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Forest, trees and agroforestry: Better livelihoods and ecosystem services from multifunctional landscapes

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Abstract

Scientific community is concerned to address contemporary issues of food production and conserve tropical forests that support the livelihoods of millions of people. A review of the literature on deforestation, forest utilization, and landscape management for ecosystem services was conducted to investigate the effect on peoples' livelihoods and the sustainability of forests in Bangladesh as a case. Results reveal that the current rate of deforestation is at 0.3% per annum meaning that, with current trends, in two decades little or no forest cover will exist in Bangladesh making the livelihoods of millions of people who depend on forest resources extremely vulnerable. We ask; can better implementation of forest policies and landscape management contribute to curb the current level of deforestation? Agroforestry systems in particular are a promising strategy to sustainably deliver food, nutritional and income security, ecosystem services and biodiversity conservation across the landscape. However, for agroforestry to become a viable livelihood venture that simultaneously delivers all these benefits, a mixture of economic and institutional support from the state is needed instead of market driven approaches or project based interventions.

Keywords: Agroforestry; Landscape management; Folk-people; Ecosystem services; Livelihoods

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1. Introduction

With the contribution of more than 17% of all global emissions, land conversion and deforestation currently emit around 1.7 billion tons of carbon annually (Olivier et al., 2013). If properly managed, tropical forests could absorb as much as 1 billion tons of carbon per year and preserve habitats for thousands of plant and animal species (Gomieroa et al., 2011; Houghton, 2007). Forests, and particularly tropical forests, are receiving increasing attention due to the multiple benefits and livelihoods options that folk people derive from them. The World Bank estimates that over 90% of the 1.2 billion people living in extreme poverty depend to some extent on forests for their subsistence (Agrawal et al., 2013). Putting this into perspective, economic contributions from the forestry sector was USD 250 billion in 2010 according to FAO estimation. This figure is more than double total ODA for 2010. Actual figures are much higher considering the limitations in data. Besides cash returns from forests, the non-cash returns such as carbon and ecosystems services are far greater (Costanza et al., 1998). Therefore, poverty reduction would be impossible without paying specific attention to the 410 million people who depends on forests for livelihoods (Rahman et al., 2010) as well as dietary diversity and nutrition (Ickowitz et al., 2014).

Deforestation is synonymous to expansion and development of agriculture and one of the pervasive environmental challenges of the world (Mena, 2001). Sharma (1992) categorized causes of deforestation into direct and underlying causes. Direct causes include urbanization, agricultural land expansion, commercial logging and conflict (Humphreys, 1996). Underlying causes of deforestation are typically population pressure coupled with poverty. At the aggregate level the causes of deforestation and degradation are often interlinked and referred to as 'wicked problems' (Howes and Wyrwoll, 2012; Noble, 2012). Attempts to reduce deforestation should acknowledge people's continuing need for food, fibre and energy. Various options that reconcile forest conservation and livelihood options for poor people should be pursued in forest research and rural development (Phalan et al., 2011). The sustainability of forest management is also significantly affected by market and policy failures. Poor economic performance also pushes nation states to speed up forest exploitation in order to generate foreign currency (Humphreys, 1996). For the demand of wood products and the problems of environmental degradation, since the 1970s, forest policies in many developed countries have been reformed (Dhakal, 2009; Strassburg et al., 2009). Such policies considerably changed the production systems and supplies of various kinds of forest products.

In the region of South and Southeast Asia, though Bhutan, India and Viet Nam have increased their forest area through vast afforestation programmes from 1990-2010, most other countries experienced a net loss of over 28 thousand square kilometers of forest, or 1% of forest cover, every year (FAO, 2010). In Bangladesh, current deforestation rate has established at 0.3% per year (Chowdhury and Koike, 2010). In the case of Eastern Bangladesh the traditional system of shifting cultivation, still the predominant farming system in this area, is a major cause of forest decline (Rahman et al., 2007a). Massive deforestation has led to declines in natural resource and increasing poverty levels for folk communities in the forest region of Bangladesh (Rahman et al., 2013; Rahman et al., 2012a).

This study aims to propose alternatives to deforestation and livelihoods opportunities for the folk people targeting better ecosystem services functions in a landscape scale through the dissemination and adoption of

agroforestry technologies in Bangladesh, It reviews the major causes of forest destruction and the resulting impoverishment of folk people. Finally, it explores the various policy and market institutions that need to be place in order for folk communities to derive sustainable livelihoods from agroforestry practices. Because, agroforestry has been widely promoted to deliver ecosystem services alongside sustaining agricultural livelihoods that previously depended on swidden agriculture (Dewia et al., 2013; Scales and Marsden, 2008). Policies play a major role in the sustainable conservation of natural resources and Bangladesh is no exception, we review the evidence that inclusive forest management has the potential to deliver multifunctional benefits for improved livelihoods, and the concomitant conservation of biodiversity and ecosystem services (Sunderland et al., 2004). We review a multitude of literature mainly peer reviewed journal articles but also governments publication and donor reports on the topic. With the help of selected key words, we searched ISI Web of Knowledge and Google Scholar for relevant literature. The following section presents our findings and discussion based on relevant hits. Key words and phrase searches included deforestation, degradation, forests, trees, agroforestry, landscapes, ecosystem, biodiversity, livelihoods, local/folk people, forest policy, and forest management.

2. Results and discussion

2.1. Forests and deforestation

By supporting the livelihoods of the folk community, forests play a role in socio-economic development (Michon, 2005). At the national level, through exportation of forest products it can help earn foreign exchange (FAO, 2006; Wiersum et al., 2006). Forests also act as important carbon sinks (Aune et al., 2005). Other roles of forests include the ecosystem services of climate stabilization, hydrological services (regulation and cleansing), improving air quality, soil enhancement and nutrient cycling (Danielsen, 2005; Daily and Ehrlich, 1999; Crook and Clapp, 1998). Munasinghe and McNeely (1995) have summarized all the functions of forests as shown in the Table 1.

In Bangladesh, deforestation is continued and reached an alarming stage. According to the National Forest and Tree Resources Assessment 2005-2007, approximately 10% of the surface area of the country remains forested (BFD, 2008). The validity of this statistic remains questionable. Available data however, suggests that 93% of Bangladesh's forests are lost or degraded. The protected area network of the country, which consists of 1.4% of the surface area, is one of the smallest in the world. Even though the current deforestation rate is relatively low (less than 1% per annum), Bangladesh is at a major risk of losing its remaining forest resources and associated biodiversity unless the trend is reversed (FAO, 2009).

The major cause of deforestation in Bangladesh is due to agricultural expansion, principally through shifting cultivation in the hill forests. Rapid human population[1] growth also has intensified pressure on forest

[1] With an annual growth rate of 1.2%, the total population of Bangladesh may increase from 156 million in mid 2013 to 185 million in 2030 (ESCAP, 2013).

resources throughout the country[2]. Forests are depleted by commercial timber exploitation and gradual conversion into pastures, and cultivated fields (Rahman et al., 2008). Besides these, forest encroachment, extensive firewood collection, forest fires and illegal logging all contribute to deforestation in the country (BBS, 2010).

Table 1. Functions of forests

Source of services	Ecosystem service	Outcomes
Timber	Biodiversity, carbon storage	Cash income
Fuel wood	Climate regulation, carbon fixing	Source of energy
Other business products, Non-wood product	Watershed protection	Habitat for people, flora and fauna
Genetic resources, Recreation and tourism	Protection of soil quality and resistance to erosion, scientific data	Aesthetic, cultural, and spiritual source

Moreover, existing forest policy in Bangladesh has a number of limitations. Most notable is that, although it vaguely commits to 'extend the scope of poverty alleviation and forest-based rural development', this policy excludes an implementation plan on how its goal will be achieved (ADB, 2004). Land tenure issues, social stratification, patronage, that influence in the sustainable forest management have not been addressed in the policy thus failed to motivate folk people who are involved in growing annual crops by slash-and-burn in large areas of the unprotected forest which does not require any investment in land (Rasul, 2005).

In the Chittagong Hill Tracts of Bangladesh, swidden cultivation is the main farming system in the forest communities and the practice is intertwined within the sociocultural identity of the folk people (ADB, 2004). Historically, swidden practices included a fallow period between 15-20 years, to allow rejuvenation of soil fertility and forest regrowth. Current rise in population is exerting pressure on agriculture land resulting is fallow periods of just 3-4 years (Riessen, 2000). This decrease has led to reductions in ecosystems services provisioning, forest and biodiversity loss and loss of top soil on large scale (Gafur, 2001). With population growth, land scarcity and loss of natural resources, poverty in these regions continues to rise (Rahman et al.,

[2] On the basis of geographical location, climate, topography, and management principles, the forests of Bangladesh can broadly be classified into: hill forests, unclassified state forests, plain land sal forests, mangrove forests, coastal forests and home gardens (ADB 2004).

2011; Rahman et al., 2010) as a result of decreasing livelihood opportunities that formerly depended on primary production and economic activities based on forest products (Chowdhury and Koile, 2010).

In order to reverse this trend, new production practices are needed that serve multiple purposes of conserving forest resources, food production, and sustainable development (Sunderland et al., 1999). Not only are innovative technologies needed but market competent policies and market institutions are also just as relevant. Agroforestry, the practice of growing trees on farm alongside crops is a well-studied and a potential to curbing deforestation and degradation in Bangladesh (Rahman et al., 2014).

2.2. Forest culture and agroforestry

Agroforestry was first practiced about 10,000 years ago in the ancient Mesopotamia, what is now currently known as Iraq, Iran, Turkey, Syria and Lebanon. The practice of domesticating trees is thought to have preceded modern agriculture and the domestication of maize, millet/sorghum, squash and beans occurred around 4000, 5000, 7000 and 5000 B.C., respectively (Haque, 1996). As an interdisciplinary subject agroforestry gained international prominence during the 1980s largely as a development imperative in the tropics (Sinclair, 1999). Agroforestry systems can meet both financial, social and environmental objectives by diversifying farm products and benefit the society (Garrity, 2004; ASB, 2001; University of Minnesota, 1996; Nair, 1990).

Table 2. Different agroforestry systems

Agroforestry System	**Brief description**	**Components (W= Woody H=Herbaceous)**	**Primary role of woody components (Prt=Protective Prd=Productive)**	**Agro-ecological adaptability**
Improved or enriched fallow	Woody species planted and left to grow during the "fallow phase."	W: fast growing, preferable leguminous H: common agricultural Crops	Prt: soil fertility and stability Prd: wood products	In Swidden cultivation areas
Taungya	Combined stand of woody and agricultural species during early stages of establishment of plantations	W: usually plantation forestry species, i.e. (Swietenia macrophylla) H: common agricultural crops	Prd: additional income from forestry species	In most ecological regions; several improvements possible

Multi-layer tree gardens (multi-strata)	Multi-species, multi-layer, dense plant associations	W: different woody components of varying form H: usually absent	Prt: soil conservation; efficient nutrient cycling Prd: various	Areas with fertile soils, good availability of labor, and high human population pressure
Multi-purpose trees of crop lands (multi-strata)	Trees scattered or arranged according to some pattern within boundaries	W: multi-purpose trees and other fruit trees H: common agricultural crops	Prt: fencing, social values, plot demarcation Prd: various tree products	In all ecological regions, esp. in subsistence farming. Sometimes integrated w/ animals.
Plantation crop combinations (multi-strata)	Integrated multi-story mixtures of plantation crops, arranged in some pattern, with possibly some shade trees and other crops	W: combination of crops i.e. coffee, coconut, or other fruit trees, or forestry species H: common agricultural crops usually present, especially with intercropping arrangements	Prt: shade, windbreak, soil protection Prd: large number of products	In humid, sub-humid regions (depending on adaptability of plantation crops); usually in smallholder subsistence system.

Adapted from Nair (1990) and Sinclair (1999)

The agroforestry practices in Bangladesh are associated with various patterns and models. Recently, practices are reinforced by the need for socio-economic and environmental sustainability. In order to better understand the basic differences between agroforestry models developed by farmers in Bangladesh, we can adopt the analysis proposed by ethno botanists for the interpretation of agricultural development. Haudricourt and Hédin (1943), Geertz (1966) and Barrau (1970) propose to distinguish two main patterns of tree domestication and field development based on major differences observed between temperate agriculture and smallholder agriculture in the tropics:

2.2.1. The ager model

Ager model is developed from the process of the historical development of cereal domestication in ancient Mesopotamia and around the Mediterranean (Michon, 2005), which refers agricultural practice in the open fields. In this model, there is a visible difference between the natural ecosystem and cultivated fields, and its productivist mentality that sustained the development of modern agriculture.

2.2.2. The hortus model

Hortus is a development of tuber crops in 'gardens'. The key word in this model is diversity of species, which also includes architectural and functional diversity (Michon, 2005). Tuber gardens and home gardens, which represent variations of the hortus model, are still major components of agroforests.

Experimental evidence supporting claims of beneficial effects of agroforestry is provided by a number of studies (Rahman et al., 2007b). Nath et al. (2005) imply that farmers' income increased through labor involvement and selling of farm products in agroforestry, which also improves the ecological conditions of farms and surrounding areas by increasing tree coverage, reduction of soil erosion, and maintaining soil fertility. A good number of landless and marginal farmers in Bangladesh earned their livelihood from seasonal work in agroforestry systems (Alam et al., 1996). The cash received from agroforestry are mainly used for purchasing or leasing of land, buying bullocks, agricultural implements, and other social obligations, meeting educational expenses, repaying of loans, etc., (Siddiqui and Khan, 1999). It is financially more profitable for folk farmers in comparison with traditional cultivation. The net present value (NPV), internal rate of return (IRR) and benefit/ cost (B/C) of agroforestry are significant and much higher compared to many agricultural projects (Kibria et al., 1999; Rahman and Islam, 1997). In Bangladesh, agroforestry is mainly a subsistence practice where varieties of understory and tree crops grown together, and also with livestock, poultry and/or fish (Akhter et al., 1997), which is a part of the long heritage of traditional agroforestry practices in the country and in other Asian regions (Siddiqui and Khan, 1999; Abedin and Quddus, 1991; Abedin et al., 1990).

Agroforestry and accompanying management practices can and have been extended vastly in the swidden cultivation fields. Seedlings of selected forest species can be planted together with crops such as rice, wheat, maize and the young trees develop along with the fallow vegetation. Forest culture through swidden cultivation thus is profitable even on small plots (Michon, 2005) through a smooth adaptation of practices, avoiding drastic change in the entire farming system.

2.3. The policy option for agroforestry adoption and scientific debates

In spite of many policy and project efforts, the adoption of agroforestry still remains relatively low in Bangladesh (Rahman et al., 2008). Attempts to promote agroforestry by field projects have been constrained by local institutional arrangements, land tenure rights, market environment, and credit facilities available to farmers (Rahman et al., 2008). Research has shown that the traditional farming habits make it challenging for adoption of new farming practices. Nonexistent market channels for wood, products, fruits, berries and other products also hinders folk farmers from investing in agroforestry. This is coupled with the fact farmers would rather grow food crops for subsistence than engage in agroforestry with no market demands for its products (Rahman et al., 2012b; Mai, 1999). Tenure insecurity combined with frequent displacement cultivates a feeling of insecurity, discouraging investment in better land, including fallow, management. Tenure insecurity also limits access to formal credit required for initial investment and for procuring the agricultural inputs (Rahman et al., 2012; Rasul et al., 2004; Mai, 1999).

Market assessment and strategic marketing of agroforestry products are essential for agroforestry enterprise success (Shamsuddin and Mehdi, 2003). Although profitability of intermediate and final products sold off farm is crucial. Various types of models and levels of model complexity, for specific user groups and use purposes are essential for up-scaling agroforestry in Bangladesh. Kumar's (2006) review study of Asian agroforestry summarizes that, in order for agroforestry to be a viable livelihood option in many part of Asia, there need to be institutionalized channels of support to adoption. And the support should be first and foremost come from the state with a mixture of market influence.

The question then is, at a landscape level, whether tree cover increases should be segregated (natural forest + intensive agriculture) or integrated (multifunctional landscapes, e.g., agfororestry)? There are a number of arguments for either favoring spatially-segregated or integrated, multifunctional landscapes in respect of different environmental functions with respect to the biodiversity conservation agenda, segregated areas of natural forest with minimum human disturbance are considered very important. In this sense none of the 'integrated' land uses can be a substitute for strict protected areas (Sayer et al., 2013; Noordwijk et al., 2001). However, in purely agricultural areas, 'integration' may be best to provide a range of folk livelihood needs, e.g. income and food, as well as biodiversity conservation. Also, segregated areas are unlikely to be respected by folk communities unless there are clear benefits associated with such respect. Some form of 'integration' may be needed to achieve such incentives (Noordwijk et al., 2001). Phalan et al. (2011) expressed the same idea with the 'land sharing' and 'land sparing' concepts as both approaches require careful design and implementation to be effective.

3. Conclusion

Loss of biodiversity and ecosystem functioning due to deforestation and agricultural intensification is a major issue of concern in Bangladesh. Increasing farmers' knowledge on agroforestry and enhancing adoption of agroforestry in the degraded forest margins of Bangladesh is a viable strategy to protect forest, ecosystem services provision, and poverty alleviation.

By understanding local land tenure arrangements and traditional agricultural practices in the present and historic perspective, we presented potential pathways to agroforestry adoption in Bangladesh. Competent government policies are needed to bridge folk communities to markets for agroforestry products (Sunderland et al., 2009; Abbot et al., 2001; Sutherland, 2000).

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