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Assessing land use changes and livelihood outcomes of rural people in Chittagong Hill Tracts region, Bangladesh

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Abstract

Land use change is a pressing concern for the livelihoods of people in tropical developing countries. Changes in land use from swidden agriculture to smallholder tree dominated areas producing timber, fruits and cash crops can result in changing livelihood outcomes for rural communities. This paper examines land use patterns of rural households and the association with food production and income across three different zones of various forest proximity across a landscape gradient (remote, intermediate and on-road) in Chittagong Hill Tracts region of Bangladesh. We conducted in-depth semi-structured surveys of households (175-300) and farm owners (30) to collect information on people's perceptions of land use change, present land use patterns and contributions to food production and income. Our research found that more than half of the surveyed households experienced a decline in the land available for food production over the past 30 years. The land use patterns revealed decreasing crop lands (mainly swidden farms) and an increase in areas of planted trees within this landscape. However, household use of the reduced crop land has not affected food production in the on-road zone, whereas the diversity of food sources has declined. People living in more remote areas engaged in swidden farming and used larger areas of crop and fallow lands, fruit orchard and accessed natural forest lands that provide a diverse reservoir of food sources. The current land uses contribute to variations in annual household income across zones, with remote dwelling people earning less to those living closer to urban areas in the intermediate and on-road zones. In summary, this transition of land uses over three decades and changes in income and food availability cannot be generalised across the region because of zone specific differences. We recommend a broader and context-reliant landscape management approach in consideration of the diversity of forest and tree benefits for the livelihoods of people in the region.

Keywords: *Forest and trees; Swidden farming; Land use; Food; Income*

1. Introduction

For many centuries shifting cultivation has coexisted with agriculture to provide subsistence foods and crops for income of rural communities in tropical developing countries (van Vliet et al., 2012; Fox et al., 2000). Shifting cultivation is often termed *swidden farming* defined as "any continuing agricultural system in which impermanent clearings of forest lands are cropped for shorter periods in years than they are fallowed" (Conklin 1961,p27). Widespread variation of the swidden farming has been characterised by the availability of land, labour and capital; demographic changes (settlements), agronomic features (cropping), soil and climatic conditions and state policies over time and space. Notably in recent decades, swidden farming systems have changed from subsistence farming to more commercially orientated land uses through the adoption of cash crops and smallholder tree cover in many parts of Southeast Asia, Latin America and sub-Saharan Africa. In the countries of South Asia, South-East Asia and Latin America (i.e. India, Laos, Peru, and Guatemala), land use change from swidden farming practices to commercial crops (i.e. cocoa, cassava) and plantation trees for rubber, palm oil, charcoal and wood products, has contributed to an increase in income for rural households (Behera et al., 2016; Cramb et al., 2009; Dressler et al., 2017). This transition from swidden to mainly cash crops by farmers has also been reported to have increased a household's ability to purchase a wide range of foods, such as meat and vegetables, and improved overall food security (Cramb et al., 2009; Rahman et al., 2017). This shift can also mean a corresponding decline in the diversity of land uses (in part swidden farms and fallow lands) and reduced numbers of crops grown in these farming systems and food sources from natural forests (Castella et al., 2012; Cramb et al., 2009; McLennan & Garvin, 2012; Thaler & Anandi, 2017). The changes in land uses from subsistence to commercial crop production has also affected the availability and accessibility of lands for uses by people in Latin America and South-East Asia regions (Coomes et al., 2016; Cramb et al., 2009; Vongvisouk et al., 2014).

Recent studies from across the tropics have shown that, due to land use transitions, the benefits accrued to rural communities from forests and other non-forest land uses can vary or

differ across a single landscape (Rasmussen et al., 2017; Sunderland et al., 2017; Vongvisouk et al., 2014; Fantini et al., 2017; Broegaard et al., 2017). Given this context, to understand the relationships between forest and agrarian changes with the concomitant livelihood outcomes, it is necessary to consider a broader landscape scale approach that encompasses a more systematic socio-ecological approach (Sunderland et al., 2017). Although broad definitions are largely lacking, landscapes represent a complex mosaic of natural resources (forest and non-forest land uses) which is managed for achieving multiple objectives (Reed et al., 2020). Landscape approaches as they relate to conservation, agriculture and other land uses seek to address the increasingly complex and widespread environmental, social and political challenges that transcend traditional management boundaries. As such, they are not prescriptive, deterministic or siloed in disciplines; they require multi-and inter-disciplinarity, defying definition and characterization (Pfund, 2010; Reed et al., 2020).

Bangladesh, one of the most densely populated countries in the world, is experiencing increasing pressure on its remaining natural resources, including its forests (BFD, 2020). The decline in natural forests has continued and the net forest conversion increased from 5800 ha in 2000 to 8200 ha in 2010 and 10,000 ha in 2017 (FAO, 2020). The natural forests alone in the Chittagong Hill Tracts (CHT) region have declined from 172,000 ha in 1963 to 84,000 ha in 1990 and to 70,000 ha in 2005 (FAO, 2015). The gradual loss of trees either for revenue generation or through illegal felling and clearing/burning practices in swidden farming has increased the area of non-forestland in this region (Ahammad & Stacey, 2016). Swidden farming has been a traditional form of agriculture primarily practiced by local ethnic communities in the region (UNDP, 2009), although its long-term contribution to local livelihoods and forest conservation has been questioned due to the loss of forest area, population growth and ineffective land management (Gafur et al., 2003; Rahman et al., 2011; Thapa & Rasul, 2006). Most often the tribal populations of the region are termed as “ethnic communities” by government to define their livelihood, natural resource uses and cultural practices in Bangladesh (MoCHTA 2020). However, the swidden farming practices of ethnic communities of the region has not been well recognised in national land use or forest policy of the country. In the last two decades have government extension programmes (mainly under

forest and agriculture) considered the improvement of swidden farming land uses and promoted timber/fruit tree-based land uses within these ethnic communities as beneficial to conservation for soils, the restoration of forests and the enhancement of food security (Ahammad & Stacey, 2016; Rahman et al., 2016). However, the trends and impacts of these land use changes on food security and household income are rarely documented. So, understanding the current land uses and their association with livelihood outcomes will benefit existing forest policy for the region especially how forest and tree benefits can be well managed with the changing land uses.

This paper examines the current land use patterns and their associations with the livelihood outcomes of rural people in three forest-agriculture contexts (i.e. remote, intermediate and on-road zones) in the CHT region of Bangladesh. These three zones represent a land-use modification from natural forests to planted tree based land uses and agriculture characteristics with swidden farming to planted or fruit orchard land uses. They also possess variations in terms of economic activities as well as different degree of proximity to roads and market in the CHT region (e.g. remote zone is the furthest from the main road and market, but close to natural forest areas) to form a landscape gradient of change (Deakin et al., 2016) (Figure 1, see also Table 1). To understand the current land use patterns and the associations with the livelihood outcomes of rural households, this study addresses three questions: 1) how do people perceive land use change and have these changes affected food production over the past 30 years?; 2) what are the land use patterns in terms of planted tree covered lands, crop lands, fruit orchard and fallow land by households across the three zones? and 3) how do forest and non-forest lands contribute to food production and income across the three zones? In this paper, ‘forest’ refers to natural forests and planted forest land is used to represent planted tree cover established by the households. Non-forest land includes agricultural lands used for annual crops (e.g. cereals, vegetables) in swidden farming (upland) and low-land agriculture, fruit tree orchard with fruit trees and crops (i.e. orange, banana, pineapple) and fallow lands (e.g. mixed vegetables and banana).

2. Methods and materials

2.1. Study area setting

The CHT region is located in South-Eastern part of Bangladesh and comprised of three administrative districts (Rangamati, Bandarban and Khagrachari). The CHT region comprises predominantly of agrarian communities whose livelihoods largely rely on diverse agriculture farming and the uses of forest resources. On average half of the annual income of all CHT households is generated from different agriculture related sources (UNDP, 2009). Local ethnic people are involved in the use of a wide range of forest and tree products including non-timber forest products (NTFs) for both subsistence and income-generated purposes (Ahammad, Stacey, & Sunderland, 2019). People use more than 60% forest products, including the NTFPs they collect for their own usage, while selling the remaining 40% at local markets to generate cash income (Kar & Jacobson, 2012; Misbahuzzaman & Smith-Hall, 2015). The dependence on forest resources is relatively higher in more remote locations from town/urban centres, but, in general, 50% of the raw materials used in building permanent or temporary shelters are timber or NTFPs (Ahammad et al., 2019).

Swidden farming is a traditional agricultural practice used predominantly by tribal groups, which accounts for almost 16% of all land use in the CHT each year (Bala et al., 2013). In remote parts of the region, people mostly rely on swidden farming for cultivating a wide range of annual crops followed by fallow land for growing bananas and trees (Ahammad & Stacey, 2019)(Table 1). Key features of economic and environmental resources including forest and land uses across the landscape transition and study area are shown in Table 1. The proportion of the swidden farming practices is relatively higher in and around government owned forests, where people rely on this land use type having limited land ownership or access to roads and thus markets in the region. Until the end of the 19th century a significant part of the lands was inhabitated by the ethnic communities who maintained swidden farms across the CHT region. Government policy to build the hydroelectricity dam construction in 1950s, in-migration in the 1980s, and natural resource management policy centered on plantation and fruit orchard development resulted in diverse impacts on the availability and

accessibility of land for the ethnic communities in the region. Estimates of the swidden farms relative to other land uses and the numbers of ethnic communities (tribal populations) relying on the land use practices is absent in government records. Current swidden farming activities are managed alongside planted fruit-tree species (e.g. pineapple, banana, jackfruit, mango) in areas of relatively more secured and private land ownership of the households and better access to markets. Intensive forms of agricultural land use (i.e. a mixture of fruit trees and teak plantations, often termed agroforest systems), are now observed in almost one-third of the areas closest to the markets and roads (Bala et al., 2013). Aside from swidden farming, small area in the valleys and low-lying lands are used for cultivating irrigated agricultural crops.

The CHT contains natural and planted forests over almost two-third of the lands in the region (BFD, 2020). The natural forest is broadly characterised by evergreen and deciduous tree species accounting for approximately 15–20% of the total forest types. Planted forests are mainly comprised of planted tree covers of teak (*Tectona grandis*) and Gamar (*Gmelina arborea*). These occur both in government reserve areas, as well as on private lands. Contrary to forested lands in CHT region, trees are largely distributed on farms in the form of home garden in the rest of the country (Byron, 1984). Commercial approaches to increasing plantations on hilly lands or home gardens is a relatively new concept in CHT region and has been popular since the 1990s. There is no record of the amount of privately-owned land that has been converted to planted forest, but in many villages of CHT region, agricultural lands have been gradually converted to planted forest, mainly with teak or gamar (Table 1). Although timber harvesting in government-owned natural forests is currently prohibited in Bangladesh, the region still supplies a significant amount of valuable timber from private planted forests to meet the large regional and national demand (Ahammad & Stacey, 2016).

2.2. Methods of data collection

This study is based on data collected through surveys of rural households across the three study zones (remote, intermediate, on-road) in CHT region (Figure 1). By conducting a scoping survey in 2016, three distinct zones were selected for the identification of villages along them for data collection (Ahammad & Stacey, 2016). Each zone has different proximity to the main road (depending on the modes of transports). The remote zone is relatively distant from the main road (approximately 45 km) and people travel 2–3 hours by water transport (motorized boat) to access to district town. While villages in the intermediate zone are located within 5-8 km of the major road transport (by bus or motorbike). The villages in the on road zone are within proximity to the main road within 1-3 km of each village. Each zone was comprised of four sample villages, with a total of 12 villages being selected for the main (i.e. household and farm) surveys undertaken in 2015-2016 (Figure 1). The household and farm surveys were conducted on the households in four villages from each zone (Table 2).

2.2.1 Household surveys

Household surveys were undertaken within 304 households, selected randomly from 12 villages within the three zones in the CHT region. In the 12 villages, 60% of a total of 475 households were surveyed over one year, from May 2015 to September 2016 (Table 2). Households were surveyed using structured questionnaire interviews conducted by trained enumerators who were familiar with the local languages and each zone of the region. Each household survey was completed in one sitting, although any residual issues were investigated further, more informally, where necessary. Usually the head of the household was the respondent for the structured questionnaires. In the absence of the head of the household, another family member, aged 18 years or older was interviewed.

We interviewed the respondents in relation to their perceived land use changes over the past 30 years, the present land use, the size of planted tree holding area, the types of food crops cultivated and the relative contributions of forestland and tree covered land to the household's annual income for 2015-2016 (Table 2). The respondents were asked, "How has

land use changed in your households in the past 30 years?". The answers to the perceived land use changes were collected as the responses "increased", "decreased" and "stayed the same". Then we asked, "What is the size of total land holding of this household and the specific land uses?". The survey also covered information on household economic activities and their relative contributions to the annual income for 2015-2016. Due to a lack of willingness on behalf of the participants, and the time-consuming nature of finding out income-related information, only 176 households offered any information on their annual income. We asked the respondents, "What are the main income sources for the household, and what are their relative contributions". By asking this question, we quantified the roles of forestland, including natural forests and planted trees, non-forestland and other sources in the household income in monetary terms.

2.2.2 Farm survey

Following the household survey, 30 household farms were surveyed to gather information on the food produced from their land (i.e. crop lands, fruit orchards, fallow land) including food gathered in forests (i.e. wild foods such as vegetables, bamboo shoots) and planted tree lands (Table 2). The patterns of land use and associated food production capacity were the focus of the farm survey. From a total 30 sub-samples, we selected 10 from each zone (2-3 in each village). The respondents were selected based on their engagement in farming activities and a categorisation of the dominant land use types (agricultural, planted trees and fruit orchard land uses) in each village of the zone. A farm typology was developed for the dominant land uses (i.e. seasonal or annual crops, fruits and trees) and categorisation of households for farm surveys by undertaking a group discussion at village level. The farm-level information collected included: the patterns of land use (crops and tree-based land for timber and fruit orchards and fallow land) for each household (seasonal or annual); the most important land uses and crops; and the total food production (produced and gathered from the forest). All information was based on the previous 12-months memories of the respondents. Each farm represented the combined area that the respondent cultivated for agricultural purposes, including seasonal crops, fallow land, fruit orchards and planted tree areas (Sunderland et al., 2017). For the sake of consistent terminology in this study, the terms " 'farm' and 'land' " were used interchangeably in the surveys, analysis and discussions.

2.4. Data analysis

Both qualitative and quantitative information was collected from the household and farm surveys. The qualitative data relates to the responses of the household respondents on perceived land use changes, while the quantitative data includes the size of the land uses, including planted tree holding area, and the amount of food and income contributions from forestland and tree cover lands. Following the sustainable livelihood framework of DFID (1999), data related to the livelihood capital/assets (i.e. natural such as forest or tree lands, agricultural crop lands etc.) and strategies (i.e. agriculture cultivation, waged activities, forest or tree product harvesting) were collected to determine the livelihood outcomes (i.e. income, food production). The livelihood outcomes investigated mainly focused on the data relating to food production and income, and the livelihood strategies relating to forests, planted trees and other land uses including waged activities, employment etc.

In the first stage of the data analysis, the household responses relating to land use change (i.e. increase, decrease or stayed the same) for the 30-years period from 1990 to 2015 were quantified. The proportions of the qualitative responses "increased", "decreased" or "stayed the same" were calculated from the total household responses, and a further categorisation was made at the zone level. Second, the average size of the land used for crops, fruit, planted tree areas for timber and fallow land was estimated at the household level, and the subsequent variations were calculated across the three zones. Third, the annual mean amount of food produced and gathered from these different land sources was estimated at the household level, and then further categorised across the zones to determine their relative difference. For the agricultural crops and fruit production, the amount of food produced by the farmers in the last season was calculated and adjusted to represent one year. The amount of forest-source foods gathered was calculated based on the respondents' recall of the last three months . Based on the memory of the respondents, we calculated the approximate amount of foods gathered from natural forest or planted tree areas for each household annually. Finally, information collected on the cash income from forest (e.g. natural, planted trees) and non-forest (i.e. agriculture, fruit, wages, employment, business, others) sources were calculated to give the total annual income of each household and provide relative comparisons across the zones. The amount of food gathered from natural forests and consumed by households was

reported by the households. The income from agricultural crops, fruit and forest products was calculated based on their relative prices at the market.

The main statistical analysis used involved frequency analysis and descriptive statistics (i.e. mean, standard deviation and error, Pearson's chi-square and correlation). Pearson's chi-square test of independence was conducted to find relative differences in the perceived changes in land uses for food production in the households in the three zones. To elucidate the significant difference of land uses, sources of food production and income at zone level, the Kruskal-Wallis (nonparametric) test was used (Corder and Foreman, 2014). The Kruskal–Wallis test uses a chi-square distribution to show the significant difference between food production and annual income exists or not at the zone level. To identify a specific pair of zones that differ significantly, a post-hoc analysis was done by using Mann-Whitney-Wilcoxon test. Statistical Package for the Social Sciences (SPSS) v.23 software was used for all the calculations and statistical analyses.

3. Results

3.1. Household land use by zone

The surveyed households reported changes (increase, decrease, same) in the amount of their land under food production over the past 30 years (1985-2015). Figure 2A shows significant

differences in the perceptions of the respondents who reported change in their land use for food productions (χ^2 = 76.19, df= 2, p=0.000). Over half of the households (56%) experienced a decrease in the size of their lands used for food production, while just over a quarter (28%) reported no change. Only 16% reported an increase. The changes in land use reported by the households differed across the three landscape zones (χ^2 = 31.91, df= 4, p=0.000). A high proportion (70%) of households in the on-road zone experienced a reduction in their lands used for food production. In the intermediate zone, relatively more households (40%) used crop lands for food production stayed the same. Only in the remote villages near forests, more households (27%) reported an increase in the amount of lands used for food production over the 30-year period.

The reported current land use patterns included agricultural lands for annual crop cultivation, fallow land, fruit orchards, and planted tree cover for timber (Figure 2B). Overall, crop cultivation was the main land use in 50% of the households in all zones, followed by 23% of the households with planted tree cover, 15% with fallow land, and 10 % with fruit orchard (Figure 2B). Crop land was also the main use of approximately 60% of the households in both the remote and on-road zones but contributed only 30% in the intermediate zone. There were more fallow lands in the households of remote zones (35%) than in the intermediate (8%) and on-road (5%) zones. In contrast, 50% of the households in the intermediate zone reported having managed tree cover lands compared to only 25% in the on-road and 8% in the remote zones. Fruit orchards were maintained by 12% of the households across the intermediate and on-road zones, but by only 5% in the remote zone.

The size of land used for crop agriculture, planted tree cover, fruit and fallow (left uncultivated) varied among the households in the three zones. Among the types of land use, planted tree cover occupied the greatest area (mean: 1.07±0.10 ha), followed by crop land (mean: 0.57±0.53 ha), fruit (mean: 0.25±0.05 ha) and fallow land (mean: 0.21±0.01 ha) (Table 3). Comparatively, the size of annual crop land (mean: 0.8 ha) and fallow land (mean: 0.5 ha) use was greater in the remote households than in the intermediate (mean crop land:

0.4 ha, fallow land: 0.33 ha) and on-road (mean crop: 0.3 ha; fallow:0.34 ha) zones (Table 3). The area of land used to cultivate fruit was greater in the intermediate (0.562±0.12 ha) than on-road (0.10±0.10 ha) and remote (0.06±0.04 ha) zones. Household-managed planted tree areas were greater in the on-road (mean:1.3 ha) and intermediate (mean: 1.2 ha) zones compared to the remote zone (mean:0.7 ha). In total, as of the surveyed year (2015-2016), the mean land holding size for all households were 1.91±1.89 ha, with size being greater in the intermediate zone (2.36±2.17 ha) than in the remote (1.62±1.16 ha) and on-road (1.72±2.03 ha) zones.

The land use (crop land, fruit land, fallow and planted tree land) areas significantly differed across the zones (Kruskal-Wallis test, Table 3). Post-hoc analysis shows the size of crop land used by households in remote zone was significantly larger than intermediate (p=0.000) and on-road (p=0.000) zones (Mann-Whitney-Wilcoxon test). The size of fruit land used by the households in the on-road was significantly lower than intermediate (p=0.000) and remote (p=0.000) zones. The significant difference was also found for fallow land which was larger in remote (p=0.000) and intermediate (p=0.000) zones than on-road. But only significant difference of large planted tree land used in intermediate zone than remote (p=0.000).

3.2. Land use for food production

The main food crops produced by the household land holdings were agricultural and fruit orchards for cash and subsistence uses. Table 4 presents the amount of food produced from different types of land use, including gathering from forests. In 2015-2016, the average amount of food produced by the surveyed households was 8093±814 kg (Table 4). Crop lands were mainly used for food production (5026±736 kg yr^{-1}) compared to fallow land (1697±368 kg yr^{-1}), fruit (962±185 kg yr^{-1}) and gathering in natural forestland (430±70 kg yr^{-1}). Rice, maize, different leafy and root vegetables, beans, tobacco and turmeric were grown

on crop lands. The food gathered from natural forests mainly comprised vegetables, flowers and fruit.

The amount of food produced and gathered from the various land uses differed significantly across the zones (Table 4). The amount of food produced and gathered was greater in the on-road zone (10096±1821 kg yr^{-1}) compared to the remote (7410±1331 kg yr^{-1}) and intermediate (6830±905 kg yr^{-1}) zones. Among the food sources, the highest crop production was also in the on-road zone (8526±1493 kg yr^{-1}), which was twice the amount in the remote (3480±827 kg yr^{-1}) and intermediate (3109±583 kg yr^{-1}) zones. The crop production in on-road was significantly higher than intermediate ($p=0.006$) zone. On the other hand, fruit production was found to be the highest in the intermediate zone (1300±317 kg yr^{-1}), followed by the on-road (1068±378 kg yr^{-1}) and remote (962±185 kg yr^{-1}) zones. No significant difference was found for fruit production within the zones. The amount of food produced and gathered from fallow land and forest land was significantly greater in the remote ($p=0.001$) and intermediate ($p=0.003$) zone than on-road. Forest sourced food gathered was also significantly higher in remote ($p=0.003$) and intermediate ($p=0.007$) zones than on-road.

3.3. Relative contributions of forest and non-forest sources to household income

The economic activities reported by the households, include from forest land (forest and tree product collection) and non-forest including crop agriculture, fruit orchards, waged labour, employment and small businesses, which provided diversified sources of annual income. The mean annual income for the households was USD 1662±99 yr^{-1}, with agriculture-related activities contributing the highest economic returns (USD440±57 yr^{-1}) (Table 5). Employment generated the second highest income (USD297±65yr^{-1}) to the households, for those engaged in a formal job, followed by small business (USD211±37 yr^{-1}). Forest income (USD175±30 yr^{-1}) came from the collection of forest and tree products including bamboo, foods and timber, and was slightly higher than the waged (USD162±23yr^{-1}) and fruit

(USD159±18 yr^{-1}) incomes. Livestock provided USD129±30 yr^{-1}, just higher than the other income activities (rent and driving: USD102±25 yr^{-1}).

Household economic activities and associated income contributions differed among the three zones. The overall mean annual household income was higher in the intermediate zone (USD1989±201 yr^{-1}) than in the on-road (USD1728±179 yr^{-1}) and remote (USD1239±100 yr^{-1}) zones (Table 5). Agriculture provided the highest source of household income in the on-road and remote zones (USD567±146 yr^{-1} and USD515±71 yr^{-1} , respectively), which was almost double that of the intermediate zone (USD234±40 yr^{-1}). Agriculture income in the remote zone was significantly higher than intermediate zone (p=0.000), but lower than on-road zone (p=0.002). In contrast, in the intermediate zone, employment generated the highest annual income (USD570±162 yr^{-1}) which was also slightly higher than any other sources among the zones. Forest and tree sourced economic activities (selling timber, bamboo and food) provided the second highest income source (USD204±36 yr^{-1}) in the households of the remote zone. Forest income was significantly higher in the intermediate (p=0.004) and remote (p=0.000) zones than the on-road (Mann-Whitney-Wilcoxon test). In the intermediate zone, fruit-based income (USD274±41 yr^{-1}) was the second major source of income, followed by forest and tree products (USD257±72 yr^{-1}) and small business (USD222±59 yr^{-1}). Compared to the remote and intermediate zones, income from small businesses and waged activities were relatively high in on-road (USD340±84 $yr^{-1}$and USD288±50 yr^{-1} respectively) zone. Wage income of the households in the on-road was significantly higher than the remote (p=0.000) zone.

The Pearson's correlation analysis indicated the relationships between the different income sources of the households and their total household income (Table 6). Total household income was positively correlated with employment (0.567) followed by agriculture (0.493), fruit (0.400), livestock (0.371), forest (0.243) and small business activities (0.236) (Table 6). Only waged income was found to be negatively correlated with total income. At the zone level, agricultural land use was correlated with total household income in the on-road (0.756)

and remote (0.696) zones. On the other hand, forest sourced income was related to total household income in the on-road (0.408) and intermediate (0.294) zones. The same pattern of relationship exists for waged income and total household income in the on-road zone. However, livestock income was positively related to the household income in the remote (0.592) and intermediate (0.491) zones.

4. Discussion

The current land use patterns of the CHT show a small increase in planted tree cover due to the decline of agricultural production areas over the past 30 years. The increase in areas with planted trees and fruit orchards has been associated with the decline in farm areas used mainly for swidden farming. Our findings are similar to those of studies that have determined that swidden landscapes are being transformed by a higher proportion of planted tree cover in the Southeast Asian region (Cramb et al., 2009; Newby, Cramb & Sakanphet, 2014). The decline in swidden farming in the CHT region is also consistent with a global review by Heinimann et al. (2017), leading the authors to project a continued decline of swidden over the next 20 years, and its complete disappearance across Asia, Africa and Latin America by 2090. Heinimann et al. (2017) pointed to the disappearance of swidden farming in Bangladesh by 2030, although they did not identify the land use trends that might replace this form of land use. The findings from the CHT study revealed a replacement of swidden farm areas with a trend towards mainly planted tree cover across the three zones. This decline in size of swidden farms is likely a response to the state policies in restricting the traditional forms of land uses and their changes over the past years.

The land use extent and planted tree cover differed across the remote, intermediate and on-road zones of the region. This finding supports those of McLennan & Garvin (2012), who revealed that the abandonment of traditional subsistence agriculture, followed by new land uses with timber plantations varied among the five communities depending on their locations in Costa Rica. Coomes et al. (2011) determined that initial land size and the mode of land acquisition influenced the changing land use and acquisition of tree cover in the swidden

farming system of an Amazonian peasant village. In the CHT region, households in the intermediate and on-road zones had larger land holdings and more tree-cover land, including fruit orchards, with secure ownership being more prevalent in these zones than in the remote area. Conversely, the crop land and fallow areas were larger in the remote zone, with the households having limited tree-cover land. The remotely located people have been settled under a government resettlement programme without any title to land ownership. Overall, the households that maintained swidden farming without secure ownership had smaller holdings. Thus, the geographic location differed in terms of management regime, which contributed to different current land use sizes in the region. The size of the present land uses held by ethnic communities in the region has been contingent upon the types of ownership provided to them in accessing forests and swidden farms in the region.

The contribution of land use to overall food production or gathering varied along the three zones in CHT. The food production (cereal, vegetables) is largely subsistence oriented in the remote location, although people maintain diverse food production from swidden farming, and fallow and fruit-tree land uses. The greater food production from swidden farming contrasts with the finding of Islam et al. (2007), who reported relatively low food production from land used in swidden farming. This suggests that generalisations about the declining role of swidden farming in subsistence level food provision may underestimate the importance of the land use for maintaining diverse food sources in different landscapes. Alternatively, households had relatively small crop land areas and large tree cover areas in the on-road zone, but their capacity for food production tended to increase. This finding supports research that found farm size patterns were not a barrier to high productivity in Indonesia (White, 2018). The recent increase in growing cash crops (vegetables, beverage, spices food groups), and the intensive use of lands, has contributed to the increase of food production capacity in the on-road zone. However, people's dependence on forest-sourced food has tended to decline in the intermediate and on-road zones, where the expansion of planted tree areas has resulted in monoculture timber plantations and cash crops affecting the diversity of food sources and diets. This trend implies a possible trade-off between planted

tree cover and diverse food provisioning services such as wild vegetables gathered from fallow land and forests in CHT region.

Looking at the incomes from various livelihood strategies, agricultural and fruit orchard land use is a major contributor to the household economy, with employment and livestock also being significant. Agriculture related activities has contributed to relatively higher household income in remote zone indicates the economic importance of crop (swidden farming) and fallow land uses has not declined here although cash crop increased in the region. It is further noted that livestock only significantly contributes to the household income of remotely located households due to the availability of large crop and fallow lands as well as proximity to forest lands used for grazing. Overall fruit orchard and employment sources show a positive trend to the increase of household income across the zones.

Cash-crop agriculture, planted tree land and off-farm activities including employment, have contributed to an increased income for the households in the intermediate and on-road zones. The highest annual household income in the intermediate zone indicates an increased income contribution from the employment sector and forest and tree sourced timber. This agrees with the findings of Roshekto et al. (2013) who reported that planted tree land uses enhanced income and options for diversifying the livelihood strategies in Indonesia. Waged-income activities increased in the on-road zone as a result of changes in land uses towards intensive agriculture, involving cash crops, fruit orchards, and the timber-harvesting sector (i.e. planted tree cover), which have required more labour. As a result, a direct reliance for income on the forest sectors remains high in the remote and intermediate locations, but waged activities associated with timber harvesting are viable alternative economic activities to the low income households in the on-road area. Nevertheless, neither forest income nor waged activities will sustain the economies of households that do not have access to, or the economic capital to adopt tree areas in the on-road zone. This is of concern to the people in the remote zone, where swidden farming and natural forest use is not a sustainable way to maintain their incomes in the long-term.

5. Conclusions

This study explores land use patterns and their association with livelihood outcomes (food production, income) in rural households along three zones in different forest/agriculture landscapes of CHT of Bangladesh. Our study revealed a diverse range of land use, from crop-lands under swidden farming practices to fruit orchard, fallow land and planted tree covers. The transition from swidden farming to tree cover land uses cannot be generalised across the CHT region. For instance, there was more crop land used under swidden farming practice in the remote location, while this decreased in the on-road and intermediate zones, being replaced by fruit orchards and planted tree areas. In examining livelihoods, it was revealed that the largest area of tree-based land use had a positive association with household income, which included waged activities related to timber harvesting. Notably, the use of smaller crop lands has not affected the level of food production in the on-road zone, where people without access to crop land or household owned tree cover lands are likely to depend on waged activities to secure their income. Only in the remote locations do higher proportions of households uses cropland, forestland and fallow lands for diverse food sources, with and options for food security.

Our findings offer a critical insight into land use transition patterns/trends, and the need for specific interventions for maximising the benefits of forest and tree-based land across the broader landscape. The economic value of planted land influences household land-use decisions, promoting a transition from swidden agricultural land uses to tree plantations in specific locations of the region. However, swidden farming remains an important land use practice in rural livelihoods despite this practice viewed as a low-level contributor in food production. This supports evidence of upland farmers pursuing swidden as a varied and open-ended practice in response to external pressures of government and dramatic land use changes across the landscape (Dressler et al. 2018). Remotely-located people use swidden farming and natural forests (i.e. state owned) to secure a diverse range of dietary and income options in the CHT region. People in the intermediate location manage swidden farming with

other intensified land use practices (planted trees and fruit orchards) to secure their food sources despite better access to market and roads. Nevertheless, the decreasing trend of swidden farming has raised concerns over its future replacement with planted land uses to generate diverse food and income sources in the remote area. The current national forest policy of Bangladesh has advocated for the development of plantations alone for the region rather than specifying a more integrated approach for forest, agriculture and plantation management at the landscape scale. Since the current planted land use has considered only economic gain over a wide range of livelihood benefits including food and environmental services, a more inclusive land management strategy can contribute to supporting forest and tree based land uses which meet the long-term diverse livelihood needs of the region.

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Table 1: Key economic and environmental features including forest and land uses across three study zones from 2015-2016 (adapted from Ahammad and Stacey 2016).

	Remote	Intermediate	On-road
Economic activities	— Agricultural farming (mainly paddy, vegetable, turmeric, sesame, beans, banana) — Forest product harvesting and trade in timbers and NTFPs — Day labour	— Agricultural farming (mainly paddy, vegetable, turmeric, ground nut, beans) — Forest product harvesting and trade in timber and NTFPs (bamboo) — Fruit-tree gardening (e.g. mango, cashew nut, pineapple, pomelo etc.) — Day labour — Employment	— Agricultural farming (e.g. paddy, tobacco, potato, seasonal vegetable) — Day labour — Forest trade — Employment — Small business — Land rent
Land use types	— Upland agricultural (swidden farming practices) — Natural and planted forest with teak trees land uses — Fallow land covered by grass, scattered trees and banana	— Upland agricultural (swidden farming practices) — Small low-land agriculture — Secondary forest — Plantation — Fruit-tree orchard	— Mainly low-land rotational agriculture — Very small upland agriculture (shifting cultivation practices) — Secondary forest — More plantations — Small fruit-tree orchard
Forest types	— Natural forest (tropical evergreen) — Planted tree cover	— Mixture of forest types: mostly natural forest with planted trees	— Mostly planted tree cover areas
Forest management regime	— State forest reserve	— State forest reserve — Community reserve — Private plantation	— State forest reserve — Private plantation
Distance to sub-district/district market	— 2-3 hours by boat	— 0.5-1 hour by motorbike	— 30 minutes by motorbike

Table 2: Summary of data collection methods (2015-2016)

	Variables of interests to the study	Number of participant households (hhs) surveyed
Household surveys	Perceived experiences of land use changes; present land holdings, main land use type and household tree-cover area	304 hhs
	Annual income	171 hhs
Farm surveys	Detailed land use information, annual food production (main sources of food production including gathering)	30 hhs
Farm typology exercise	Village-level information on land uses, main crops, tree cover areas	12

Table 3: Comparison of the mean size (ha) of land used for crop, fruit, fallow and planted tree covers across the three zones (remote, intermediate and on-road zones) in the CHT region (source: household surveys 2015-2016). $\chi 2$ and P values are given for Kruskal–Wallis tests (comparison of medians). Different superscript indicates significant differences between the specific zones calculated by Mann-Whitney-Wilcoxon test.

Land use types	Mean size (n=305)	Remote (n=92)	Intermediate (n=104)	On road (n=108)	*χ2*	P *value*
Crop land	0.57±0.53	0.72±0.05[a,b]	0.26±0.04[c]	0.28±0.03[c]	68.99	0.000
Fallow land	0.21±0.01	0.51±0.07[a,b]	0.10±0.02[c]	0.04±0.02[c]	93.18	0.000
Fruit /orchard land	0.25±0.05	0.52±0.06[b]	0.64±0.07[b]	0.17±0.03[a,c]	45.71	0.000
Planted trees land	1.07±0.10	0.45±0.06[a]	0.93±0.08[c]	0.76±0.09	13.43	0.001

[a] significantly different from the intermediate zone, $p<.05$.
[b] significantly different from the on-road zone, $p<.05$.
[c] significantly different from the remote zone, $p<.05$.

Table 4: Comparison of the mean amount of food in kg/household^{-1} year^{-1} produced from forestland and non-forest land sources across the three zones (remote, intermediate and on-road zones) (source: farm surveys 2015-2016). $\chi 2$ and P values are given for Kruskal–Wallis tests (comparison of medians). Different superscript indicates significant differences between the specific zones calculated by Mann-Whitney-Wilcoxon test.

Land use for food production	Mean total (n=30)	Remote (n=10)	Intermediate (n=10)	On road (n=10)	$\chi 2$	P *value*
Crop land	5026±736	3480±827[b]	3109±583[b]	8526±1493[a,c]	9.83	0.007
Fallow land	1697±368	2806±757[b]	2034±635[b]	328±107[a,c]	17.87	0.000
Fruit /orchard	962±185	432±167	1300±317	1068±378	6.58	0.037
Forest/trees	430±70	781±135[b]	406±87[b]	140±43[a,c]	16.46	0.000

[a] significantly different from the intermediate zone, p<.05.
[b] significantly different from the on-road zone, p<.05.
[c] significantly different from the remote zone, p<.05.

Table 5: Comparison of annual household incomes from various sources (mean income in USD ± standard error) across the three zones (remote, intermediate and on-road) (source: household surveys 2015-2016). $\chi 2$ and P values are given for Kruskal–Wallis tests (comparison of medians). Different superscripts indicate significant differences between the specific zones calculated by Mann-Whitney-Wilcoxon test.

	Total (n=171)	Remote (n=54)	Intermediate (n=58)	On-road (n=59)	*χ2*	P *value*
Agriculture	440±57	515±71[a,b]	234±40[c]	567±146[c]	21.34	0.000
Fruit	159±18	137±23[b]	274±41[b]	65±19[a,c]	27.35	0.000
Forest/trees	175±30	204±36[b]	257±72[b]	68±30[a,c]	17.71	0.000
Wages	162±23	21±6[b]	163±40	288±50[c]	19.99	0.000
Livestock	129±30	180±45[a,b]	186±75[c]	25±8[c]	23.15	0.000
Employment	297±65	98±38	570±162	210±88	1.12	0.571
Small business	211±37	62±28[a,b]	222±59[c]	340±84[c]	13	0.002
Other	102±25	71±32	83±47[b]	151±48[a]	11.95	0.003

[a] significantly different from the intermediate zone, p<.05.
[b] significantly different from the on-road zone, p<.05.
[c] significantly different from the remote zone, p<.05.

Table 6: Association between specific income sources and total household income across the three study zones indicated by Pearson's correlation.

Income sources	Total household income	Zone level total household income		
		Remote	Intermediate	On-road
Agriculture	0.493	0.696	0.206	0.756
Fruit	0.400	0.328	0.419	0.441
Forest	0.243	-0.108	0.294	0.408
Wage	-0.208	-0.190	-0.259	-0.345
Livestock	0.371	0.592	0.491	0.040
Employment	0.567	0.293	0.649	0.462
Small Business	0.236	0.298	0.239	0.186
Others	0.178	0.031	0.179	0.226

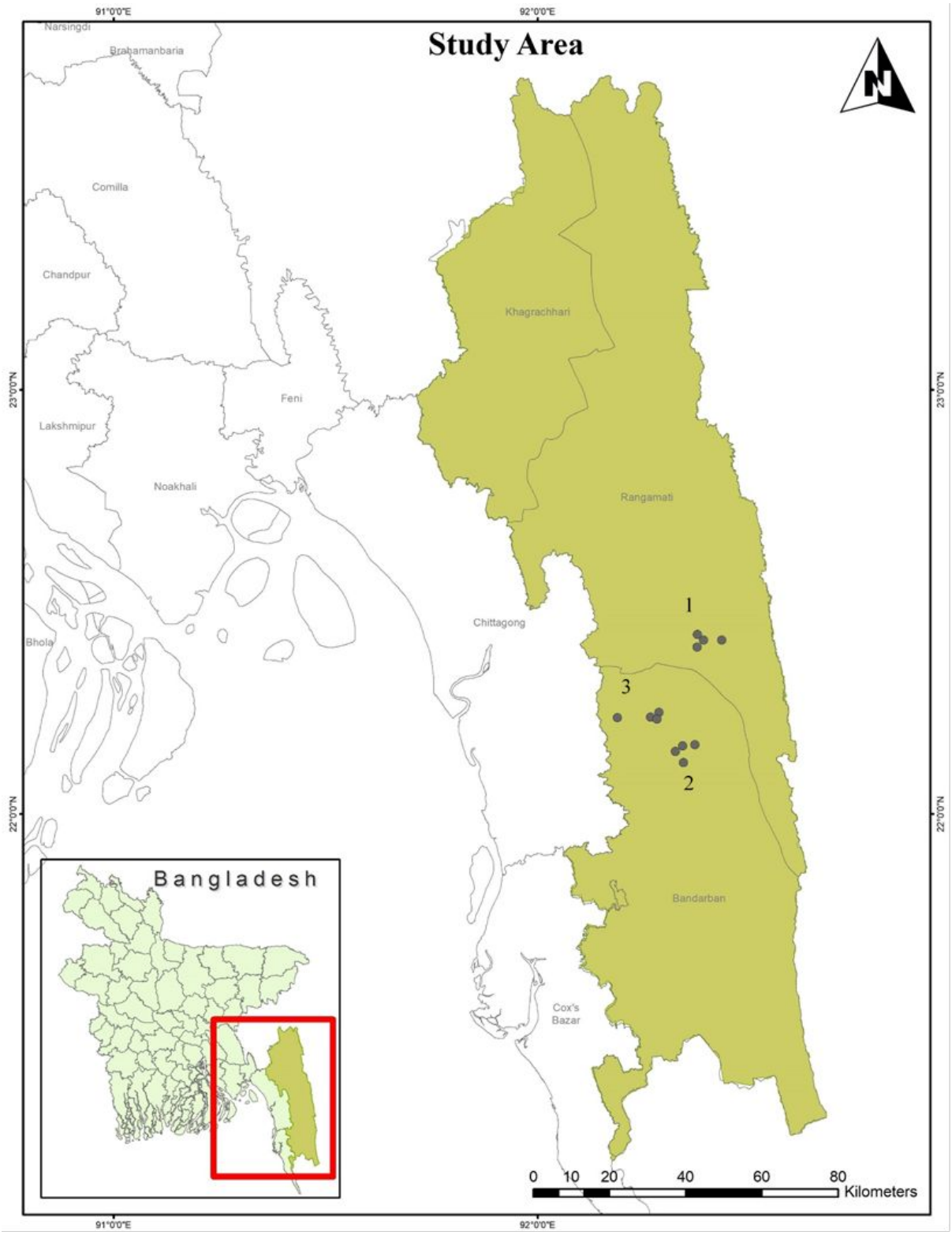

Figure 1: Study villages indicated by dot point on the map across the three zones: 1: remote; 2: intermediate and 3: on-road in the CHT region of Bangladesh

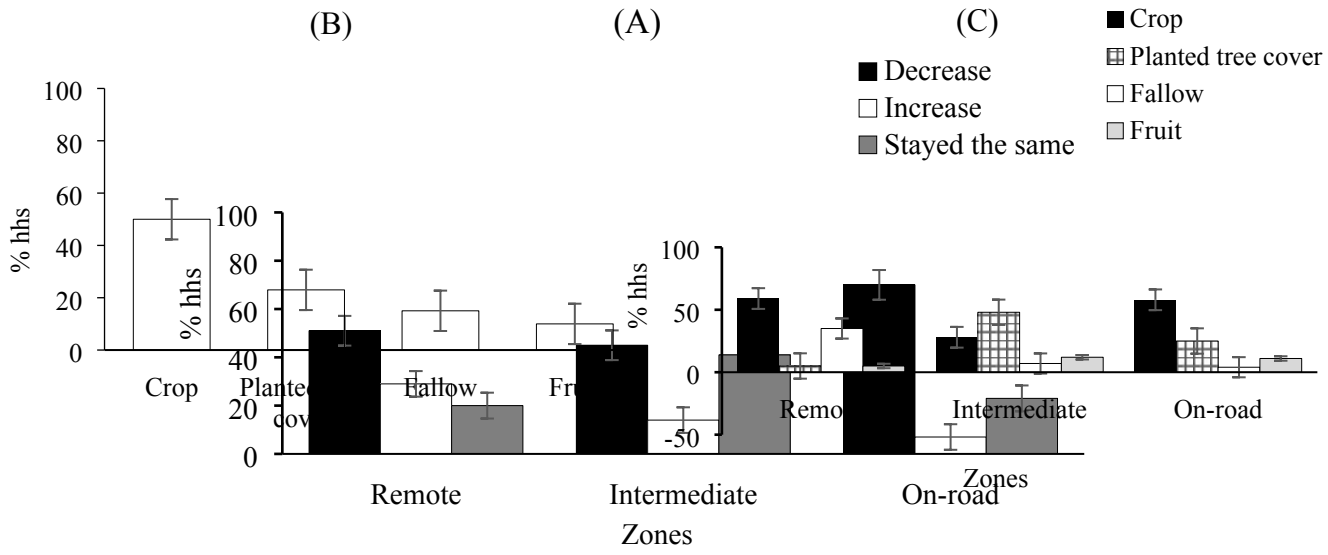

Figure 2: (A) Percentage of households (n=304) that experienced changes in the amount of their land used for food production in the period 1985-2015; (B) Percentage of households using lands for four main purposes (crops, planted tree cover, fallow, fruit orchard); (C) Percentage distributions of household land use at the zone level. hhs=households.