

Ecological footprint of the Hill Tracts of Chittagong in Bangladesh

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Abstract. This paper presents the environmental degradation in terms of ecological footprint of the Hill Tracts of Chittagong in Bangladesh. To estimate the present status of the ecological footprint of the Hill Tracts of Chittagong in Bangladesh, primary and secondary data were collected, and a quantitative method for ecological footprint developed by Wackernagel was used to estimate the environmental sustainability. Environmental status in the Hill Tracts of Chittagong is poor for all the upazilas (sub-districts). The environmental status in the Hill Tracts of Chittagong has degraded mainly due to shifting cultivation and tobacco cultivation.

Key words: Ecological footprint, shifting agriculture, Hill Tracts of Chittagong

Introduction

Chittagong Hill Tracts (CHT) is the only extensive hill area in Bangladesh and the area of the Chittagong Hill Tracts is about 13,184 km², of which 92% is highland, 2% medium highland, 1% medium lowland and 5% homestead and water bodies. Total population of CHT is 13,310 996, of which about 51% is tribal people. Agriculture is the main source of livelihood of these populations. The tribal populations here are the most disadvantaged group of populations in Bangladesh. Shifting agriculture locally known as jhum is still the cultivation systems in this region with little impact of different plans and programs to promote the agricultural land use patterns. As a result the tribal populations are suffering from food insecurity and the shifting agriculture has led to irreversible destruction of forest for food resulting ecological degradation.

Promoting sustainable development in uplands of Chittagong Hill Tracts poses important challenges. The incidence of poverty is very high and the uplands are essentially caught in a vicious cycle of

poverty, food insecurity and environmental degradations. Land use practices i.e. jhum cultivating in uplands not only causes severe losses of soil and essential plant nutrients and degradation of the resource base but also negatively impact on the livelihoods and resources base downstream. Wider environmental impacts also occur in the form of reduced biodiversity, reduced ability of the ecosystem to regulate the stream flow and reduced carbon absorption. Also recent large scale cultivation of tobacco which demands huge amount of fuel wood for curing is a threat to the forest ecosystems in the Hill Tracts of Chittagong. Moreover, deforestation also created threat to local ecosystem. The question arises to know how serious is the environmental degradation resulting from shifting and tobacco cultivation.

Ecological footprint is an ecological stability indicator. The theory and method of measuring sustainable development with the ecological footprint was developed during the past decade (Wackernagel and Rees 1996, Chambers *et al.* 2000). The ecological footprint is a measurement of sustainability illustrating the reality of living in a world with finite resources and it is a synthetic indicator used to estimate a population's impact on the environment due to its consumption; it quantifies total terrestrial and aquatic area necessary to supply all resources utilized in sustainable way and to absorb all emissions produced always in a sustainable way. Apart from analyzing the present situation, ecological footprint provides framework of sustainability planning in the public and private scale.

Several studies have been reported on applications of ecological footprint during past decade to address environmental sustainability (Wackernagel *et al.* 1999, Monfreda *et al.* 2004, Zhao *et al.* 2005, Medved 2006, Chen and Chen 2006, Bagliani *et al.* 2008, Niccolucci *et al.* 2008, Bala and Hossain 2010). This technique has been applied to wine production (Niccolucci *et al.* 2008), regional level (Zhao *et al.* 2005, Bala and Hossain 2010), national level (Medved 2006, Chen and Chen 2006, Bagliani *et al.* 2008), and national and global level (Wackernagel *et al.* 1999). The ecological footprint has been jointly used combining emergy analysis to evaluate ecological footprint for regional level (Zhao *et al.* 2005) and national level (Chen and Chen 2006, Bagliani *et al.* 2008, Wackernagel *et al.* 1999, Niccolucci *et al.* 2008) as well as to assess ecological footprint and biocapacity (Monfreda *et al.* 2004, Medved 2006, Bagliani *et al.* 2008). No study has been reported on environmental degradation in CHT. This paper presents the environmental degradation of the Chittagong Hill Tracts of Bangladesh.

Materials and Methods

Field level sample survey

A multi-stage sampling was designed for selecting the farm households from the Hill Tracts of Chittagong consisting of Bandarban, Rangamati and Khagrachhari districts. The sampling framework consists of primary sampling unit of district, secondary sampling unit of upazila, pre-ultimate sampling unit of village and ultimate sampling unit of household. First of all nine upazilas were randomly selected from each of the three districts and these districts are shown in Fig. 1. Then three villages were randomly selected from each upazila. The ultimate sampling units (i.e., farm household) from each of the villages were selected by stratified random sampling method with proportional allocation, where farm categories viz., landless (<0.05 acre), marginal (0.05-0.49 acre), small (0.5-2.49 acre), medium (2.5-7.49 acre) and large (7.5 acre & above) farms were considered as the strata. A total of 1779 households was sampled from the selected villages and the selected villages are shown in Table 1. In addition, a Focus Group Discussion was held with the sub-assistant agricultural officers of 10 blocks of Khagrachhari sadar upazila on jhum (jhum) cultivation on 16 April 2009 in the Khagrachhari upazila agricultural extension Office.

Data collection and analysis

Data on population, crop, tobacco, livestock and forestry were collected to estimate the environmental degradation at upazila levels in Bangladesh from upazila offices of Government: Department of Statistics, Agriculture, Fishery and Livestock. Information collected using multi-stage stratified sampling was used to develop logit models to identify the factors affecting household food security.

Computation of ecological footprint and biological capacity

District	Upazila
Bandarban	Sadar, Alikadam and Ruma
Rangamati	Sadar, Barkal and Kaptai
Khagrachhari	Sadar, Mahalchhari and Dighinala

Table 1. Selected upazilas from the Hill Tracts of Chittagong.

Ecological footprint represents the human demands, taking into accounts the production and supply of resources (energy, food and materials) and assimilation of the wastes (in all forms) generated by the analyzed system. Ecological footprint of a given population is the total area of productive land and water required to produce all the resources (energy, food and materials) consumed and to absorb the waste generated by that population of a region or nation using prevailing technology and resource

management practices. The ecological footprint calculation is based on the average consumptions data converted into uses of productive lands. The bioproductive land is divided into 6 categories according to the classification of the World Conservation Union: (1) cropland, (2) grazing land, (3) forest, (4) fishing ground, (5) build-up land, (6) energy land.

Total ecological footprint is the sum of the ecological footprints of all categories of land areas which provide for mutually exclusive demands on the bio-sphere. Each of these categories represents an area in hectares, which is then multiplied by its equivalence factor to obtain the footprint in global hectares. One global hectare is equal to 1 ha with productivity equal to the average of all the productive ha of the world. Thus, one ha of highly productive land is equal to more global hectares than 1 ha of less productive land. The ecological footprint can be expressed as:

$$\text{Footprint (gha)} = \text{Area (ha)} \times \text{Equivalence Factor (gha/ha)} \quad (1)$$

where

Equivalence Factor = the world average productivity of a given bioproductive area / the world average potential productivity of all bioproductive areas.

Equivalence factor represents the world average productivity of a given bioproductive area relative to the world average potential productivity of all productive areas and it is the quantity of global hectares contained within an average hectare of cropland, build-up land, forest, pasture or fishery. The structure of the computation of ecological footprint is shown in Fig. 2.

An important part of the ecological footprint analysis of a region or zone is represented by the calculation of its Biological Capacity (Biocapacity)

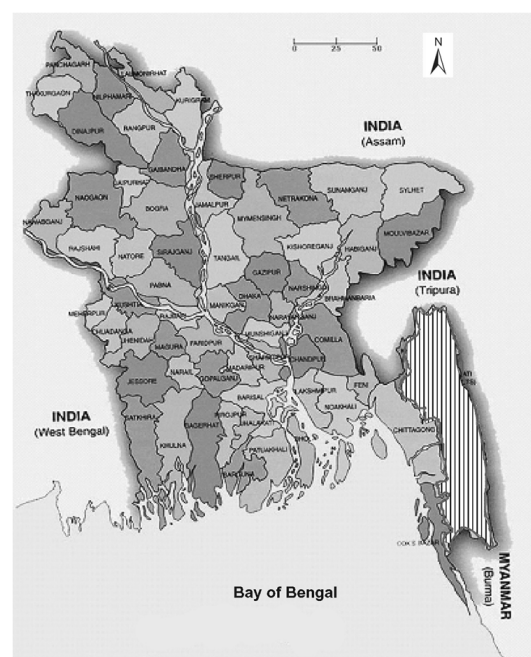


Fig. 1. Map of Bangladesh. Vertical pattern part is investigated area.

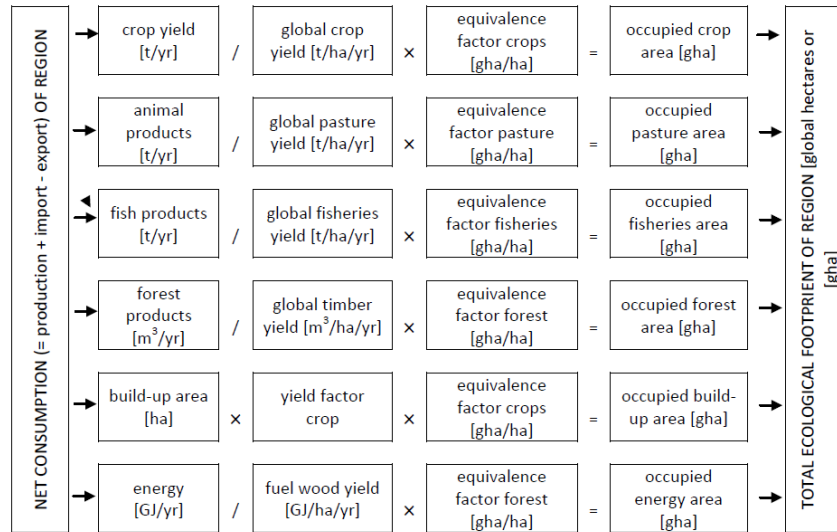


Fig. 2. Structure of ecological footprint computation.

that takes into account the surfaces of ecologically productive land located within the area under study. Biological capacity represents the ecologically productive area that is locally available and it indicates the local ecosystems potential capacity to provide natural resources and services. Biological capacity is the total annual biological production capacity of a given biologically productive area. Biological capacity can be expressed as:

$$\text{Biocapacity (gha)} = \text{Area (ha)} \times \text{Equivalence Factor (gha/ha)} \times \text{Yield factor} \quad (2)$$

where

$$\text{Yield factor} = \text{Local yield} / \text{global yield}$$

Total biocapacity is the sum of all bioproductive areas expressed in global hectares by multiplying its area by the appropriate equivalence factor and the yield factor specific to that country/locality. The structure of the computation of biocapacity is shown in Fig. 3. Biological capacity can be com-

pared with the ecological footprint, which provides an estimation of the ecological resources required by the local population. The ecological status is expressed as the difference between biocapacity and ecological footprint. A negative ecological status ($BC < EF$) indicates that the rate of consumption of natural resources is greater than the rate of production (regeneration) by local ecosystems (Rees, 1996). Thus, an ecological deficit ($BC < EF$) or surplus ($BC > EF$) provides an estimation of a local territory's level of environmental sustainability or unsustainability. This also indicates how close to sustainable development the specific area is.

Results and Discussion

Ecological footprint at upazila level

Major crop areas of nine upazilas in the Chittagong Hill Tract (CHT) are shown in Table 2. T. Aman is the major crop for all the upazilas except Ruma upazila. The area for Boro cultivation is lower than

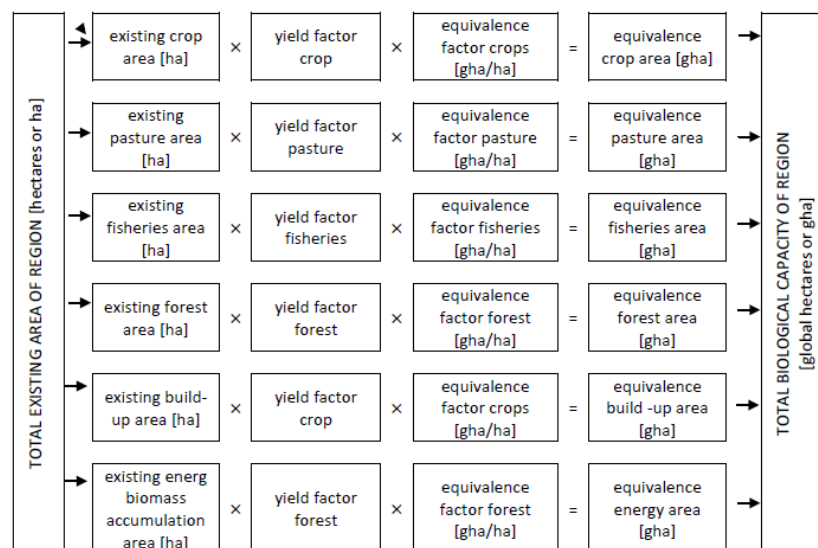


Fig. 3. Structure of biological capacity computation.

Sl. No.	Upazila	Total area (ha)	T. Aman* area (ha)	Boro* area (ha)	Jhum area (ha)	Tobacco area (ha)
1	Bandarban Sadar	50198	2648	1040	850	350
2	Alikadam	88615	1600	203	920	610
3	Ruma	61668	45	7	2000	81
4	Rangamati Sadar	54618	720	319	350	0
5	Barkal	76088	385	310	305	350
6	Kaptai	27336	1150	1846	340	40
7	Khagrachhari Sadar	29791	3550	1517	550	40
8	Mahalchhari	24864	3050	1400	405	31
9	Dighinala	69412	4760	1914	680	1800

* aman and boro are rice cultivars

Table 2. Major crop areas in 2008-2009 of different upazilas

that of T. Aman area except Kaptai upazila. Among the nine upazilas, the highest area for Boro is in Dighinala (1914 ha) followed by Kaptai (1846 ha). The Boro area in the Ruma upazila is very negligible. The highest jhum area is in Ruma (2000 ha) followed by Alikadam (920 ha) and Bandarban Sadar (850 ha) while the highest tobacco area is in Dighinala (1800 ha) followed by Alikadam (610 ha). There is no tobacco in Rangamati Sadar. The present status of contributions of crop production

including tobacco, livestock, horticulture and forest products to environmental degradation in terms of ecological footprint of nine upazilas of the CHT of Bangladesh are estimated and these upazilas are Bandarban Sadar, Alikadam, Ruma, Rangamati Sadar, Barkal, Kaptai, Khagrachhari Sadar, Mahalchhari and Dighinala.

Fig. 4 shows the contributions to ecological footprint from different resources in the nine upazilas. For all these upazilas the contributions to ecological

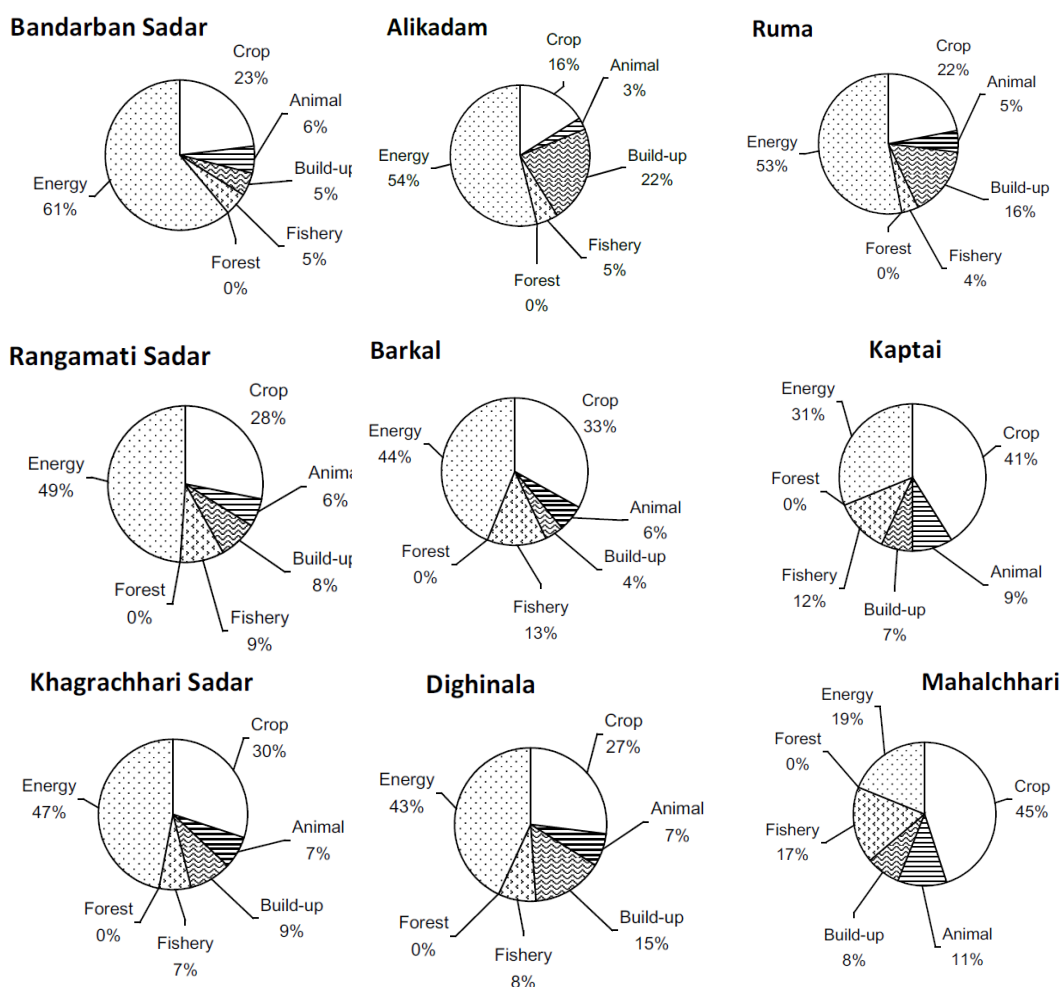


Fig. 4. Percent ecological distribution of nine upazilas of CHT region.

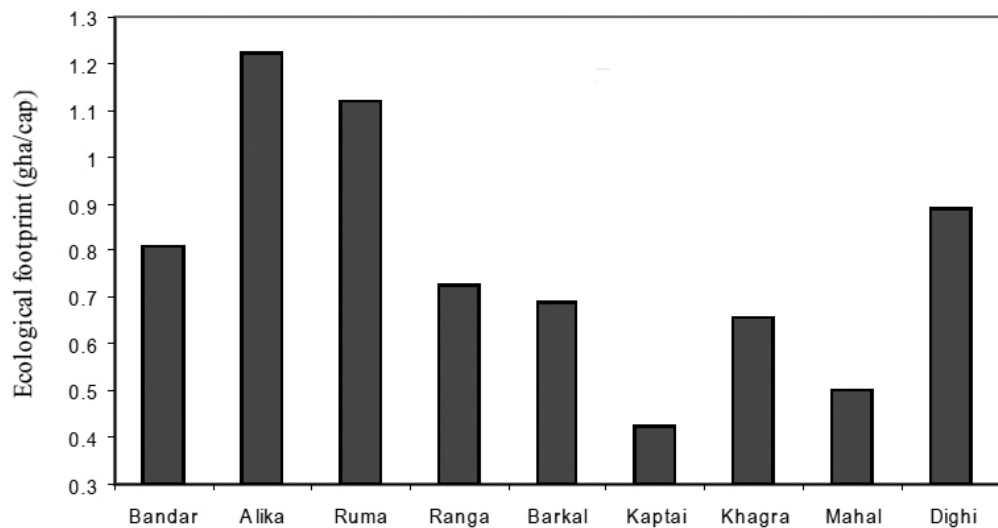


Fig. 5. Ecological footprint of different upazilas.

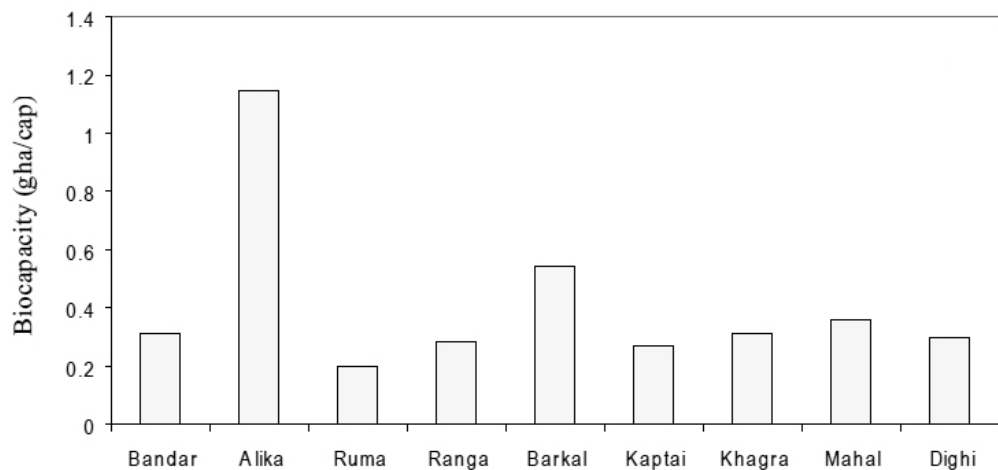


Fig. 6. Biological capacity of different upazilas.

footprint from energy is 19-61%, from crop is 16-45%, and from build-up area is 4-22%. But the contribution from energy is the largest in Bandarban Sadar and it is 61%.

Fig. 5 shows the ecological footprint in the nine upazilas. The largest ecological footprint is at Alikadam (1.223 gha/cap) followed by Ruma (1.119 gha/cap) and the lowest ecological footprint is at Kaptai (0.426 gha/cap). This implies that Alikadam and Ruma have suffered serious environmental degradation and Kaptai is the least suffered upazila.

Fig. 6 shows the biocapacity in the nine upazilas. Alikadam has the largest biocapacity (+1.145 gha/cap) and the lowest is at Ruma (+0.201 gha/cap).

Fig. 7 shows the ecological status in the nine upazilas of Bandarban Sadar, Alikadam, Ruma, Rangamati Sadar, Barkal, Kaptai, Khagrachhari Sadar, Mahalchhari and Dighinala. The ecological status of all the upazilas is negative that implies that these upazilas are facing environmental degradation. The ecological status of all the upazilas is deficit because huge amount of wood are used in the kiln for tobacco processing in addition a large amount of leaves and trees are burnt out for the cul-

tivation of jhum. Bala and Hossain (2010) assessed the ecological status in the nine upazilas of the coastal zone of Bangladesh. They found that out of nine upazilas, two upazilas are ecologically surplus and the rest of five upazilas are ecologically deficit. Wackernagel et al. (1999) also reported that the ecological status for Bangladesh as a whole is -0.20 gha/cap. The average ecological status (-0.2) of Bangladesh is marginally deficit, but the ecological status (-0.914) of Ruma is 4.5 times of the national average of Bangladesh and needs policy and programs to arrest the growth and reduce the degradation.

This research shows that the environmental status in the CHT region is poor for all the upazilas. The environmental status in the CHT region has degraded mainly due to jhum and tobacco cultivation.

Policy Implications

Agricultural systems of the Hill Tracts of Chittagong are still traditional with marginal yield i.e. jhum cultivation resulting soil erosion and an expanding coverage of tobacco cultivation along banks of the hilly rivers which results in rapid depletion of

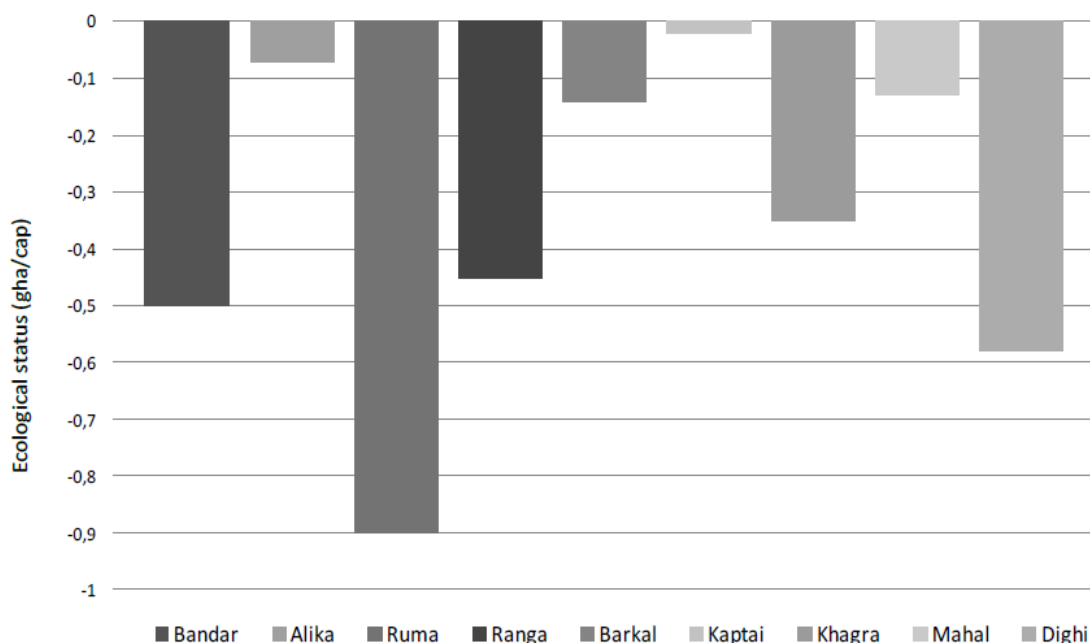


Fig. 7. Ecological status (gha/cap) of different upazilas.

the nearby reserve forests for kilning the tobacco. These traditional agriculture and expanding coverage of tobacco cultivation are the threats to the environment and even this rapid expansion of tobacco cultivation may cause the total destruction of the reserve forests of the Hill Tracts of Chittagong within a short period of time. Our findings of this study analysis suggest the following policy implications: The findings suggest that fruit trees with other horticultural crops to control soil erosion and landslides, banning of tobacco cultivation to avoid deforestation, micro credit, extension service, infra-structural development for access to market and development of marketing channels for agro products need promotion of environmentally sustainable and economically viable agricultural systems.

Conclusions

Environmental degradation in terms of ecological footprint of nine upazilas of three districts of the Hill Tracts of Chittagong are estimated. The environmental status in the CHT region is poor for all the upazilas. The environmental status in the CHT region has degraded mainly due to jhum and tobacco cultivation.

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