

# Causes and Impacts of Rural Land Fragmentation in the Coastal Belt of Bangladesh

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**Abstract.** Identification of root causes and associated impacts of land fragmentation is necessary to reduce future fragmentation and mitigate its impacts. Thus, the purpose of this study was to explore the causes and impacts of land fragmentation in a purposively selected coastal Upazila (sub-district) of Bangladesh. This study is carried out mainly based on the collected information from the individual representative of the selected 133 households. It discloses that most of the households observed the land fragmentation during their possession because of rapid population growth and breaking the joint/extended families into nuclear families. In fact, land fragmentation can increase or decrease a particular land use type. However, the results of this research confirm that there are no significant ( $p > 0.07$ , based on the number of households) associations found between increasing and decreasing homestead land. In contrast, the number of households with cropland significantly ( $p < 0.0001$ ) decreased, whereas the number of households having wetlands significantly ( $p < 0.04$ ) increased. The surveyed households have been practicing high-yielding varieties of crops, using biofertilizers, possessing new land, and changing their income sources for adapting to new land use behavior. The surveyed villagers opine that the land fragmentation problem could be managed by encouraging people living with extended/joint families, vertical use of land, adopting land use policy, etc. The results of this community-reported study can be used to mitigate the impacts of land fragmentation in the coastal rural area of Bangladesh.

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## 1. Introduction

The land is a physical entity because of its topography and spatial nature (Islam et al., 2016). Nowadays, it is facing serious threats of deterioration due to unrelenting anthropogenic pressure and unharmonious use with its capacity (Bhore and Chauby, 2014). It is the most important resource in Bangladesh that provides food, shelter, most of the raw materials, culture, farming, non-farming employment, etc. (Hasan, 2017; IUCN & BFD, 2016). Our social norms and livelihood are very much allied with land (Hasan, 2017). The country accommodates more than 166.50 million people in 147570 sq. km. area. It has a population density of 1125 per sq. km (BBS, 2020). But it is the lowest land-man ratio country in the world because of its small area as well as rapid population growth. The land-man ratio is about 0.06 hectares per person (Hasnat et al., 2018a; Hossain and Yoshino, 2020). It is estimated that the country's total population will exceed 190 million in 2030 and we will have to produce 25 percent extra food grains through less cropland than now (Al-Amin et al., 2016).

Bangladesh has three major physiographic regions i.e., floodplain (79%), terraces (9%), and hilly regions (11%) (Brammer, 2016). The country has approximately 84 percent agricultural land which includes croplands, forests, wetlands, tea estates, and salt pans. But, the growing demand for non-agricultural land is a great threat countrywide. It was

estimated that the depleting rate of agricultural land was 0.27 percent (Hossain, 2015). In addition, fragmented land is one of the key barriers to using agricultural land efficiently (Alemu et al., 2017; Austin et al., 2012; Hasnat et al., 2018b; Vijulie et al., 2012).

Land fragmentation is dividing a piece of land, it may be a habitat or special type of land, into several smaller plots. For example, a farm is made up of a large number of physically isolated parcels (King & Burton, 1982; Bentley, 1987, van Dijk, 2003, Sulisty, et al., 2020). It reduces the effective area for crop cultivation (Dhakal & Khanal, 2018; Muhamud & Joyfred, 2015). It is considered a sort of land degradation because the productivity of land decreases due to such kind of degradation. The increase in land fragmentation has reverse consequences on agricultural activities as well as types of technology used in agriculture (Jansen, 1986). It is a crucial topic in many developing countries. Hence, several research works have been found on land fragmentation over the world.

Many researchers examine the relationship between land fragmentation and agricultural productivity in China (Shuhao, 2005), in Vietnam (Hristov, 2009; Sundqvist & Andersson, 2006), concerning the mountainous district (Niroula & Thapa, 2007) in Nepal (Paudel et al., 2013), in Bulgaria (Di Falco et al., 2010), in Ghana (Danquah et al.,

2019), in Tanzania (Rao, 2019), in Japan (Kawasaki, 2010), in the Southern region of India (Manjunatha et al., 2013), in Romania (Vijulie et al., 2012), in Nigeria (Austin et al., 2012; Balogun & Akinyemi, 2017), and in Ethiopia (Alemu et al., 2017; Looga et al., 2018; Knippenberg et al., 2020). They found both positive and negative impacts of land fragmentation. In addition, Dhakal & Khanal (2018) and Lusho & Papa (1998) explored the impacts of land fragmentation on agricultural productivity including the causes of land fragmentation. Moreover, Demetriou et al. (2013) developed a method namely the 'global land fragmentation index' to quantify the land fragmentation in a case study of Cyprus. Gedefaw et al. (2019) examined farmers' willingness to voluntary land consolidation processes, whereas Abdollahzadeh et al. (2012) recognized farmland consolidation as a suitable instrument to solve the fragmentation problem. Likewise, some significant factors i.e., household income, labor force, education level, and land ownership were found to negatively affect land fragmentation (Obayelu et al., 2019).

Furthermore, the costs and benefits of land fragmentation in Rwanda were explored by Ali et al. (2018) while Deininger et al. (2017) investigated the correlation between land fragmentation and an increase in cultivation cost in India. Moreover, Dhakal & Khanal (2018) found the effect of land fragmentation on machinery use and crop production. Latruffe & Piet (2014) assessed the effects of land fragmentation on farm performance in France. But the

researchers have found only a few studies on land fragmentation in the context of Bangladesh. In Bangladesh, Al-Amin et al. (2016) carried out their research focusing on the impacts of land fragmentation on soil fertility while Wadud (2005) focused on agricultural productivity. Hence, it is high time to conduct research on land fragmentation and understand its causes, impacts, and coping mechanisms in Bangladesh. The main aim of this research is to explore the causes and impacts of rural land fragmentation in the study area. The specific objectives are: (a) to draw the socio-economic profile of the households including the amount of land occupied by the local communities; (b) to explore the rates of land fragmentation during the current tenant's possession; (c) to identify the reasons and impacts of land fragmentation; and (d) to explore the specific effects of land fragmentation on agriculture and existing adaptation measures.

## 2. The Methods

The purposively selected Dumki Upazila lies in the northern part of Patuakhali District with an area of 95.81 sq. km. There are five Unions (the lowest administrative unit of Bangladesh's local government) under the Upazila having total households of 15,542 and a population of 70,655 with a density of 737 per sq. km. The Upazila is surrounded by Bakerganj Upazila of Barisal District to the north, Patuakhali Sadar (main) Upazila to the south, Bauphal Upazila to the

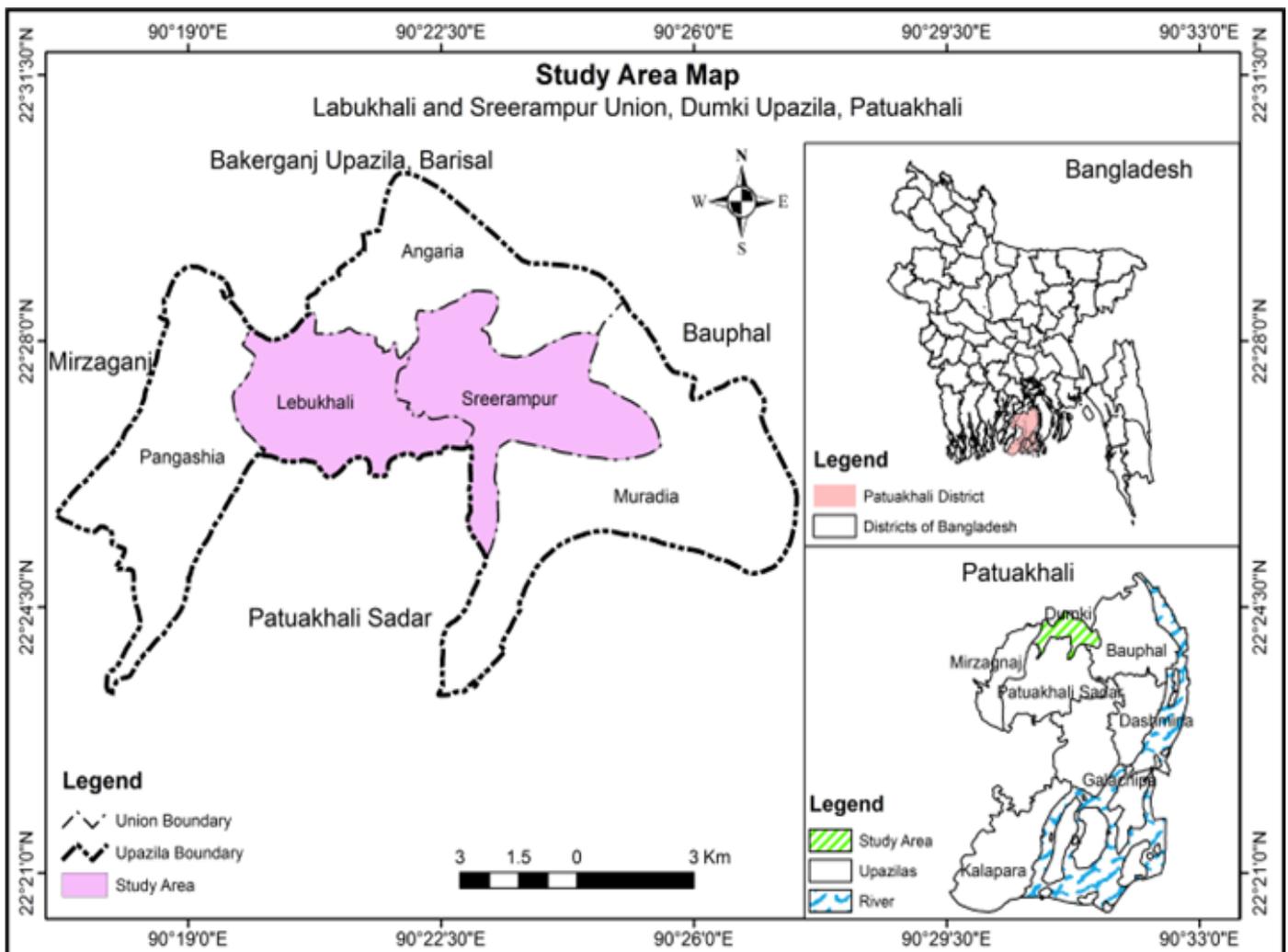


Figure 1. Labukhali and Sreerampur Unions have been elaborated in the contexts of national and sub-district level maps.

east, and Mirzaganj Upazila to the west (BBS, 2012). From this Upazila, Labukhali, and Sreerampur Unions are selected as case studies to conduct a detailed understanding of the fragmentation of the rural land (Figure 1).

Figure 2 presents the study framework used in this study. The study is carried out based on primary and secondary data and information. Secondary sources were mainly journal articles, published and unpublished research reports, and online documents. On the other hand, primary data are gathered through household questionnaire surveys in the study area.

Overall, 66 households (out of 2607) from Labukhali Union and 67 households (out of 3866) from Sreerampur Union were surveyed based on a 90 percent confidence level. The semi-structured questionnaire was developed and finalized with a pilot survey in the study area. The interview session was carried out in the Bengali language (the native language of Bangladesh). Because most of the inhabitants of the study area are illiterate or less educated, they replied to the underlying causes and different impacts of land fragmentation in Bengali, which were translated into English. Finally, the samples were proportionately distributed among the villages of the selected two Unions (Yamane, 1967). The first stage of data checking was done at the desk. However, after the completion of the survey, the second and final stage of data checking was done through field cross-checking. The obtained field data were processed and analyzed through SPSS software (17.0 version) and MS Excel (10 Version). Mapping was done using ArcGIS software (10.3 version).

### 3. Result and Discussion

#### Socio-economic Profile of the Households including Land Area

All out of 133 arbitrarily chosen households were communicated for the survey in the study area. The study has found that business and service are quite higher and dominant professions contrasted with other professions in the surveyed households. Around 30 percent of households' main income source is business followed by about 29 percent of service. Then again, agriculture and day labor are both less than 20 percent, and foreign remittance and assistance from relatives cover a very negligible portion of the selected households (Figure 3).

The income of a family mainly relies on the nature of the profession of the household head. As found earlier, business and service are the dominant sources of income among the surveyed households which make a nominal level of money for life survival. The mean monthly income of the surveyed households is 22.34 thousand BDT, where the minimum is 3 thousand BDT and the maximum is 100 thousand BDT after adding income from the earnings of other family members. Overall, 805 family members are found among the surveyed households comprising 53.4 percent male and 46.6 percent female. More family members may fragment more of the lands. This study found on average more than 6 persons in every household.

The total land area of the surveyed households (n=133) is about 11,401 decimals including a minimum of 5 decimals to a maximum of 350 decimals. Out of the total household land, about 20.7 percent is homestead land, 74.6 percent cropland, 3.6 percent wetland, and 1.1 percent other lands (forest and fallow land). The average rate of household land is about 85.7 decimals while homestead land is about 17.8 decimals, cropland 63.9 decimals, wetland 3.1 decimals, and other lands 0.9 decimals (Figure 4).

#### Rates of land fragmentation during the current tenant's possession

This study explored that land fragmentation occurred in about 92.5 percent of the total surveyed households during the present tenant tenure. About 63.9 percent of households' homestead land has been fragmented (ranges 1 -3 times; average 1.18 times) during this period followed by 45.1 percent of households' cropland (ranges 1-2 times; average 1.17 times). Table 1 shows details about the rates of household land fragmentation during the current landholder's tenure.

#### Reasons and impacts of land fragmentation

This study recognized population growth and associated land use change such as establishing houses for newly formed nuclear families, road-bridges construction, creation of wetland, etc. as the key causes of land fragmentation which further contribute to reducing cropland in the study area. Yunus & Harini (2005) also found a decreasing trend of agricultural land in the Yogyakarta Special Province in Indonesia because of population growth as well as roads and built-up area extension. Population growth was also identified by many other researchers (Harini, Yunus, & Hartono, 2012; Muhamud & Joyfred, 2015) as the contributing factor to land transformation including land use change and fragmentation.

This study identified about 30.3 percent of households that considered the growing population or population increase as the main cause of land fragmentation in the study area after considering the reasons for all types of land fragmentation. They identified population increase as the key cause because it is related to all other reasons for land fragmentation such as increasing nuclear family, increasing crop production or food security, etc. Table 2 shows that the creation of the nuclear family was identified as the second most reason (29.3 percent) by the representatives of the selected households, followed by the intention to increase crop production (14.4 percent), digging canals or ponds (13.8 percent), and creation of roads/ bridges for public movement (12.2 percent).

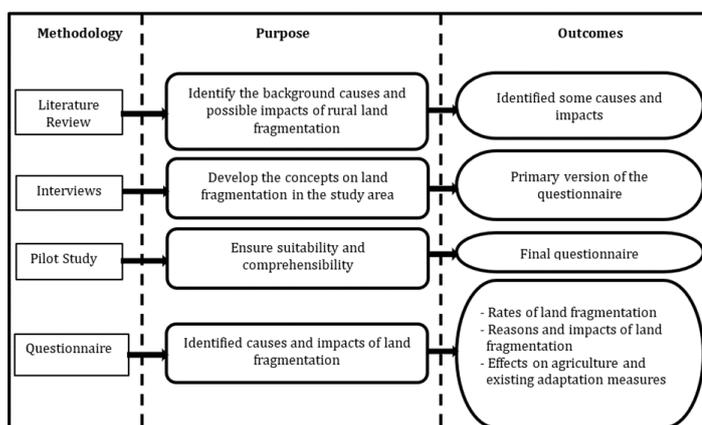


Figure 2. The study framework represents the methodology, purpose, and outcomes.

Figure 5 shows the percentage of positive or negative impacts of land fragmentation in the study area. About 33.8 percent and 23.3 percent of households in the study area opined that land fragmentation has not any positive or negative impacts respectively on their daily life. However, most of the households stated that it has several impacts (both positive and negative) on daily life, including residential facilities, the status of cropland and wetland, family income, social conflict, etc. About 33.8 percent of households mentioned that new homestead land has been created due to land fragmentation while 23.3 percent of households said it decreased homestead land. There is no significant difference ( $p > 0.07$ ) between the number of households with increased and decreased homestead land. The surveyed households pointed out that the main negative impact of land fragmentation is reducing cropland in the study area. They stated that about 54.1 percent of households' cropland has been reduced, which differs significantly ( $p < 0.0001$ ) from the number of households with created cropland by land fragmentation. It also reduced wetlands by filling up/ developing land for other purposes including housing. Some studies conducted in the different regions of the world also explored the negative effects of land fragmentation i.e., Hristov (2009) in the Republic of Macedonia; Vijulie et al. (2012) in Romania; Demetriou et al. (2013) in Cyprus; Latruffe & Piet (2014) in France; Larson et al. (2014) & Ali et al. (2014) in Rwanda; and Dhakal & Khanal (2018) in Nepal.

This study explored some positive impacts of land fragmentation, for example, the creation of wetlands.

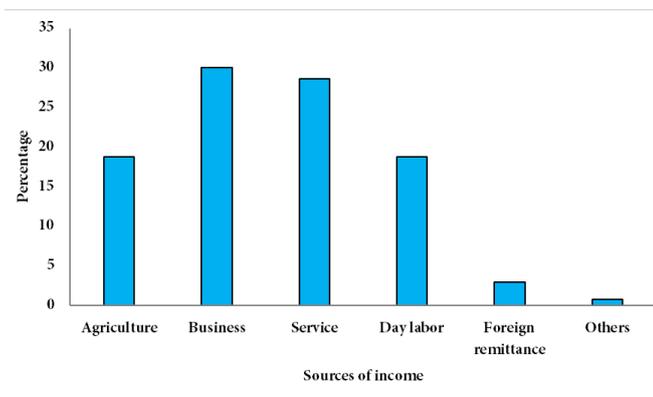


Figure 3. The main source of family income, mainly encompasses agriculture, business, service, day labor, foreign remittance, and others (Source: Study results, 2019).

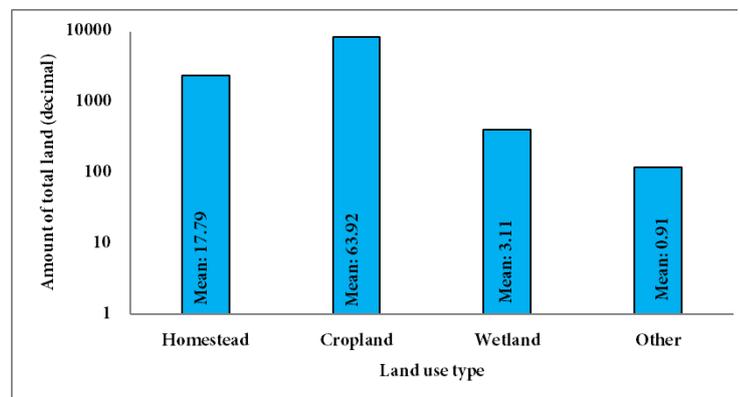


Figure 4. Total land, mainly encompassing homestead, cropland, wetland, and others (Source: Study results, 2019).

Table 1. Rates of households' land fragmentation during the current land holder's tenure

| Variables                                   | Homestead land | Cropland  | Wetland    | Other lands | Total land |
|---|----------------|-----------|------------|-------------|------------|
| N   | 133 (%)        | 133 (%)   | 133 (%)    | 133 (%)     | 133 (%)    |
| Land fragmentation occurred                 |                |           |            |             |            |
| Yes   | 85 (63.9)      | 60 (45.1) | 15 (11.3)  | 3 (2.3)     | 123 (92.5) |
| No  | 48 (36.1)      | 73 (54.9) | 118 (88.7) | 130 (97.7)  | 10 (7.5)   |
| Frequency of land fragmentation (Yes group) |                |           |            |             |            |
| Mean  | 1.18           | 1.17      | 1.00       | 1.00        | 1.53       |
| Minimum                                     | 1              | 1         | 1          | 1           | 1          |
| Maximum                                     | 3              | 2         | 1          | 1           | 5          |
| Sum   | 100            | 70        | 15         | 3           | 188        |

Table 2. Reasons for land fragmentation in the study area

| Responses                     | Homestead | Cropland | Wetland | Other lands | Total |
|-------------------------------|-----------|----------|---------|-------------|-------|
| N                             | 100       | 70       | 15      | 3           | 188   |
| Population increases          | 31        | 28.6     | 40.0    | -           | 30.3  |
| Nuclear family                | 37        | 22.9     | 13.3    | -           | 29.3  |
| Betterment of crop production | 7         | 24.3     | 6.7     | 67.7        | 14.4  |
| Digging canals/ponds          | 13        | 8.5      | 40.0    | 33.3        | 13.8  |
| Roads/bridges construction    | 12        | 15.7     | -       | -           | 12.2  |

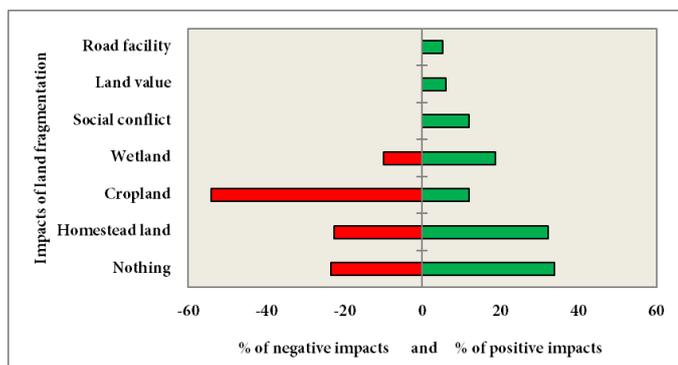


Figure 5. Impacts of land fragmentation (multi responses), for example, the figure highlights the most impacted land use is on cropland due to intense land fragmentation.

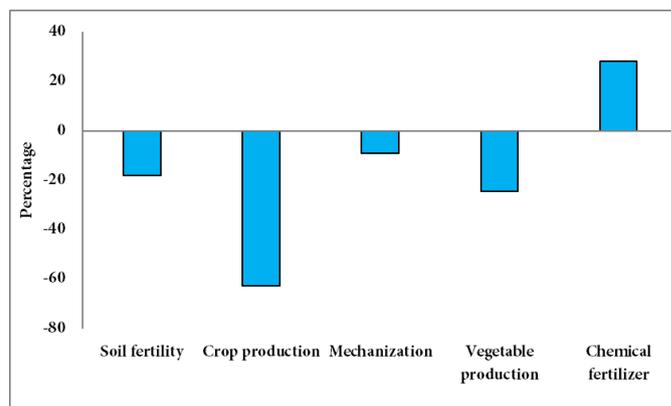


Figure 6. Adverse effects on agriculture (multi responses, n=78), for example, the use of fertilizer has a negative impact on overall crop production due to decreasing trends of soil fertility.

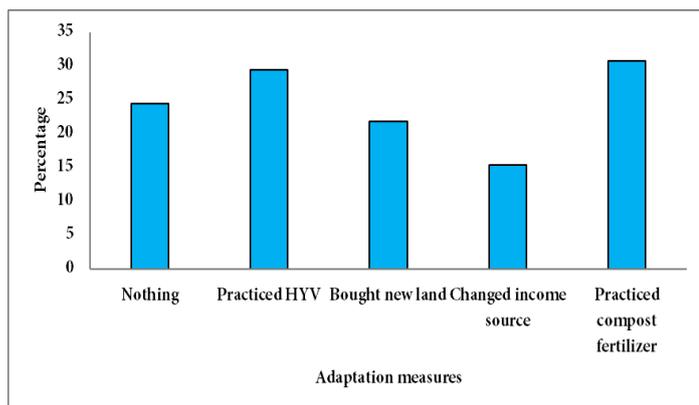


Figure 7. The chart reveals existing adaptation measures to cope up with the decreasing cropland across the study area.

#### 4. Conclusion

Land fragmentation is one of the spatial processes of land transformation. This study focuses on the causes and impacts of land fragmentation in a coastal area of Bangladesh. Based on the findings, it has been found that business and service were the leading professions as the surveyed households occupied only an average of about 64 decimals of agricultural cropland in the study area. Most households have experience land fragmentation. This research explored several causes and impacts (both positive and negative) of land fragmentation in the study area. Population growth and breaking the joint/extended families into nuclear families were identified as the main causes of spatial fragmentation of land. Reducing cropland has been identified as the key effect of this spatial process.

The respondents opined that they have been adapting to the land fragmentation process by increasing the use of compost fertilizer, cultivating high-yielding varieties, possessing new land, and changing the sources of household income. Most of the representatives of the surveyed households recommended that stopping the breakup of joint/extended families could be a solution to tackle land fragmentation. They further suggested adopting a land use policy, controlling land selling in terms of agricultural to non-agricultural use, and ensuring vertical uses of land for minimizing the impacts of land fragmentation. The results of this study can be used to reduce the impacts of land fragmentation in rural Bangladesh. Further research can be done focusing on district or regional cases.

fragmentation is found as the indirect agent of decreasing soil fertility (17.9 percent) and the barrier to practicing mechanization (9.0 percent) in agriculture. Likewise, Di Falco et al. (2010) in Bulgaria; Manjunatha et al. (2013) and Deininger et al. (2017) in India; and Alemu et al. (2017) in Ethiopia found higher production costs because of the negative consequences of land fragmentation.

The villagers of the study area have been practicing some adaptation measures to tackle these effects although about one-fourth are not practicing any actions to adapt to such effects. However, the community people are using compost fertilizers (30.8 percent) to recover the agricultural production that was reduced because of land fragmentation. About 29.5 percent of households are cultivating high-yielding varieties (HYV) followed by creating new land by buying for suitable use and changing the family's income source (Figure 7).

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