Renewable Energy 94 (2016) 410–417

Contents lists available at ScienceDirect

Renewable Energy

journal homepage: www.elsevier.com/locate/renene

Fuelwood energy pattern and biomass resources in Eastern Himalaya

B.P. Bhatt [a], S.S. Rathore [b], Moanaro Lemtur [a], Bikash Sarkar [a, *]

[a] ICAR Research Complex for Eastern Region, ICAR Parisar, P.O. B.V. College, Patna, 800 014, Bihar, India
[b] Directorate of Rapeseed-Mustard Research, Sewar, Bharatpur, 321 303, Rajasthan, India

ARTICLE INFO

Article history:
Received 26 October 2015
Received in revised form
3 February 2016
Accepted 9 March 2016
Available online 31 March 2016

Keywords:
Biomass
Eastern Himalaya
Energy
Fuelwood
Forest depletion

ABSTRACT

The paper describes the fuelwood consumption and energy pattern in Eastern Himalaya. The fuelwood consumption was estimated to be 1.79, 2.12 and 3.07 ton/capita/year, respectively, in tropical, sub-tropical and temperate climate. The fuelwood availability was observed to be 8.47 m tons against the projected requirement of 22.21 m tons during the year 2001, indicating a deficit by with of 61.0% between demand and supply which is expected to increase to 77.0 and 83.0%, respectively, by the year 2011 and 2021. The data revealed that labour energy expenditure on firewood collection was highest (86.78 MJ/capita/year) in tropical zone and lowest (36.90 MJ/capita/year) in temperate region. Fuelwood energy consumption was, however, recorded highest in temperate region (51.88 MJ $\times$ 10^3/capita/year) as against of 30.25 MJ $\times$ 10^3/capita/year in tropical zone. Among various activities, cooking required maximum energy, followed by space heating. The estimated growing stock was not able to sustain the rate of fuelwood consumption. Hence, restoration of degraded lands is need of the hour not only to meet the energy requirements of the tribal folk but also to maintain the ecological balance in fragile eco-system of the region, where slash and burn agriculture has already caused severe environmental degradation.

1. Introduction

In India, and in other developing countries, the demand for Fuelwood, the most common and important source of traditional energy for residential uses, cooking and other, has grown far faster than supply. Although it has already reached serious proportions, technically and economically sound means exist both for reforestation and for improving the efficiency with which wood and other biomass fuels are burnt [32]. In general, half of all energy (commercial and biomass) consumed in India is used for cooking food. This is nearly double the energy (fossil fuel, electricity) consumed by agriculture and industrial sector combined.

Tribal communities of North East Himalayan (NEH) region of India heavily rely on forest resources for their subsistence. Shifting cultivation is the mainstay of economy in NEH region. The region has more than 80% un-classed forest and its administrative control rests with the Autonomous District Councils of different states. The Govt. owned forests are only 10% in the region indicating poor access to certified seed and clonal orchards. Lack of quality seed and planting material has restricted the regeneration of forests to a great extent in the fragile ecosystem of NEH region. The management of un-classed forests is very poor and felling of green trees for shifting cultivation is a common practice in un-classed forests inspite of the fact that apex court of India has imposed a ban on felling of green trees in 1996 [9]. Due to fast depleting forest resources, crop productivity has also declined remarkably in the region since the crop husbandry is interlinked with the forest resource [42]. Until three decades ago, *Jhum* cultivation was not alarming as its cycle was 15–20 years. But, of late, has been reduced to 3–5 years partly due to population explosion and partly to loss of fertile soil due to over exploitation of forest resources [36].

Fuelwood has been defined as one of the most significant causes of forest decline in many developing countries. According to one estimate, wood fuel accounts for over 54% of all global wood harvests per annum [31], suggesting a significant and direct role of firewood in forest loss. For many developing countries including India, firewood constitutes the cheapest and most accessible source for the majority of the population, especially those living in rural areas [34]. India's 87% cooking energy demand is met from non commercial fuels, and the demand for fuelwood has grown far faster than the supply [1]. About 90% tribal population of Eastern Himalayan region use biomass as an important source of energy. However, shifting cultivation coupled with excessive deforestation

* Corresponding author.
E-mail addresses: directoricarrcer@gmail.com (B.P. Bhatt), sanjayrathorears@gmail.com (S.S. Rathore), narolemtur123@yahoo.com (M. Lemtur), bikas_sarkar2003@yahoo.com (B. Sarkar).

http://dx.doi.org/10.1016/j.renene.2016.03.042
0960-1481/

for timber and firewood extraction has caused severe environmental degradation in the region. Although firewood is the only source of energy, there is a dearth of basic information about rural energy supply and consumption pattern, and its impact on forest resource. At the same time, energy planners overlook this most essential energy use and planning priorities are commercial energy demand rather than for household energy requirement. Although, scattered information is available on energy requirement of different ethnic groups of the region [9,26,27,43], firewood requirement in different agroclimatic zone including projected firewood demand in Eastern Himalayan region is not known. Keeping this fact in view, in the present investigation, an attempt has been made to estimate firewood requirement along an agro-climatic zone together with a projected firewood demand. Further, firewood consumption with environmental perspective has also been discussed.

2. Study area and climate

North Eastern Hill (NEH) region comprises the states of Manipur, Meghalaya, Nagaland, Sikkim, Tripura, Arunachal Pradesh and Mizoram (lying between 21.50° and 29.50° N latitude and 85.5°–97.5° E longitude) and represents a distinct agro-climatic area of India. The hilly states of the region have a total geographical area of 183,741 km^2 (5.589% of India) and is populated by 12.41 m people (1.13% of the country). NEH region is characterized by undulating topography, wide variations in altitude, rainfall, temperature and soil conditions. The climate is typically monsoonic, with about 85% of the total annual rainfall occurring during the rainy season. The average maximum temperature during the rainy season is 30 °C and average minimum temperature 14 °C, with a maximum and minimum of 20 and 8 °C, respectively, during the winters.

Slash and burn agriculture (locally known as *jhum*) is the mainstay of economy of the rural folk. Rainfed agriculture occupies 65% of the total cultivated area. Rice is a staple crop of the region, occupying 72% of the total cultivated area, followed by maize and pulses. Other crops include ginger, colocasia, turmeric, sweet potato, potato, cassava, chilies, cucumber, tapioca, Elephant foot yam, dioscorea, French bean, leafy vegetables, sesamum besides some fruit plants like pine apple, banana, passion fruit, Assam lemon etc. in the *jhum* fields.

2.1. Shifting cultivation and biomass

Slash and burn agriculture is one of the most important factors for land degradation, followed by firewood, timber and other minor forest produce extraction. Shifting cultivation alone accounts for 4.36 million ha of degraded area hence it is a serious threat to the livelihood of indigenous people of NEH region. According to one estimate, land degradation is two fold higher in Eastern Himalayan region compared to national average [3]. The problem of land degradation is a major threat in the states like Manipur, Nagaland, Sikkim and Meghalaya where more than 50% of total geographical area is already degraded (Table 1). The loss of top most fertile soil has been accounted for 30–40 t/ha/yr during first year of shifting cultivation, which increases subsequently to 146 and 174 t/ha/yr during second and third year of cultivation, respectively [6]. Hence immediate measures are required for restoration of degraded lands through agro forestry interventions.

2.2. Agro forestry and biomass interventions

Biomass remained the principal component of rural domestic energy in India and most of the developing countries. Extensive farming for fuelwood could be the alternative to bridge the gap between the demand and supply and hence, efforts are needed for mass afforestation of suitable fuelwood species in degraded areas. Indigenous tree followed by bamboo species could be given due importance in mass afforestation reforestation, so as to meet out the energy requirements.

In order to have 1/3rd of the total reported land area of the country (300.7 m ha) under forest/tree cover; it is necessary to have approximately 100 m ha under forest or other tree plantations. Presently, 63.73 m ha are under forests of which 20 m ha are degraded. Only 37.73 m ha areas exist under good forest cover. However, it is estimated that about 20 m ha outside the forest areas has been brought under tree cover through various tree planting programmes taking total area under tree cover to 57.73 m ha. Therefore, another 42 m ha are required to be brought under tree cover within and outside forest area, *i.e.*, agroforestry and social forestry. The report of the Task Force on Greening India for livelihood security and sustainable development (2001) [40] has recommended that this may be achieved through Joint Forest Management (14 m ha) and agroforestry (28 m ha) within ten years. The six species identified by the Task Force to be covered under agroforestry include *Acacia nilotica*, *Bamboo* spp., *Casuarina equiselifolia*, *Eucalyptus* spp., *Populus* spp. and *Prosopis cineraria*. National Agriculture Policy (2000) [33] of India underlined the need for diversification in agriculture with the promotion of integrated development of rainfed areas on watershed basis and augmentation of biomass production through agroforestry with demand-driven community participation. Agroforestry is also essential for carbon sequestration besides food and livelihood security.

The entire Eastern Himalaya is characterized by extensive bamboo forests, which have considerable socio-economic value. Among, seven sister of eastern region, Mizoram occupies largest forest area under bamboo (30.8%), followed by Tripura (27.13%) and Meghalaya (26.0%). Bamboos are integral to the culture of India, particularly for whole of northeast India, which account for nearly 50% of the total bamboo resource of the country. In respect of bamboo species diversity, India ranks third, *i.e.*, next to China (300 species) and Japan (237 species). Within India, North Eastern region possesses largest species diversity. Out of 126 plant species available in India, nearly half of the variability is available in Eastern Himalaya. This resource has also been considered valuable for agroforestry owing to its short gestation period and recurring return [12].

Tribal communities of NEH region use this potential resource for food, shelter, furniture, handicraft, medicines and various ethno-religious purposes [41]. Owing to multifarious nature of bamboo resource, it is considered minor forest produce of high value [44].

The annual production in India is 3.2 million tones with average per hectare production of 0.33 ton. The yield varies considerably depending upon the intensity of stocking and biotic interference. In North-East, the high annual yield is from *Meloccana baccifera* with 5 tones (dry wt./ha), followed by *Bambusa tulda* (3.1 t/ha). From *Bambusa bamboos* and *Beta vulgaris* plantations with 12 m × 12 m spacing yielded almost 10 t/ha per annum in Madhya Pradesh. It has been reported that afforestation of ravine lands with nursery transplants of *Dendrocalamus strictus* has the potential to provide the highest net annual return when compared to *Dalbergia sissoo* and *Eucalyptus* spp.

In view of ongoing shifting cultivation practice in the region on the one hand and decreasing forests on the other, concerns are being expressed over erosion of bamboo germplasm. Bamboo species are particularly suitable for short rotation forestry and conservation point of view because they have fastest growing nature compared to other species. Moreover, during the secondary succession, after slash and burn agriculture, the bamboo species are