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Wasteland reclamation strategy for household timber security of tribes in Jharkhand, India

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Abstract: The study sought to examine the timber dependency on forests and evolve wasteland reclamation strategy to eliminate the forest dependency in Bundu block of Ranchi District in Jharkhand, India. Multi-stage random sampling technique was applied to select 164 tribal households from 9 sample villages. Data were collected using structured interviews and non-participant observations which were analyzed using descriptive statistics *viz*., frequency, percentage, mean and range. Results revealed that forests contributed maximum timber (136.36 m^3 $annum^{-1}$) followed by traditional agroforestry (69.09 m^3 $annum^{-1}$), community forestry (41.33 m^3 $annum^{-1}$) and homestead forestry (35.71 m^3 $annum^{-1}$). Timber extracted is mostly consumed in housing (124.66 m^3 $annum^{-1}$) followed by agricultural implements (82.71 m^3 $annum^{-1}$), furniture (35.25 m^3 $annum^{-1}$), carts/ carriages (17.60 m^3 $annum^{-1}$), fencing (10.23 m^3 $annum^{-1}$), cattle shed/ store house (9.10 m^3 $annum^{-1}$) and others (2.94 m^3 $annum^{-1}$). Forests were exposed to timber pressure of 136.36 m^3 $annum^{-1}$ (48.27%) posing ample deforestation and degradation. The strategy consisted of timber and bamboo plantations is designed which would secure 1065.60 m^3 $annum^{-1}$ of timber, 0.455 lakh $annum^{-1}$ of bamboo culms, 568.26 tons $annum^{-1}$ of bamboo leaf and agricultural products. The strategy would yield income of Rs. 34210.78 $household^{-1}$ $annum^{-1}$ and employment of 67.15 person-days $household^{-1}$ $annum^{-1}$. Financial viability of proposed interventions has been worked out by meticulous economic calculations of Net Present Value, Benefit Cost Ratio and Internal Rate of Return. The execution of strategy would eliminate the current unsustainable timber extraction, safeguard the future timber predicament and ensure environmental security.

Keywords: Bamboo, Timber, Tribes, Wasteland reclamation

INTRODUCTION

Timber is a renewable, sustainable, attractive, strong, durable and cost effective natural building material that combines beauty, superior performance and environmental advantage (Binkley and Earhart, 2005; Pirard *et al*., 2016). Its flexibility and versatility offer a multitude of structural applications such as beams, walls, flooring, cladding, containers, packing cases, formwork, large timber panels, agricultural implements, fencing, hutments, housing, furniture, scaffolding, mine props *etc*. (Chandramolly and Islam, 2015; Gangoo *et al*., 2015). Timber materials have unique aesthetic appeal, provides acoustic, thermal and strength performance, store carbon dioxide and the manufacture process of wood products requires smaller amounts of energy (Shukla, 2003). The demand for timber is met through supplies from government forests and non-forest sources such as farmlands and homestead gardens (Chandra *et al*., 2008; Islam, 2008). The total growing stock of India's forest is 4498.73 million m^3 and the annual timber production is only 3.175 million m^3 (Nayak *et al*., 2014). The situation regarding timber at current productivity is not grave but moratorium on fellings and market demands creates pressure. The paradox is that forests produce 70% timber and 30% fuel wood, while the demand for wood is around 70% as fuel wood and 30% as timber (Rai and Chakrabarti, 2001). The estimates by TERI (Aggarwal *et al*., 2009) put the demand-supply gap for fuel wood and timber at 100 and 14 million tonnes respectively. This really aggravated the situation. The pressure on forests for timber is 5 times more what they can withstand, as a matter of sustained productivity. Exploitation of forest biomass is a common way for small timber security among forest fringe dwellers in India (Khanduri *et al*., 2002). Most of the population in rural as well as urban sectors chiefly depends on forests directly to meet the timber requirement. About 275 million (World Bank, 2006) to 350- 400 million (MoEF, 2009) people living in forest fringes depend upon forests for timber required for agricultural implements, house construction, fencing *etc*. The total annual consumption of wood in constructions and furniture as well as for agricultural implements is 48.0 mil-

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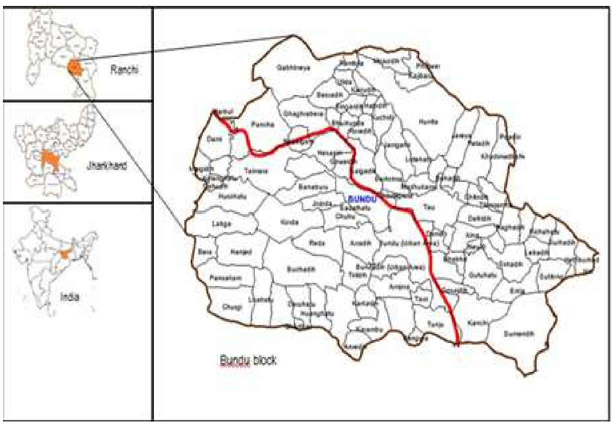
lion m^3 in Round Wood Equivalent in India. However, the total timber production is 45.95 million m^3, showing a gap of 2.05 million m^3 annually (FSI, 2013). Of the total timber production of 45.95 m^3, the forests procure 3.175 m^3, whereas, the trees outside forest (TOF) produces 42.774 m^3 (Nayak *et al*., 2014).

The extraction and consumption situation of timber in rural sectors plays an important role in the socioeconomic, cultural, religious, ethical, traditional, spiritual, farming and geo-environmental conditions of a region (Dangwal, 2005). Increasing trade in timber has supported economic growth and has helped in reducing poverty in a number of developing countries (Anonymous, 2016). There is strong evidence that timber play a significant role in the livelihoods of the world's rural poor to which India is no exception. The timber accrued Rs. 2185.37 household^{-1} annum^{-1} contributing 7.83% of the total income among indigenous people of Bundu block in Ranchi district of Jharkhand (Islam *et al*., 2015a). Collection and sale of timber are the main source of income for the forest dwelling population in many countries (Yadav and Basera, 2013; Belcher *et al*., 2015; Langat *et al.*, 2016; Htun *et al*., 2017). The dependency of *Munda*, *Oraon* and *Lohara* tribes on the forest resources for timber has become an integral part of day-to-day life in Bundu Block of Ranchi district of Jharkhand state, leading to incessant illicit extraction. The timber resources cater to daily livelihood needs of tribes in terms of housing and fencing materials, poles, utensils, ornamental and decorative purposes, musical instruments, agricultural implements, carving woods, furniture, fuel wood, charcoal, kindling, medicines *etc*. in Jharkhand. The timber is largely extracted from forests, besides some traditional agroforestry, community forestry and homestead forestry and consumed for packing cases, agricultural implements, furniture, housing, sports goods, cart and carriages building, cattle sheds, store houses, fencing, scaffolding, ladder and cremation in tribal societies of Jharkhand (Islam *et al*., 2015b). Widespread poverty and lack of livelihood opportunities often make these people to resort illicit over-exploitation of timber from the forests. Hence, with such a huge tribal population and extensive dependence pattern, the over-exploitation and unsustainable harvesting has resulted in severe forests degradation, biodiversity depletion and diminished biomass productivity (Islam *et al*., 2014; Baba *et al*., 2016). Wasteland reclamation strategy by timber (*Gmelina arborea* and *Tectona grandis*) and bamboo (*Dendrocalamus strictus*) plantations is identified as the best eco-friendly option for timber and bamboo production besides forest conservation and livelihood diversification in the Block. The implementation of the proposed strategy would have substantial positive impacts towards social, economic, ecological and cultural security on sustainable basis.

MATERIALS AND METHODS

Study area and the people: Bundu Block (Map 1.) is situated between $23^{0}11'$- $23^{0}18'$ North latitude and $85^{0}35'$- $85^{0}58'$ East longitude at an altitude of 337 meters above MSL in Ranchi District of Jharkhand state in India. Total geographical area of the Block is 25097 ha, with a breakup of 69.25% un-irrigated cultivable land, 17.44% forest, 8.41% irrigated cultivable land, 3.59% culturable wasteland, 1.29% unculturable wasteland and 0.02% non-agricultural use (Anonymous, 2009). The locality falls under Bundu Range of Khunti Forest Division, with largely Northern Tropical Dry Deciduous Forest ($5B/C_2$) of Chhotanagpur plateau (Champion and Seth, 1968). Total human population of the Block is 62509 (31624 males and 30885 females) living in 88 revenue villages and 11495 households and differentiated as; 60.74% Schedule Tribes (*Munda*, *Oraon* and *Lohara*), 4.76% Schedule Caste and 34.50% other caste groups (Census of India, 2011). Rain-fed agriculture using dry land varieties of paddy is the main land use. Since, the land for agriculture is marginal and returns are uneconomic, the forest resources are viewed as a viable source of livelihoods. The tropical monsoon climate is divisible into three distinct seasons, *viz*., rainy, winter and summer with average annual rainfall of 1413.60 mm, mean minimum temperature of 24°C and mean maximum temperature of 37.2°C (Anonymous, 2009).

Sampling procedure and data collection: Simple random sampling technique (Ray and Mondol, 2004) was employed to select nine (10%) sample villages, namely Korda, Jojoda, Husirhatu, Banaburu, Nehalgara, Ghagrabera, Hesapiri, Roredih and Kuchidih, from a total of 88 villages in the Block. Complete enumeration of the sample villages was carried out and the village level land use data were collected from secondary sources namely, village records, departmental officials documents, reports of Block Office, Bundu and Jharkhand Space Application Centre (JSAC), Ranchi and internet. A sample of 164 (20%) tribal households consisting of all categories of the land holders



Map 1. *Location of the study area.*

was drawn by simple random technique from the sample villages for household survey. Household heads or eldest members were treated as respondents. Data on the extraction and consumption pattern of timber were collected by personal interviews of the respondents through a well-structured pre-tested interview schedule and non-participant observations (Mukherjee, 1993). Collection and consumption estimates of timber were made at each household by requesting the respondents to quantify the amount of timber they collect from various sources and use day-to-day for various purposes. Average annual per capita timber extraction and consumption were estimated by dividing the household quantity with the number of individuals in the family and the total annual timber extraction and consumption were estimated by multiplying the figures with the total population of the sample villages.

Data analysis: Simple descriptive statistics *viz*., range, frequency (f), mean (x) and percentage (%) were used for analysis of the data (Snedecor and Cochran, 1967) and the results were displayed through tables and chart. The proposed wasteland reclamation strategy using high valued timbers (*Gmelina arborea* and *Tectona grandis*) and bamboo (*Dendrocalamus strictus*) is based on resources availability, socioeconomic status, public preferences, productivity and soil-plant compatibility. Standard project worth measures like Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) have been used to work out the economic potentials of forestry interventions using following standard equations (Singh, 2007).

Net present value (NPV): Net Present Value (NPV) of an investment is the discounted value of all cash inflow net of all cash out flows of the project during its lifetime.

The NPV are calculated by the formula:

$$NPV = \sum_{t=1}^{n} (B_t - C_t)/(1+i)^t \text{ .... Eqn (1)}$$

Where, B_t = benefits in year t, C_t= cost in year t, n = number of year i = discount rate (12%)

Benefit/ cost ratio (BCR): Benefit/ Cost Ratio (BCR) of an investment is the ratio of the discounted value of all cash inflows to the discounted value of all cash outflows during the life of the project. The BCR are calculated as:

$$\text{Benefit/Cost Ratio} = \frac{\sum_{t=1}^{n} (B_t)/(1+i)^t}{\sum_{t=1}^{n} (C_t)/(1+i)^t} \text{ .... Eqn (2)}$$

Where, B_t = benefits in year t, C_t= cost in year t, n = number of year i = discount rate (12%)

Internal rate of return (IRR): Internal rate of return (IRR) theoretically calculates the maximum rate of interest that a project can repay on loans while still recovering all investment and operating costs. The IRR of a project is the discount rate at which the NPV equals zero. In other words, the IRR is the discount rate at which the present value of revenues equals the present value of costs.

The IRR is the discount rate i such that

$$\sum_{t=1}^{n} (B_t - C_t) / (1 + i)^t = 0, \text{ .... Eqn (3)}$$

Where, Bt = benefits in each year; Ct = costs in each year; i = the discount rate; t = 1, 2, - n and n= number of years.

RESULTS AND DISCUSSION

Land use classification: Analysis of the land use data (Table 1.) in the sample villages indicated the dominance of land area under cultivation (53.06%) which is differentiated as un-irrigated (47.10%) and irrigated (5.96%). Of the total net sown area 58.89% is lowland (*Doin*) and 41.11% upland (*Tanr*). Forest (28.47%) is the second important land use category covered mainly under Northern Tropical Dry Deciduous Forest (5B/ C_2) type (Champion and Seth, 1968). Other land use categories were cultivable waste (10.68%) and non-agricultural use (7.79%). Per household net sown area, forest area, cultivable waste and non-agricultural use in the sample villages were 1.87, 1.0, 0.38 and 0.28 ha respectively. The analysis confirmed that 189.43 ha of cultivable wastelands are available to develop strategy using timber and bamboo plantations for timber security in the sample villages.

Table 1. Land use classification in the sample villages.

Land use (ha)	Villages								
	Korda	**Jojoda**	**Husirhatu**	**Banaburu**	**Nehalgara**	**Hesapiri**	**Roredih**	**Kuchidih**	**Ghagrabera**
Village area	617.58	185.40	497.63	322.49	143.33	308.23	195.59	211.67	397.02
Forest	264.37	21.93	242.84	65.56	31.03	54.20	24.48	44.79	70.30
Cultivable waste	71.38	13.90	9.60	12.32	15.04	10.09	12.47	24.17	20.46
Fallow land	44.47	8.66	5.98	7.67	9.37	6.30	7.79	15.08	12.76
Non-agricultural uses	27.48	23.10	25.77	21.36	15.07	22.22	20.74	26.43	42.12
Net sown	209.88	117.81	213.44	215.58	72.82	215.42	130.11	101.20	251.38
Irrigated	11.18	18.06	11.89	77.12	2.02	3.90	1.25	10.73	35.34
Un-irrigated	198.70	99.75	201.55	138.46	70.80	211.52	128.86	90.47	216.04

Anonymous (2009)

Table 2. Timber plantation on 94.72 ha of cultivable wasteland in the sample villages.

Year	Investment		Income		Net income (Rs. Lakh)	Discount factor @ 12%	NPV at 12%	Employment (Person days)
	Particular	Amount (Rs. Lakh)	Particular	Amount (Rs. Lakh)				
1st	Pe	30.14	Ic	13.64	-16.50	0.893	-14.74	12787.20
2nd	Pm	12.67	Ic	13.64	0.97	0.797	0.77	7104.00
3rd	Pm	10.87	Ic	13.64	2.77	0.712	1.97	7104.00
4th to 14th	Pm	120.45	-	0.00	-120.45	0.636-0.205	-46.24	36467.20
15th	Pm + Th	33.53	Gt (4736 $m^{3)}$	828.80	795.27	0.183	145.53	25901.18
16th to 19th	Pm	43.80	-	0.00	-43.80	0.163-0.116	-6.08	13260.80
20th	Pm + Th	67.42	Gt + Tt (7104 + 4736 = 11840 m^3)	2900.80	2833.38	0.104	294.67	59780.16
21st to 24th	Pm	43.80	-	0.00	-43.80	0.093-0.066	-3.46	13260.80
25th	Th	33.87	Tt (7104 m^3)	2486.40	2452.53	0.059	144.70	33878.98
Total	-	396.55	-	6256.92	5860.37	-	517.12	209544.32[a]

NPV = Rs. 517.12 lakh, BCR = 5.47, IRR = 32.13%, Pe = Plantation establishment, Pm = Plantation maintenance, Th = Timber harvesting, Ic = Intercropping, Gt = Gamhar timber, Tt = Teak timber , a Plantation (land preparation, pit digging, fertilizer and insecticide application, weeding, hoeing *etc*.)- @ 95 man days ha^{-1} (@ 10 seedlings planting man day^{-1}), Maintenance - @ 35 man days ha^{-1}, Timber harvesting @ 4.769 man days m^{-3} (Pant, 1984), Intercropping- @ 50 man days ha^{-1} (Mani,

Table 3. Bamboo plantation on 94.71 ha of cultivable wasteland in the sample villages.

Year	Investment		Income		Net income (Rs. Lakh)	Discount factor @ 12%	NPV at 12%	Employment (Person days)
	Particular	Amount (Rs. Lakh)	Particular	Amount (Rs. Lakh)				
1st	Pe + Ic	19.23	Ic	13.64	-5.59	0.893	-4.99	197943.90
2nd	Pm + Ic	12.12	Ic	13.64	1.52	0.797	1.21	6724.41
3rd	Pm + Ic	11.65	Ic	13.64	1.99	0.712	1.41	5872.02
4th	Pm + Ic	11.65	Ic	13.64	1.99	0.636	1.27	5303.76
5th	Bh + Ic	17.16	Sc +Ic	240.94[a]	223.78	0.567	126.88	16216.17
Total	-	71.81	-	295.50	223.69	-	125.78	232060.30[b]

NPV = Rs. 125.78 lakh, BCR = 3.41, IRR = 163.82%, Pe = Plantation establishment, Ic = Intercropping, Pm = Plantation maintenance, Bh = Bamboo harvesting, Sc = Sale of culms, a Total culms = 2400 ha^{-1} @ 6 culms $clump^{-1}$, market price = 100 $culm^{-1}$, b Plantation (land preparation, pit digging, fertilizer and insecticide application, weeding, hoeing *etc*.)- @ 169 man days ha^{-1}, 2nd year maintenance- @ 31 man days ha^{-1}, 3rd year maintenance- @ 22 man days ha^{-1}, 4th year maintenance- @ 16 man days ha^{-1} (Pandey and Naik, 2003), Intercropping- @ 50 man days ha^{-1} (Mani, 2006), Harvesting- 18.29 culms man day^{-1} (Pant, 1984).

Table 4. Household timber security through wasteland reclamation strategy in the sample villages.

Land use intervention	Product/ Yield	Area (Ha)	Rotation (Year)	Income (Lakh Rs. $annum^{-1}$)	Employment (Person days $annum^{-1}$)
Timber plantation	Gamhar timber- 11840 m^3, Teak timber- 11840 m^3, Field crops (up to 3rd year)	94.72	20/25[a]	234.42	8381.77
Bamboo plantation	Bamboo culms- 2.27 lakh, Bamboo leaf- 568.26 tons $annum^{-1}$, Field crops	94.71	5	44.74	46412.06
Total	-	189.43	-	279.16	54793.83

a Proposed rotations of gamhar and teak are 20 and 25 years respectively.

Timber requirement and accessibility: People primarily require small timber for house construction and repair, agricultural implements, rural furniture, hutments and fencing. It was observed during the study that 10 small timbers having a length of 3-5 m and a diameter of 8-13 cm are commonly utilized annually to meet the household timber requirement. Average timber requirement per household was thus, worked out to be 0.346 m^3 $annum^{-1}$ accounting a total timber demand of 282.49 m^3 $annum^{-1}$ (Fig. 1.). Forests (136.36 m^3 $annum^{-1}$) are the main source of timber supply followed by traditional agroforestry (69.09 m^3 $annum^{-1}$), community forestry (41.33 m^3 $annum^{-1}$) and homestead forestry (35.71 m^3 $annum^{-1}$). Forests contribute alone 48.27% of the total timber requirement while rest 51.73% timber requirement is fulfilled by traditional agroforestry, community forestry and homestead forestry. Results enunciated that there is a considerable pressure on forests for meeting the timber requirement of the tribes. Acute poverty, low literacy and awareness, substandard socio-economic conditions, traditional severity, easy accessibility of forests and availability of inadequate markets, low communication and transportation facilities hinder the tribes to access

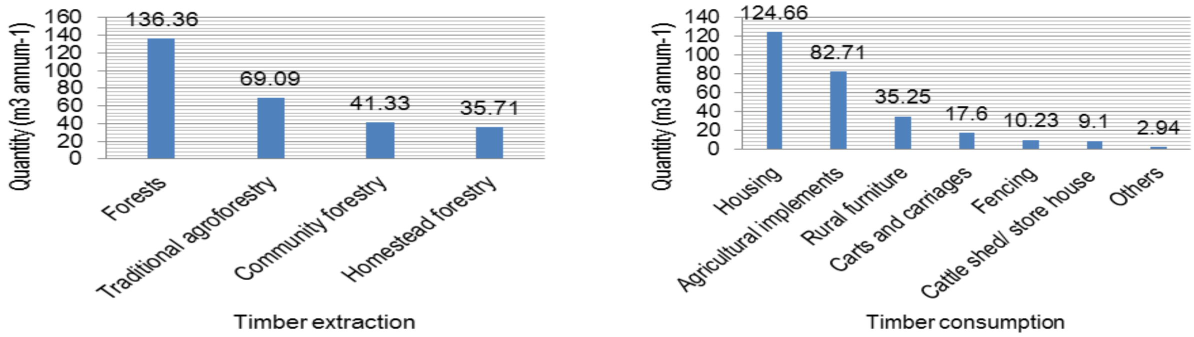


Fig. 1. *Timber extraction and consumption by the tribes in the sample villages.*

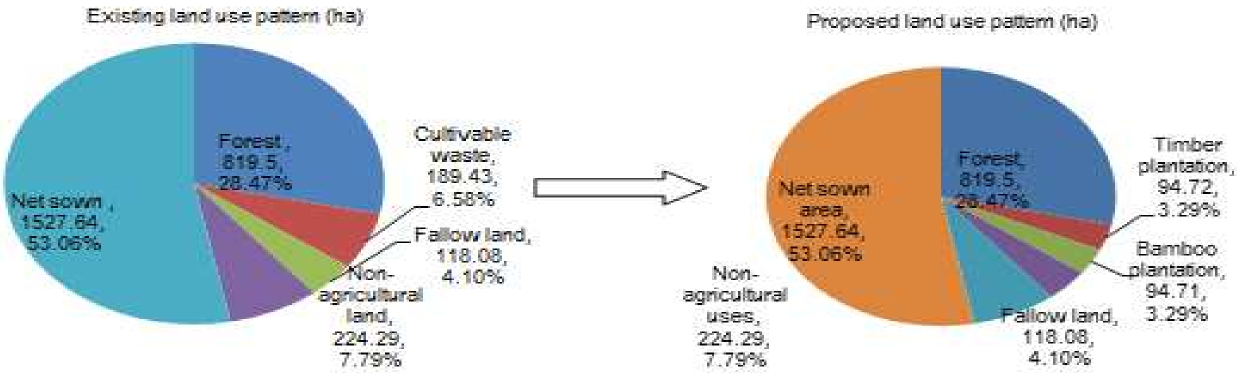


Fig. 2. *Strategic re-orientation of land resources in the sample villages.*

substitute of timber for their household consumption (Chandramolly and Islam, 2015).

The timber extracted is mostly utilized in housing (124.66 m^3 $annum^{-1}$) followed by agricultural implements (82.71 m^3 $annum^{-1}$), rural furniture (35.25 m^3 $annum^{-1}$), carts and carriages (17.60 m^3 $annum^{-1}$), fencing (10.23 m^3 $annum^{-1}$), cattle shed/ store house (9.10 m^3 $annum^{-1}$) and others such as scaffolding/ ladder/ cremation *etc*. (2.94 m^3 $annum^{-1}$) (Fig. 1.). Construction of *katcha*, mixed or *pucca* houses, making agricultural implements such as ploughs, harrows, rollers, clod-crushers, tool handles *etc*., manufacture of low cost rural furniture such as chairs, stools, desks, tables, benches, beds, shelves, lockers *etc.* are the main sectors where major fraction of the timber is consumed. Important tree species being utilized to meet day by day timber requirement are *Shorea robusta*, *Dalbergia sissoo*, *Gmelina arborea*, *Pterocarpus marsupium*, *Acacia nilotica*, *Anogeissus latifolia*, *Ougeinia dalbergiodes*, *Mangifera indica*, *Artocarpus heterophyllus*, *A. lacoocha*, *Terminalia belerica*, *T. arjuna*, *T. chebula*, *T. tomemtosa*, *Mallotus philippinensis*, *Syzygium cumini*, *Albizzia procera*, *A. lebbeck*, *Lagerstroemia parviflora*, *Zizyphus jujuba*, *Pongamia pinnata*, *Aegle marmelos*, *Azadirachta indica*, *Tamarindus indica*, *Anthocephalus cadamba*, *Cedrela toona*, *Melia azedarach etc*. The findings are in consistent with the studies of Sapkota and Oden (2008), Sarmah and Arunachalam (2011) and Sati and Song (2012).

Wasteland reclamation strategy: Limitations of timber production in agriculture fields, community lands and homesteads and unavailability of alternatives for these resources coerce the tribal households to secure their timber needs from forests (Islam *et al*., 2015b). Low productivity of forests coupled with ever-increasing demand for timber due to huge and increasing forest fringe population contributes to the forest degradation (Aggarwal *et al*., 2009). Hence, the development and diversification of non-traditional and economically viable timber and bamboo plantations on 189.43 ha wastelands can alleviate the timber scarcity besides contribution to forest resources conservation and restoration of ecosystem services. Based on the analysis of land use classification and existing pattern of timber requirement and accessibility, specific wasteland reclamation strategy having timber (*Gmelina arborea* and *Tectona grandis*) and bamboo (*Dendrocalamus strictus*) interventions has been developed. Accordingly, re-orientation of the land use pattern has been suggested based on need, topography, productivity and soil-plant compatibility (Fig. 2.). The wasteland reclamation strategy comprising timber and bamboo plantations have marvelous potential for timber security besides mitigation of timber induced forests degradation, socioeconomic development, improvement in quality of life, ecological stability and sustainable livelihood (Singh and Quli, 2011). The strategy will secure an income of Rs. 279.16 lakh annum^{-1} and employment opportunities of 54793.83 person days annum^{-1} in the sample villages.

Timber plantation: The plantation of gamhar (*Gmelina arborea*) and teak (*Tectona grandis*) in combination with cereals, vegetables, fodder gasses and some other shade bearing crops on cultivable wastelands are proposed as agroforestry intervention for the eco-friendly reclamation of wastelands which would sustain the life-support system by assured supply of timber besides facilitating the conservation of already depleted forest resources. The employment and income generation, poverty alleviation and climatic amelioration would be the additional gains from the agroforestry plantations. The expected economic returns along with the employment generation, out of the timber product of agroforestry are calculated and recorded in Table 2.

The market demand of gamhar (*Gmelina arborea*) and teak (*Tectona grandis*) timber is very high fetching a very good economic return. Timber plantation has been one of the consistent favourite investments of legendary investor, it might not be a glamorous business but it definitely is a profitable one enhancing the potential for return while reducing risk at the same time (Binkley and Earhart, 2005). Establishment of block plantation of gamhar (*Gmelina arborea*) and teak (*Tectona grandis*) on 94.72 ha of cultivable wastelands at 3.25m x 3.25m spacing and timber harvesting in 15th, 20th and 25th year of plantation combined with inter-cropping of agricultural crops in the interspaces during initial three year of plantations will ensure a considerable income and employment generation. The gamhar (*Gmelina arborea*) trees on 20 year rotation will produce about 4736 m^3 of timber from 50% harvesting in 15th year and about 7104 m^3 of timber from another 50% harvesting in 20th year. The teak (*Tectona grandis*) trees with 25 years rotation will give a timber volume of about 4736 m^3 from 50% harvesting in 20th year and about 7104 m^3 of timber from another 50% harvesting in 25th year. The gamhar (*Gmelina arborea*) and teak (*Tectona grandis*) farming together will produce about 23680 m^3 of timber at a production rate of 10 m^3 ha^{-1} annum^{-1} besides other products in terms of fuel wood, leaves, twigs, crop products *etc.* The 94.72 ha of block plantation on cultivable wastelands will fetch net revenue of Rs. 234.42 lakh annum^{-1} from the sale of gamhar (*Gmelina arborea*) and teak (*Tectona grandis*) timber, fuel wood and crop products and will generate an employment potential of 8381.77 person days annum^{-1} (Table 2).

Bamboo plantation: Bamboo's diversity of uses and its great versatility qualified it as a multiple alternative to the timber for the rural people in general and tribal people in particular (Kithan, 2014; Lalhmingsangi and Sahoo, 2016). Plantation of bamboo (*Dendrocalamus strictus*) as agroforestry intervention with intercropping cereals, vegetables, fodder gasses and some other shade bearing crops on wastelands are projected for the eco-friendly reclamation of wastelands available in the target villages. The intervention would contribute towards assured supply of variety of goods and services besides agro-economic, socio-cultural, religious, spiritual, ecological and livelihood security and sustainability of the local people. The major challenges associated with bamboo plantation are lack of modern techniques, influence of middlemen, limited marketing facilities and lack of co-operative societies which needs proper attention during the implementation of the strategy. The expected economic returns along with the employment generation, out of the bamboo are calculated and recorded in Table 3.

Bamboo plantation as an economic resource has a great potential in generating income and employment for rural poor, unskilled labourers and landless people. Economics of establishing block plantation of bamboo (*Dendrocalamus strictus*) at 5m x 5m spacing and bamboo production in 5th year of plantation combined with cultivation of agricultural crops in the interspaces every year, show that this rural enterprise is highly profitable (Rawat *et. al*., 2008). The bamboo plantation through this agroforestry system on 94.71 ha of cultivable wastelands will produce about 2.27 lakh culms having a height of about 6-15 m and diameter of 6-10 cm and 568.26 tons of leaf annually besides crop production in interspaces of 40 ha every year. The 94.71 ha of bamboo block plantation on cultivable wastelands will fetch net revenue of Rs. 44.74 lakh annum^{-1} from the sale of bamboo culms at a rate of Rs.100 culm^{-1} and crop products and will generate an employment potential of 46412.06 person days annum^{-1} (Table 3.).

Analysis of wasteland reclamation strategy for timber security: A comprehensive summary of products, yield, area, rotation, income and employment of the wastelands reclamation strategy suggested for timber security of tribes in the locality indicated that the timber (*Gmelina arborea* and *Tectona grandis*) and bamboo (*Dendrocalamus strictus*) plantations together will procure 1065.60 m^3 annum^{-1} of timber, 0.455 lakh annum^{-1} of bamboo culms and 568.26 tons annum^{-1} of bamboo leaf besides production of field crops which can relieve substantial anthropogenic pressure on the forests alleviating forest degradation (Table 4.). The sample villages have labour force (15-60 years) of 3586 comprising 2054 working people (1315 main workers and 739 marginal workers) and 1532 unemployed people (Anonymous, 2009). Thus, the unemployment rate in the tribal communities is 1.88 household^{-1}. The gross annual income from various sources is Rs. 27908.54 household^{-1} among the tribes (Anonymous, 2009). The low earnings coupled with acute unemployment in the tribal households is creating many socioeconomic, human, food and nutritional, livelihood, cultural and ecological problems. Implementation of wastelands reclamation interventions suggested will generate an employment opportunity of 67.15 person days household^{-1} annum^{-1}. Sale of gamhar timber, teak timber, bamboo culms, bamboo leaves and agricultural products produced from various wastelands reclamation interventions suggested will generate an annual income of Rs. 34210.78 household^{-1}. The implementation of these wastelands reclamation interventions will build up the livelihood assets (physical, natural, human, financial and social) of tribes and forest dwellers by augmentation of productivity, supply of basic needs, creation of employment opportunities, enhancement of income, relief of pressure on nearby forests, safety net functions, training and capacity development, development of avenues for small scale industries, infrastructural development, ecosystem goods and services and maintenance of culture and traditions *etc*.

Conclusion

Based on the ground realities, a scheme of agroforestry for reclamation of wastelands, available in the Bundu Block of Jharkhand state of India, has been worked out for boosting up the livelihoods support of tribes, by production of bamboo and high valued quality timbers like gamhar and teak. The expected tangible returns in terms of huge income and employment generation is likely to motivate the target population for expeditious adoption of this magnificent scheme. The intangible outcome of this scheme would not only help in gainful reclamation of the wastelands, rather would also facilitate the forest conservation, by diverting the livelihood needs of the target populations from forest to the agroforestry areas. Subsequent climatic, soil and water ameliorations, in due course, will have a very far reaching positive impact in resolving the environmental and socio-economic issues of the entire area, which at present suffers a lot due to unrewarding agriculture and precarious recession in forest productivity.

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