Vulnerability of Riverine-Island Dwellers in the Face of Natural Disasters in Bangladesh. Sustainability 11:1623.

Sarker MNI, Wu M, Alam GM, Shouse RC (2020a). Livelihood diversification in rural Bangladesh: Patterns and determinants in disaster prone riverine islands. Land use policy 96:104720.

Sarker MNI, Wu M, Alam GM, Shouse RC (2020b). Livelihood resilience of riverine island dwellers in the face of natural disasters: Empirical evidence from Bangladesh. Land use policy 95:104599.

Sarker MNI, Wu M, Alam GMM, Shouse RC (2020c). Life in

riverine islands in Bangladesh: Local adaptation strategies of climate vulnerable riverine island dwellers for livelihood resilience. Land use policy 94:104574.

Swapan MSH, Gavin M (2011). A desert in the delta: Participatory assessment of changing livelihoods induced by commercial shrimp farming in Southwest Bangladesh. Ocean Coast Manag 54:45–54.

Talukder B, Saifuzzaman M, VanLoon GW (2016). Sustainability of agricultural systems in the coastal zone of Bangladesh. Renew Agric Food Syst 31:148–165.

Wilson C, Goodbred S, Small C, Gilligan J, Sams S, Mallick B, Hale R (2017). Widespread infilling of tidal channels and navigable waterways in the human-modified tidal deltaplain of southwest Bangladesh. Elementa 5:.

Yesmin R, Mohiuddin ASM, Uddin MJ, Shahid MA (2014). Land use and land cover change detection at Mirzapur Union of Gazipur District of Bangladesh using remote sensing and GIS technology. IOP Conf Ser Earth Environ Sci 20:.

Zarin R (2015). Livelihood Activities of Female Labor Engaged in Shrimp Farming in South- Western Region of Bangladesh. J Bus Technol 9:1–22f