Green Growth and Forestry in Punjab

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Green Growth and Forestry in Punjab

1. Introduction

Punjab, "the land of five rivers" is a small state, with only 1.57% (50, 362 sq. km) of the country's total geographical area, lying between latitude 29^0 33' and 32^0 32' N and longitude 73^0 53' and 76^0 56' E. The state is situated in the north western part of the country between two rivers, the Ravi and the Ghagger. The state shares its boundaries with the other states of Jammu and Kashmir, Himachal Pradesh, Haryana and Rajasthan and the neighbouring country Pakistan. In 1966, the state was trifurcated into three parts i.e. Punjab, Haryana and Himachal Pradesh. During this period, the state had only 3.72% (1875 sq. km) of the total geographical area of the state under forest cover , which has now increased to 6.49% (3271 sq. km) and accounts for 0.41% of the total geographical area of the country (FSI 2013 and PFD 2014).

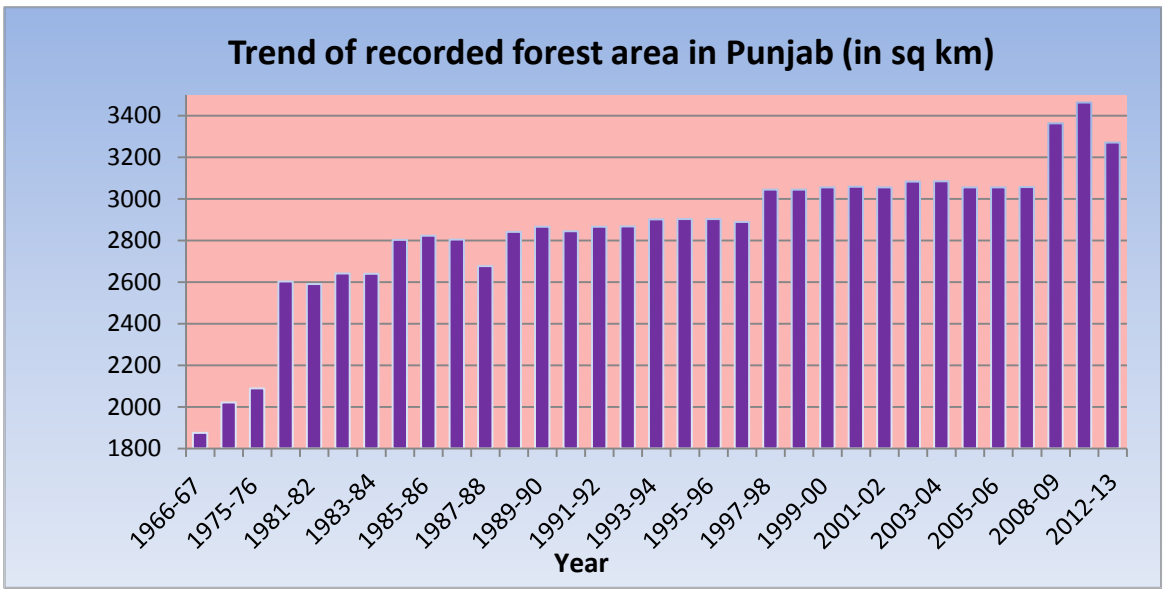

Figure 1: Trend of recorded forest area in Punjab State.

This chapter aims to emphasize the issues of forestry sector and provide roadmap for green growth through analysis of issues in the state of Punjab The first section gives the state of forest resources. It details out the forest and tree cover, policy context, ownership and management pattern of forests in Punjab. The second section elaborates the key issues afflicting forestry sector in the state. The third and final section provides the roadmap and strategies to address the issues.

2. State of Forest Resources

2.1 Forest and Tree cover: Punjab

Punjab has 3,271 sq. km of the forest and tree cover accounting for 6.49% of state's geographical area (FSI2013). Out of this area, 1772 sq. km constitutes forest cover and 1499 sq. km of area is under tree cover (ibid). Of the total, dense forest is nil, moderate dense forest is 1.46%, open forest is 2.06% and scrub forest is 0.07% in the state (ibid). The recorded forest area in the state is only 3084 sq. km, hence suggesting that significant area of forest and tree cover lies outside the recorded forest area (ibid).

Table 1: Legal status of forests in Punjab state

S. No	Category	Area (sq. km)	% of the total area
1	Reserved Forest	44	1.43
2	Protected Forest	1137	36.87
3	Unclassed Forest	1903	61.71
	Total	**3084**	**100.00**

Source: FSI, 2013

Around 62% of the forest area in the state is unclassified, which suggests a large area of the forest in the state has not been surveyed and rights of local people have not been settled. The reserve forest constitute only 1.43% of the forest area, which has twelve wildlife sanctuaries, two zoological parks, three dear parks and two community reserves (DoFWP, undated). Community reserves of Lalwan in Hoshiarpur and Keshopur-Chamb in Gurdaspur district are the first notified community reserves in the country under the Wildlife Protection Act of 1972. These reserves enable conservation of biodiversity on the community lands with the support of state forest department.

The per capita forest and tree cover in the state is estimated as 0.012 ha. Hoshiarpur (20%), Roopnagar (18.50%), Nawanshahar (8.66%), Gurdaspur (5.43%) and Patiala (2.49%) are the major districts contributing maximum forests cover in term of their respective geographical area. While Fatehgarh Sahib (0.25%), Mansa (0.27%), Jalandhar (0.38%), and Firozpur (0.49%) are the districts having least forest area in term of their respective geographical area (FSI, 2013).

In the state around 9.5% of the geographical area is hilly and undulating which is about 52% of the total forest area in the state. This comprises of Shivalik foothills and plain in the north and north eastern fringe. This region is popularly known as Kandi area.

Based on Champion and Seth classification of forest types the state has seven types of the forests which include northern dry mixed deciduous forests, dry deciduous scrub forests, dry tropical riverine forests, Khair-sissu forest in foothills, Butea forests and saline/alkaline

scrub savannah, dry bamboo brakes and Shiwalik chir pine forests. In northern dry mixed deciduous forests, the vegetation is xerophytic in nature and there is a preponderance of species like *Acacia catechu, A. leucocephala, A. nilotica, Anogeissus latifolia* etc.

Dry deciduous scrub forests are mostly found in Kandi tract. The accompanying dry deciduous scrub forest consists of *Nyctanthus arbotristis, Carissa opaca, Grewia tenax* etc. Most of these areas have remained under section 4 and 5 of the Punjab Land Preservation Act, 1900. As a result of this Act, vegetation over these areas has generally improved especially in upper parts of the catchments and along the Choe banks. Plantations of economically important species like *Acacia catechu* (Khair) and Bhabbar grass has also been undertaken in these areas.

Khair-Sissoo forests are found along the streams. They are scattered in nature. These are mostly man-made forests as a result of plantings in the foothills along choes (streams) and mand areas. In addition to Khair and Sissoo, Eucalyptus hybrid has been planted over substantial areas.

Butea forests and saline/alkaline scrub savannah have mostly been converted into plantations of commercial species like Eucalyptus species, *Dalbergia sisso* (Shisham), *Acacia catechu* (Kikar), *Morus alba* (Mulberry) etc. Small patches of natural vegetation survive in village wastelands in the plains.

Dry bamboo brakes (*Dendrocalamus strictus*) are located in certain parts of Hoshiarpur and Roopnagar districts bordering Himachal Pradesh and Gurdaspur. The forests of Karanpur and Bindraban in Dasuya Forest division are mainly bamboo areas where Bamboo (*Dendrocalamus strictus*) occurs gregariously.

Shiwalik Chir pine forests consist of *Pinus roxburghii* (Chirpine) found in elevations above 850 meters above mean sea level (msl) in parts of Bari Khad, Dehrian, Chattarpur, Dhar, Dunera and Nurpur Bedi forests (TERI, 2002).

2.2 Change in Forest Density

There is no area under dense forest cover in the state. Moderately dense forest area has increased by 13 sq. km from 2005 to 2013 in the state because of plantations and management efforts. Area under open and scrub forests is around 60% of the total forest cover in the state. It has increased by 220 sq. km between 2005 and 2013 due to pressures of fuel wood and fodder harvest in the state (Fig 2).

This increasing trend of the open forest in the state is mainly in the district of Ludhiana, Hoshiarpur, Gurdaspur, Bathinda, Roopnagar and Nawashahar. From last two FSI reports (2011and 2013), the open forest area has increased maximum in Ludhiana district, which is around 4 sq. km. While in Bathinda, Hoshiarpur, Nawanshahar and Roopnagar districts, the open forest has increased 1 sq. km each. This is mainly due to the increasing pressure on the forest area by the local population, their dependency on the forest, convergence of forest area into agriculture area as well as for the habitation.

Table 2: Change in forest density classes in Punjab from 2005 to 2013 (unit: sq. km)

S. No.	Category	Year				
		2005	**2007**	**2009**	**2011**	**2013**
1	Dense Forest	0	0	0	0	0
2	Moderate Dense Forest	723	733	733	736	736
3	Open Forest	835	931	931	1028	1036
4	Scrub Forest	15	20	20	37	37
	Total	**1573**	**1684**	**1684**	**1801**	**1809**

Source: FSI, 2005; FSI, 2007; FSI, 2009; FSI, 2011; FSI, 2013

Similarly, the trend in the shrub area in the state also shows the increasing trend since past few years. The shrub area in the state was 15 sq. km in 2005, which increased to 20 sq. km in 2009, 37 sq. km in 2011 and 2013. The percentage increase in the shrub area from 2005 to 2013 is estimated to be 146%. Hoshiarpur, Gurdaspur, Ludhiana, Roopnagar, Nawashahar and Patiala are the major districts where scrub area has increased extensively (FSI, 2005, 2007, 2009, 2011 and 2013).

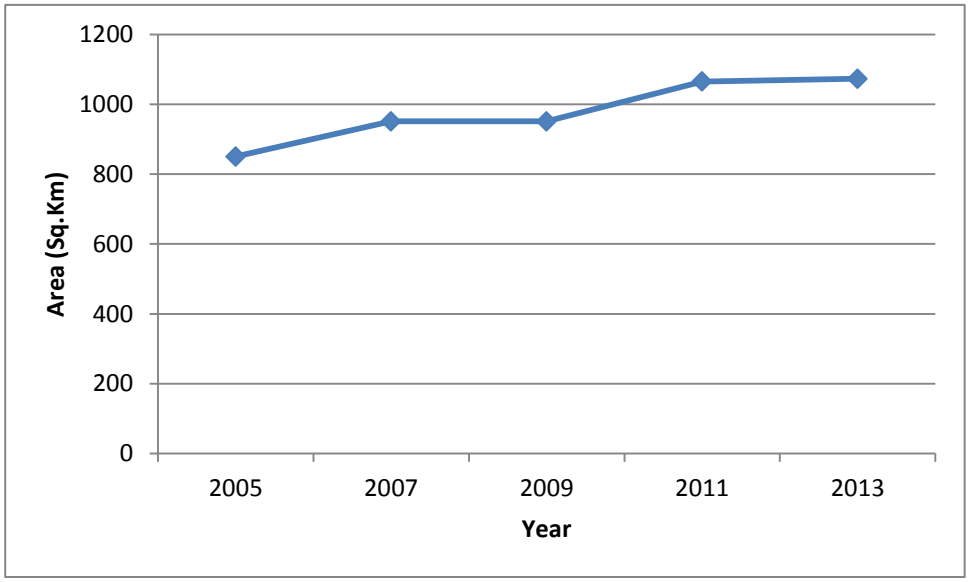

Figure 2: Change in open and scrub forest areas in Punjab from 2005 to 2013

Source: FSI, 2007; FSI, 2009; FSI, 2011; FSI, 2013

3. Policy Context- Punjab

3.1 Draft State Forest Policy

The draft state forest policy provides a legal framework to identify and accommodate all the issues and pressures on forests and wildlife resources and manage them to derive optimum environmental, social and economic benefits for the state and its residents (DoFWP, undated). The draft policy aims to increase the area under forests and tree cover from present 6.87% to 15% of the state's geographical area, and protect, conserve, improve the state's forests and other natural resources for improving the quality of soil, air and water.

3.2 Punjab State Action Plan for Climate Change, 2012

The plan elaborates on climate vulnerabilities across various sectors and discusses the strategies to adapt to these changes. It aims to protect the poor and vulnerable section of society through an inclusive and sustainable development strategy. It focuses on natural resources and agriculture, the backbone of the state economy. It takes note of the shrinking natural resources in the state due to the developmental activities, over exploitation and population pressure (PSAPCC, 2012). In future, climate change may hinder the high economic growth rate of the state especially in the agriculture sector. This have been indicated in some of the recent research studies such as Siddhu et al. (2011) indicated that change in 1^0C temperature may reduce the yield of rice and wheat crops by 3 to 10% in the state. Therefore, it makes a strong case for integrating climate change in all the state policies and programmes.

3.3 JFM guidelines, 1993

JFM programme was initiated in 1990 as a collaborative arrangement between the forest departments and local communities to regenerate and manage degraded forests. The Joint Forest Management (JFM) guidelines in the state was issued vide resolution no. 46/27/93-FT-III/8284, dated 14-07-1993 for the Kandi areas. This resolution was subsequently revised in 1995, which included active participation of people and local requirements. JFM in the state has been extended to the entire state as per the Punjab specific JFM notification 2003 in addition to the Kandi area where it was operational since 1993. JFM provisions in Punjab are applicable on reserve forests and protected forests and specifically on un-classed forests in its Kandi area involving local people through Forest Protection Committee (FPCs), Non-Government Organizations (NGOs)/ Voluntary Agencies (VAS)/Institutions/Religious Bodies etc and farmers.

3.4 Punjab Land Preservation Act, 1900

In 1900, the Government passed the Punjab Land Preservation (Choes) Act. This Act provides preservation and protection of notified parts of Punjab. This Act vests the Punjab Forest Department with management and regulatory authority over areas in the Kandi tract (the lower Shivalik hill fringes) of the state notified under the Act. This act enables the administration to temporarily regulate, restrict or prohibit cultivation, felling, grazing, quarrying and burning as also to undertake reforestation and soil conservation measures considered necessary for rehabilitation the watershed.

This Act has special significance for prevention of land degradation and can have far-reaching implications for soil and water conservation in the state. Since a large percentage of land in Punjab is under cultivation, management of the land resource so as to prevent it's overuse and degradation is a unique feature of this Act.

The areas notified under this Act, attracts Forest Conservation Act, 1980 as such areas are interpreted as deemed forests by the Supreme Court of India. It demotivates farmers to grow more trees resulting a bottleneck for achieving 15% forest and tree cover in the state.

3.5 The Cattle Tress Pass Act, 1871

This Act deals with cattle found damaging plantations and other crops. Under the Act cattle ponds are created and regulated by the civil authorities (The Cattle Tress Pass Act, 1871).

3.6 The Punjab Forest (Sale of timber) Act, 1913

The Act provides for the control of the sale of timber and the establishment of sale depots. This Act applies only to those areas that are notified in the official gazette (The Punjab Forest Act, 1913)

3.7 The Punjab Public Premises and Land (Eviction and Rent Recovery) Act, 1973

The Act deals with rent recovery and eviction of unauthorised encroachment on Government land. Under this Act, cases of encroachment on forest land are filed in the court of the sub-divisional magistrate who is also designated as 'collector' for the purpose of this Act. The civil courts have no jurisdiction for cases filed under this Act. The Divisional Forest Officers are also designated as collectors under the Act (The Punjab Public Premises and Land Act, 1973).

3.8 Ownership and management

In case of Punjab, 44% of the forest area is owned by the state government and remaining 56% by private entities or communities (table 3). Hence, the major ownership lies outside government. However, most of the private and community forests are managed by the forest department. Individuals or private firms predominantly in Kandi region own private forests.

There are two community reserves namely Lalwan and Keshopur Chhamb based in Districts of Hoshiarpur and Gurdaspur respectively (DoFWP, undated). These community reserves are managed by *Gram Panchayats* in collaboration with the Forest Department. These cover a total area 1606.80 ha (ibid). The Lalwan community reserve is situated in Garshankar tehsil of Hoshiarpur district and spread over an area of 1266.80 ha. The area was declared as community reserve vide Punjab Government Notification No. 46/78/2007/ft.V/6084 dated 22nd June, 2007. While, the Keshopur Chhamb community reserve is situated close to district town of Gurdaspur and spread over an area of 340 ha. This area was declared as community reserve vide Punjab Government Notification No. 34/13/2007/ft.V/6133 dated 25th June, 2007.

Table 3: Ownership of forests in Punjab

S. No	Ownership	Area (sq. km)	% of the total area
1	Government	1339.53	43.99
2	Private/Community	1,705.75	56.01
		3045.28	**100**

Source: DoFWLP, 2000

3.9 Joint Forest Management

In the JFM scheme, villagers are assigned a specific role in protection of forests. In return, the local people are allowed to collect dry/fallen twigs and leaves, wild fruits, medicinal herbs etc. free of cost. They are also be entitled to get fodder grasses (but not bhabber grass) from the forests free of cost where such grasses are not auctioned (Punjab State Action Plan for Climate Change, 2012).There are 1224 committees covering 1,78,333 ha of forest area (FRI, 2011). There are around 72000 families associated with JFM. They are availing benefits in form of fuel wood, fodder and other NTFPs worth 9 million INR annually (ibid).

4. Issues

4.1 Climate Change

There are various projected climate change impacts in the state of Punjab. Based on meteorological studies, it has been reported that the temperatures in the Punjab region have increased in the range of 0.5-1.0^{o}C till 2010 as compared to the base line of 1971-2000 (DoSTEN, 2012). The annual mean minimum temperature is also projected to rise by 1.9-2.1^{o}C by 2021-2050 (ibid). There are projections indicating increase in rain fall by 13.3%-21.5% with respect to base line of 1961-1990 however, rainfall during winter season is projected to decrease (ibid). These climatic variations along with various anthropogenic disturbances are affecting the distribution of species across forest areas in the state. Forests in the Shivalik region of the state which are highly fragmented because of various socioeconomic pressures are further likely to get adversely affected due to changes in rainfall and temperature. However, the Net Primary Productivity (NPP) of the forest vegetation is likely to increase by 0.6 to 1.2 kgC/m^2/year in 2021-2050 (ibid).

Economic species like *Acacia nilotica* and *Dalbergia sissoo* are declining rapidly in the state due to a combination of factors. A recent study on high rate of mortality of these two species attributes it to fungal and insect pests infestations and various biotic, climatic and environmental factors. The climatic factors such as variation in temperature, rainfall, relative humidity are creating favourable conditions for the growth of fungus and pest (DoSTEN, 2012).

A research work was conducted on the impacts of climate change in the state indicates that wheat production will come down by 1% in the next 10 years. Growth of plants will get stunted and crop will mature before time, which will have a staggering impact on the productivity of the crops.

Besides these impacts, climate change is also likely to increase incidences of forest fires and pest attack due to increase in temperature affecting survival and growth of forest vegetation in the state (DoSTEN, 2012). These could further aggravate issues related to forest based livelihoods and man-animal conflict (ibid).

4.2 Forest Degradation

As discussed earlier, the open and scrub forests constitute 60% and 45%, of the forest cover of Punjab and India respectively, which is largely degraded. Some of the key factors behind the forest degradation are demand and supply gap of forest products, shifting cultivation and forest fires, which have been discussed ahead.

4.3 Demand and supply gap in fuel wood, timber, and fodder

There is a substantial demand and supply gap in major forest products across India (Table 4). This trend is reflected across most states including Punjab. This leads to a vicious circle where the unsustainable exploitation of forests contributes to their degradation which in turn reduces the supply of products and services.

Table 4: Demand and supply gap of various forest products

	Demand (MT)	Sustainable supply (MT)	Gap/ unsustainable harvest (MT)
Fuel wood	228	128	100
Fodder (green and dry)	1594	741	853
Timber	54.94	40.70	14.74

Source: Aggarwal et al., 2009

4.3.1 Fuel wood

As per 2011 census estimates, households consume 13.4 thousand tonnes of firewood in Punjab, which is far beyond the sustainable production in the State (Census of India 2011).

Various studies underscore the relation between unsustainable extraction of fuel wood and degradation of forests (for example Bhattacharya and Joshi 2000; Heltberg et al. 2000). Unsustainable extraction is a consequence of both demand factors- increasing population, inefficient use of fuelwood, and lack of energy alternatives for poor households- and supply side issues, which include low productivity of forests (MoEF 2006).

4.3.2 Timber

In the state, it has been reported that total demand for wood for the year 2005, 2010 and 2015 are 7.24 million cum, 7.44 million cum and 8.14 million cum respectively based on approximate population growth rate of 2% (DoSTEN, 2012). However, it has been estimated that Government forests and Government managed private forests produce 0.14 million cu.m of wood in 2005-06 (DoFWP, undated). It suggests the gap in demand and supply is fulfilled from private lands through agroforestry and from government forest areas.

4.3.3 Fodder

In the state, although livestock population has been declining over the years, there is still immense pressure on forests especially in areas like Shiwalik hills (DoFWP, undated). The

livestock population in state has been decreasing continuously since 1990 showed tremendous decline from about 97 lakh in 1990 to only 71 lakh during 2007, at the rate of 1.5 per cent per annum. The cattle population in the state has declined from about 28 lakh in 1990 to about 17 lakh during 2007, decreasing at the rate of 2.29 per cent per annum (Grover and Kumar, 2012). The fodder from agricultural crops is a major source of fodder in the State. However there has been decline in area under fodder crops in the state from the average area 7.8 lakh ha during the period 1990-94 to average area of 5.83 lakh hectare area during the period 2005-09 (ibid). It has further increased the pressure on the forests leading to forest degradation especially in the Shiwalik region.

4.4 Encroachments

It is complex issues which has legal, rights and livelihood dimensions. As per government estimates, 1.34 m ha of forest area is encroached in the country (ibid). State governments have failed to act on the directives and guidelines issued by central government and Supreme Court to avoid any adverse political response which has led to further encroachments (MoEF, 2006). According to MoEF, in Punjab around 3,090 ha of forest area is under the encroachment.

4.5 Forest fires

In Punjab, forest fires are regular feature after the harvesting season when the farmers in the adjoining areas burn their agricultural residue in fields and the fires extend to the forest areas. As per a research study, around 4.23 million metric tonnes of paddy and wheat residue burnt annually in the state (Vadrevu and Justice, 2012). It has been reported that recently 124 fire incidents affecting 6537.40 hectares of forest area were reported in the state. Forest fires result loss of biodiversity and affect the productivity of the entire ecosystem. Very often, fires created in small patches spread into large areas.

4.6 Weed infestation

Weed infestation especially of *Lantana camara* is a serious threat to resurgence of forest in areas of Punjab. It is threatening to see that entire Shivalik forest range is causing destruction of forest flora and fauna, hence biological control of this weed is necessary. The Shivalik forest in the districts of Roopnagar, Gurdaspur and Hoshiarpur has been seriously affected by invasion of *Lantana camara*. Siswan-Dulwan area of Roonagar district in Shivalik spread in 2044 ha area is a biodiversity rich area and maximum part of this area is under proliferation of *Lantana camara.* In Gurdaspur district, 34.90% loss in forest cover has been attributed due to Lantana invasion. Till now, according to an initial survey, a forest area of over 500 sq. km have been lost in the state due to the invasion of *Lantana camara* and this will continue, if remained unchecked.

5. Ways forward

Punjab has 60% of forest cover under open and scrub categories, which are largely degraded. It reflects national trend, where more than 40% of the total forest cover is under

these two categories. It has been suggested that half of the degraded areas have good root stock and hence can be regenerated through assisted natural regeneration with the help of JFM committees (MoEF, 2006).

The state has set up a target to increase area under forest and tree cover from 6.82% (3271 sq. km) to 15% (7554 sq. km) by 2017 under state forestry action program, which is highly ambitious, unrealistic and a distant task. Since last 46 years the state has been able to increase the forest cover merely by 2.77%, which is around 1396 sq. km. (30 sq. km on an average annually). Thus, it is difficult to imagine the achievement of this target in the given time frame. Based on the past efforts, experience and practical situations, the state should revise its target.

Since, Punjab is agricultural state, around 82% of the geographical area is under agriculture, so there is limitation of extension of forestry activities in the state, but can explore the agroforestry for green growth in the state. With this limitation, the conservative estimate of the revised target should be around 13% of its area under forest and tree cover by 2047.

To achieve this target, we propose two scenarios. First, covering 50 sq. km area annually under green cover till 2047, this will achieve the target of 10% (5036 sq. km). Second, undertaking 100 sq. km annually under green cover, this will achieve the target of approximately 13% (6547 sq. km) by 2047 (fig 3). Of this 13% area, around 2 to 3% area could be targeted from the private lands in the form of agroforestry plantations. Rest could be taken from the forest land, community private forest land and waste land etc across the state. Species like Shisham, Kikar, Drek and Eucalyptus could be encouraged based on the site specific conditions.

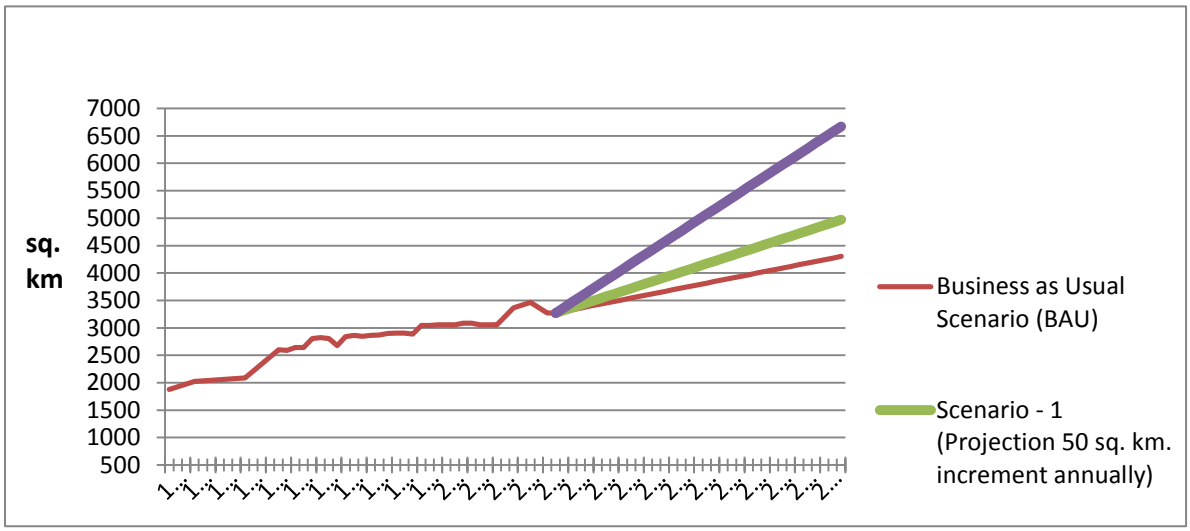

Figure 3: Probable scenarios for achieving target of 13% forest and tree cover by 2047 in Punjab

Source: TERI, 2014

Based on the above analysis, we suggest strategies to address issues of forest degradation, climate change and rights and livelihoods of local people. Gap in the demand and supply of forest products is one of the major reasons for forest degradation not just in the state but also across most of the country. Similarly, strategies to address other drivers of degradation such as forest fires, encroachments and weed infestation have been elaborated. Finally, strategies to adapt to climate change have been presented.

5.1 Supply side management of forest products

5.1.1 Development of improved planting material

The productivity of planting material can potentially be increased manifold by using superior planting stock raised through tree breeding programmes, as well as through clonal technology and tissue culture. For instance, annual productivity of a seed-raised eucalyptus plantation is presently only 6 to10 m^3 per ha, which can be increased up to 40 to 50 m^3 per ha annually with the introduction of genetically improved plants as illustrated by initiatives of Indian Tobacco Company (ITC) and The Energy and Resources Institute (TERI).

Unfortunately, tree improvement programmes have not received sufficient attention and funding. With the promulgation of the National Forest Policy (1988), the priority of forest management shifted from production forestry to conservation forestry. Consequently, research activities on silvicultural and development of improved planting material took a back seat. Limited availability of funds, and lack of coordination, efficiency and accountability among forestry research institutions are some of the other issues which plague forestry research in the country. Private sector companies such as *Pragati Biotechnology* are working on developing clones of species such Eucalyptus and Poplar in Punjab and neighbouring states. These are also popularising advanced forestry techniques such as green houses, mist chambers and root trainers. These efforts could be scaled up if

forest department could identify private companies, research organisations and NGOs and collaborate with them.

5.1.2 Promotion of agroforestry/farm forestry

Agroforestry involves the raising of trees along farm boundaries, as intercrop and as pure block plantations. The practice offers the potential to increase productivity even up to 50 cum/ha/year. There is a huge scope of increasing area under different agroforestry models. It has been estimated that 5% of the net sown area in the country can be brought under tree crops from the current level of 2% (MoEF, 2006). Area under agroforestry can be increased from 0.37% to at least 2 to 3% of the geographical area in the state by 2047.

In Punjab, agroforestry can not only help in increasing tree cover but also meeting the demand supply gap of forest products. According to the Punjab Remote Sensing Centre (PRSC2006), the state has 0.37% (188 km^2) of total geographical area of the state under agro forestry plantations. Barring districts of Gurdaspur, Faridkot and Nawanshehar, all other districts have less than 0.5% of geographical area under agroforestry plantations. The maximum area of agroforestry plantation is under Poplar, which is around 0.13% of the total geographical area of the state. It can be increased upto 0.50 to 1% by the year 2047. While other agro forestry species such as *Eucalyptus, Sisham, Kikkar and Drek* should be promoted on large scale depending upon the agro climatic and other site conditions.

Agro forestry practices can be made ecologically and economically beneficial to the farmers through developing various plantation models and promoting research on improving productivity of the farm forestry tree species. It would require extension work to educate farmers, removing legal barriers (like felling and transit restrictions), and encouraging industries to intensify their linkages with farmers. Availability of microfinance is another important factor that can go a long way in promoting agroforestry. The role of financial institutions like such as NABARD (National Bank for Agriculture and Rural Development) is important in this context.

There is a need to increase inputs in planning, implementation and monitoring on farm land plantation and seedling distribution component. Genetically improved clonal plants of Poplar, Eucalyptus and Drek etc., should be supplied by the department at reasonable rates. Forest department should strengthen Farm Forestry extension services. Package of practices for important species printed in Punjabi, Hindi and English should be supplied to tree growers. Sufficient resources should be allocated for the success of the efforts.

5.1.3 Integrated management of different types of land for meeting fodder needs

Plantation and management of forest, wastelands and agriculture lands can increase the supply of fodder. At the same time, the supply of fodder from agricultural crops needs to be increased by promoting the cultivation of leguminous fodder crops with cereals and the cultivation of grasses like elephant, napier etc. in agricultural wastelands and pasturelands (Singh, 2008).

In the state, area under fodder crops has declined by 7% from 1990 to 2005. Most of the fodder crops showed decrease in area except Guar during Kharif and Oats during Rabi season. The other major fodder crops like winter maize and *Barseem* showed a steep decline due to low market prices, shortage of labour and lack of credit facilities. Hence, availability of quality seedlings for high yielding varieties for various fodder crops along with adequate short-term credit facilities and technical trainings can go a long way to augment the fodder area (Grover and Kumar, 2012). The state needs a grazing policy to provide a strategic vision in managing the needs of livestock. Such a policy would spell out regulation guidelines for use of different types of lands for grazing as well as an integrated strategy for development of various fodder sources (Roy and Singh 2008).

5.2 Demand side management of forest

There is shortage of around 5.81 million cum of wood, which can be met through enhancing the agro forestry sector in the state. While to meet the demand of fodder, village and community lands should be taken up for the development fodder resources. Non timber forest produce, its collection, regeneration, protection and marketing should be institutionalized and farmers or collectors should be directly linked to the market to reduce the role of middle man. Regulation for felling trees on private land and community holdings should be reviewed and rationalized to as per the communities' interest in planting and protecting trees on their lands. Similarly, promotion of medicinal and herbal plants through in situ propagation and conservation practices especially in the Shiwaliks should be encouraged. Proper strategy for conservation, cultivation, marketing of herbal and medicinal plants should be included in the management plan and working plans. Ecotourism should be promoted as a management tool for forest conservation. Site should be identified to develop as Eco tourism spot with the help of local communities, NGOs, and other stakeholders in the state.

5.3 Urban forestry

Under the urban green cover, target each city across the state for urban greens that includes large scale afforestation on waste lands, railway tracks, roadside, government area under municipalities, civil societies and other institutions, which are holding the government land. Provide target of minimum 10% of geographical area to each city to enhance their green cover by the year 2047.

5.4 Adaptation to climate change

It is clear from the available research that climate change is affecting ecosystems and vegetation in the states. Vegetation in Shiwalik and Kandi areas of Punjab is more vulnerable. More research needs to be undertaken to understand the impacts of climate change on ecosystems through the use of dynamic vegetation models, which require developing a robust database on forest vegetation characteristics, plant functional types, physiological parameters, soil and water. Alao 'no regret' adaptation strategies should be implemented based on the 'precautionary principle' approach (Ravindranath et al 2006).

Around 83% of forest area in the Kandi tract belongs to the local communities and private individuals. The forest department exercise control over these forest areas under the land preservation act, 1990. In the recent past, maximum impacts of climate change were observed in these areas. Thus, the department should focus more on these areas. In the state, *Acacia nilotica* (Kikar) can be extensively used to reclaim the saline and alkaline areas. The species can survive in extreme temperature, 300 to 2200 mm rainfall and tolerate soluble salt content below 3%. Similarly water logged areas in various parts of Muktsar, Firozepur, Bathinda and Mansa districts can be reclaimed through bio drainage process by planting the waterlogged tree species such as Eucalyptus, Willow, Arjun, Jamun etc. It can lead to slowly regrowth and revival of other species, increasing ecological resilience of these areas. In the Shivalik region, enrichment planting with suitable species of trees, shrubs and grasses should be carried out on regular basis. In addition, construction of soil conservation measures such as brushwood, dry stone check dams, live hedge, terracing and slope management should be carried out to check the soil erosion, conserve moisture and recharge ground water in the entire Shivalik region.

5.5 Addressing research needs

Weeds such as *lantana camara* in Shiwalik hills region spread across the state can be addressed through biological and mechanical methods. Collaboration with research institutions such as Punjab Agriculture University (PAU) is a key to such efforts. Small scale experiments of using weeds in compost should be undertaken. These needs to be further field-tested and up scaled covering entire state.

The notified forests in the state occupy a significantly larger area than the Tree Outside forest (TOF), but they contain much lower volume. The growing stock per unit area in TOF (110.70 m^3) is three times higher than that of the natural forest (35.20 m^3) (FSI, 2003). Therefore, emphases on the research should be given more on to improve the quality of the forest through launching productivity enhancement programs within the state. This type of programs would be helpful in converting the moderate forests into the dense forests, which is almost nil at present in the state.

Saline-alkaline areas in the plains areas of Patiala, Muksar, Kapurthala and Amritsar districts are to be reclaimed through appropriate soil treatment measures and also control the fertile areas from converting into the saline, alkaline and waterlogged areas.

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Annexure: Roadmap matrix

Areas	Any policy target	Current barriers	Policy/ regulatory intervention needed	Technology needed
Short term (2020)	• 8% of the state area under forest and tree cover	• Encroachments • Forest fires • Sustainable Forest Management • Invasion of Lantana	• Enactment of the Punjab Forest (sale of timber) Act, 1913 • Ease transit and felling regulations for trees grown on private land within the state. • Include sustainable forest management practices on the lines of GIM and REDD+ in the working plan documents of the state.	• Establish hi tech nurseries throughout the state for producing quality germ plasms. • Enhance productivity through clonal and tissue culture technologies. • Launch large scale program on eradication of Lanatana camara especially in Gurdaspur, Roopnagar and Hoshiarpur districts, where it is wildly spread. • The notified forests in the state occupy a significantly larger area than the Tree Outside Forest (TOF), but they contain much lower volume, which is 35.20 m3 as compared to 110.70 m3 in TOF. Therefore, emphases should be given more on to improve the quality of the natural forests through launching productivity enhancement programs within the state. This type of programs would be helpful in converting the moderate forests into the dense forests, which is almost nil at present in the state and open forest into moderate forest. • Control over the forest fire through involving local communities and formation of Joint Forest Management Committees (JFMCs) and Forest Dependent Communities (FDCs) with the help of forest department. • Construction of fire lines and watches and ward towers in the forest fire sensitive areas. • Modern technologies like remote sensing & GIS tools should be used for proper

Areas	Any policy target	Current barriers	Policy/ regulatory intervention needed	Technology needed
				management and scientific planning of forest resources assessment. Especially on the open and scrub areas which are continuously increasing year after year in the state.
Medium term (2030)	• 10% of the state area under forest and tree cover	• Saline alkaline areas in plains of Patiala, Muksar, Kapurthala and Amristsar districts. • Waterlogged areas of various parts of Muksar, Firozepur, Bathinda and Mansa disticts • Demand of fuelwood, fodder, bamboo and minor forest produce. •	• Encourage National Forest Policy, since it permit private sector to do plantation and conservation activities on degraded forest for the improvement of forests • Forest corporation should establish minimum support price (MSP) for agro forestry species. • Include addition chapter on assessment of forest carbon stock in the working plan documents of the state. • Develop carbon forestry projects such as A/R CDM and REDD+.	• Saline-alkaline areas are to be reclaimed through appropriate soil treatment measures and also control the fertile areas from converting into the saline, alkaline and waterlogged areas. • Water logged areas are to be reclaimed through bio drainage process by planting the waterlogged tree species such as Eucalyptus, Willow, Arjun, Jamun etc. • In the Shivalik region, enrichment planting with suitable species of trees, shrubs and grasses should be carried out on regular basis. In addition, construction of soil conservation measures such as brushwood, dry stone check dams, live hedge, terracing and slope management should be carried out to check the soil erosion, conserve moisture and recharge ground water in the entire Shivalik region. • Guniea grass, Oat and Sorghum have been identified as a suitable crops for block plantation, so awareness programs should be launched to promote these species.
• Long term (2047)	• 13% of the state area under forest and tree cover	• Population pressure on forest for livelihood • Only 0.37% (188 sq km) of geographical area under	• Review the Punjab Land Preservation Act to keep away private land from Forest Conservation Act • Amend Indian Forest Act to relax	• Promote agroforestry species such as Poplar, Eucalyptus, Sisham, Drek, Neem, etc in the state. • Tree improvement programs consisting of clonal multiplication, grafting and raising seedlings by collecting

Areas	Any policy target	Current barriers	Policy/ regulatory intervention needed	Technology needed
		agroforestry • Due to 82% of the geographical area of the state is under agriculture, so there is limitation of land for forestry extension activities within the state. •	transit regulations for the species grown on private land. • State forest department should enable environment for marketing on contract farming within the state • Regulation for felling trees on private land and community holdings should be reviewed and rationalized to as per the communities' interest in planting and protecting trees on their lands.	seed from superior genotypes or certified sources should be undertaken. • Area under agro forestry species should be increased from 0.37% to 3.0% of the geographical area of the state. • Area under Poplar should be increased from 0.13% to atleast 1.0% of the geographical area of the state. • Bamboo cultivation should be encouraged as its cultivation ensures more than 25% of Internal rate of return (IRR) and returns are recurrent up to thirty years without recurring investment.

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