



Evaluation of Adopted Agro Forestry Models in Haridwar, India

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Abstract

Cultivation of tree species with agricultural crops in different combinations is practiced by farmers around the world since ancient time. One of main aspects to analyze status of agro forestry in any region is to evaluate agro forestry models of that region. The main objective of this article is to produce a framework of adopted agro forestry models in Haridwar, India. A number of agricultural crop species like wheat and other crop species like sugarcane, Chari etc. were reported with tree species like Poplar, Eucalyptus, and Other/mixed tree species adopted by the farmers. A total of 700 models were reported and studied in the sampled study area. Out of which 83.57% models (585) were poplar based, 12 % models (84) were eucalyptus based and rest 4.43 % (31) models were other/mixed tree species based. Poplar based tree-crop combinations were mostly planted by farmers. Poplar tree species was planted in 544.68 ha. (86.83%), Eucalyptus was planted in 57.72 ha. (9.20%) of land and other/mixed species were reported in 24.88 ha. (3.97%). It shows that Poplar is dominant tree species in agro forestry plantation (crop combination and land ratio wise). Most of the models (69.05%) were arranged in boundary, 25.96% in blocks and (4.99%) in scattered forms. Poplar based models are preferred in boundary patterns (70.61%), Eucalyptus based models are preferred in block patterns (63.09%) and Other /mixed tree species based models are preferred by farmers in Scattered forms (66.66%). A number of tree crop combinations were described under three major agro forestry model categories. It was also concluded that although different types of tree-crop combinations were reported in agroforestry models, the farmers purposely preferred those models which were suitable for domestic or commercial purpose therefore compromising between these two purposes. It is important to study each component of agro forestry appropriately while describing agro forestry models, tree-crop combinations, their adoption rate, plantation pattern, covered land, as well as percentage of adopters under such combinations.

Keywords: Agro forestry, Arrangement, Model, Patterns, Species, Tree-crop combination.

Introduction

There is a famous proverb in India that Farming without tree culture is incomplete. One or more tree species with agricultural crops are grown together by the farmers from centuries before. There is a farm tradition of planting/ retain different kinds of species particularly tree crops on the field bunds or corners of field to provide benefits like fruits, fodder, firewood, timber etc.. With wrong choice of tree crop combinations and their management techniques agro forestry may be unsuccessful just like any other land use practice and it will still be agro forestry¹. Agroforestry is a type of sysbiosis between tree, agriculture crop and live stock, live stock rising where each component is beneficial to other. It may be traditional and/ or introduced². Growing trees and crops on the same land is an important land-use system which is widely practiced in developing world³. Cultivating trees, agricultural crops and pastures and/or animals in intimate combination with one another spatially or temporally is an ancient practice that farmers have used throughout the world⁴. In India, fast growing exotic tree species have been introduced on-farm in order to obtain maximum monetary gains from a given land unit in a short period of time⁵. Agro-forestry practices that integrate tree, crop and animal components are

emerging as part of an intensive land management approach focused on sustainable resource use and production within given economic, social and environmental settings⁶. Alternate land use such as agro forestry, agro-horticultural, agro-pastoral, agro-silvipasture etc. are more effective when trees are not removed. Through total harvest, the species combination may be designed for nutrient release that benefits crops⁷. The three major components of agro-forestry systems are crops, trees and animals⁸. Trees are planted in different patterns in agro forestry models, in rows, in block plantation between, in boundary plantation or in scattered forms etc. While undertaking tree crops with agricultural/ fodder crops on fields, farmers are intended to plant fast growing trees species to get benefits as early as possible. Now days, a general agreement is being followed by farmers about the magnitude and scale of the integration and management of trees with other component of agro forestry. The main objective of this article is to produce a framework with two main components of agro forestry i.e. tree species and crop species of adopted agro forestry models, objective of their tree-crop combinations and their plantation pattern wise distribution in district Haridwar, India. This work is an answer to agroforestry models adopted by the farmers in the region.

Methodology

Sampling and survey: The study was carried out in Haridwar district of Uttarakhand, India. Surveys have been widely used in India in the past to collect information on forest resources use, joint forest management, social forestry adoption and psychological aspects of forest users⁹. The execution of conducted survey depended upon interviews with the sampled farmers. In order to ensure high rate of responses and significance of the answers given by the interviewees¹⁰, the information was collected through a field survey using pre-tested semi structured questionnaire and interview schedules¹¹ with adult members or head of the family. Main criteria to select study villages were their distribution under different tehsils of districts and presence of agro forestry in that area. Sampling units were selected using simple random sampling¹². About 36 villages from six blocks of three tehsils and 12 households were selected randomly from each of these villages. For detailed survey, first of all lists of selected villages in each tehsil was prepared and further another list of selected households was prepared with the help of village head for households in each village.

The 432 random households in the selected villages were surveyed to determine average land holding size, area¹³ under different land cover-land uses, crops, trees and shrubs used for various purposes and management practices. A pre-test of the both questionnaire designs was done on 36 respondents from three villages having both adopters and non adopters of agro forestry and reviewed for clarity. The input from pretesting exercise was used to make minor or additional modifications in questionnaires. After required changes done in questionnaire, the survey was conducted in the randomly selected villages.

Collection of Data: Data was collected through semi structured and pretested questionnaires survey that was intended to capture basic demographic data that were administered to 432 households for first surveys. We interviewed 426 focused exclusively on agro forestry. Only 6 responses out of 432 interviews were discarded as they could not generate enough data and information to analyze. The respondents were chosen and asked to reveal types of tree species, agricultural crop species, and other species component of agro forestry, if any and variations of tree-crop combinations present in land areas they owned. The asked questions were a mixture of both open-ended and closed ended accordingly. The farmers were allowed to provide as many responses they felt fit to answer the question. This was to let farmers fully convey themselves and not get biased with expectation or opinion of others/researcher herself.

Observation and transect walk: During surveys, field observations through transect walk were done to assess the presence of agro forestry in established plots of farmers. Personal observations were conducted to analyze actual agro forestry systems practiced by the farmers.

Data analysis: Data were cleaned sorted and coded as 0 and 1 based upon farmers response. Data were analyzed using simple statistics like frequency counts and percentage calculation, mean, average and cross tabulation of data.

Results and Discussion

Types of tree species compositions and tree crop combinations (three major categories) poplar based, eucalyptus based, other/mixed tree species based agro forestry models).

Table-1
Percentage of tree species based agro forestry models

Tree sp.	Frequency	Percentage
Poplar based model	585	83.57
Eucalyptus based model	84	12
Other/mix tree species based models	31	4.43
Total	700	100

The surveyed farmers have mentioned a number of tree species in combination with other components of agroforestry. Majority of combinations consisted major components like tree, agriculture-fodder crops and animals whereas only few models were reported combining tree species with agriculture crops or fodder crops/animal species. There are actually as many tree crop combinations in agro forestry models as there are farms. It is the farmer who actually decides what kind of agroforestry modes he has to adopt in his field supporting earlier findings of Molua¹⁴. Here another point is to be noted that although cropping prototype is similar for each model in different farms but the production activities are different in round year activities of different components of these combinations/models. Table 01 shows distribution of the tree species in agro forestry models. A total of 700 models were reported and studied in the sampled study area. Out of which 83.57% models (585) were poplar based, 12% models (84) were eucalyptus based and rest 4.43% (31) models were other/mixed tree species based. Worth mentioning is the introduction of Wheat (*Triticum aestivum*) to many combinations like with Paddy (*Oriza sativa*), vegetable or fodder/forage crops. A detailed description of these model types/ tree crop-combination is given below:

Poplar based models types: It is a general practice to combine agricultural crops with poplar plantations. Poplar being deciduous in nature, a winter crop, predominantly wheat, is intercropped throughout rotations⁵. The survey conducted in the region has shown that Poplar based agro forestry models are very popular among the farmers in the region. In total studied 700 agro forestry models, Poplar based agro forestry models are mostly preferred by the farmer in their fields as they were reported 585 in their counts. They are categorized into three categories; Poplar + agriculture crop species which constitute

about 59% of total agro forestry models, Poplar + vegetable crops that constitutes about 2% of total agro forestry models, Poplar + fodder crops which constitutes 22% of total agro forestry models and Poplar alone in woodlots, constituting about 1% of total agro forestry models. This species has been grown by farmers as boundary or block plantation. It shows that Poplar with agriculture crops is top most choice of farmers adopting agro forestry in the region. The surveyed farmers considered cultivation of Poplar easier as it allows further coppicing and regeneration after its first cultivation. The next preferred species in combination with Poplar were fodder crop species which were grown for cattle feed purpose. Almost each category, except Poplar wood lot, was practices in all combinations. Crop species like Sugarcane, Wheat, Sorghum, Maize, Ground nut, Millet, Mustard, Cabbage, Potato, Peas, Chari fodder, Berseem fodder etc. are reported in combination with Poplar tree species.

Eucalyptus based models: Combination of Eucalyptus tree species with agriculture crops can solve more objective than planting/retaining Eucalyptus alone in fields. As this table elaborates, Eucalyptus is less preferred tree species over Poplar sp. with other crop combinations. A total of 84 models were reported with Eucalyptus tree species. Here also, the agriculture crops were mostly preferred in tree crop combinations (7.28%), followed by fodder crops making 3.85% of total adopted models in the field. Very few models (0.43%) of Eucalyptus woodlots were also reported in the study area. Like Poplar species based agro forestry models, Different crop species such as Sugarcane,

Wheat, Paddy, Sorghum, Mustard, Maize, Chari fodder, Berseem fodder etc. are reported in combination with Eucalyptus based agro forestry models. However no vegetable crops were reported in combination with Eucalyptus in the study area.

Other tree /mixed tree species based models: A total of 31 models (4.43%) were reported with other/mixed tree species based models. In other tree species/mixed tree species based models, more than half of the total combinations with horticulture tree species were mostly preferred by the farmers, though making only 3% of total agro forestry models. With agriculture crop combinations, it was found to be only 1% of total agro forestry models and only Wheat and Paddy in seasonal rotation were found in combination with these tree species. Wheat was major crop grown under these models. Very less numbers of models (04) with fodder crop species like Chari and Berseem fodder were also reported in the study area, making only 0.57% of total agro forestry models. No woodlot was reported under this combination. Here, it is to be noted that cultivating irrational crop-tree combinations (with horticulture tree species based models) also occurs in some models since, production of fruits decreases with each passing year in these models. Due to which, expenditure on production cost exceeds than production output which further insists farmers to incorporate other agriculture or fodder species in combination with tree species.

Table-2
Poplar based models

Model type	Model name	Frequency	Percentage of total models
Poplar+ agriculture crop species	P+Wheat+Paddy, P+Wheat, P+Sugarcane, P+Sugarcane+Wheat, P+Sorghum+Wheat, P+maize, +Wheat, P+mustard+Wheat, P+millet+Mustard, P+ ground +Wheat, P+ millet+ wheat, P+ maize+ mustard	409	58.63
Poplar+ vegetable crop species	P+Cabbage+Wheat, P+Potato+Wheat, P+Peas+Wheat	17	2.43
Poplar+ fodder crop species	P+Chari+Berseem, P+Chari+ Wheat, P+ Chari+ mustard	154	21.97
Poplar alone	Poplar wood lot	5	0.71

Table-3
Eucalyptus based agro forestry models

Model type	Model name	Frequency	Percentage
Eucalyptus+ agriculture crop species	E+paddy+Wheat, E+ wheat, E+ maize+ wheat, E+Wheat+Sugarcane, E+Wheat+Paddy+ Sugarcane E+Sugarcane+ Wheat, E +Wheat, E+Sorghum +Wheat, E+Sorghum+ Mustard	54	7.28
Eucalyptus + vegetable crop species	-	-	-
Eucalyptus + fodder crop species	E+Chari+ Berseem, E+Chari+ Wheat	27	3.85
Eucalyptus alone	Eucalyptus wood lot	3	0.43

Table-4
Other/mixed tree species based agro forestry models

Model Type	Model Name	Frequency	Percentage
Other/ mixed tree species+ agriculture crop species	Other + paddy+ Wheat	7	1
Other/ mixed tree species + Horticulture crop species	P+ Mango+Wheat, P+Mango+ Sugarcane, P+ Mango, E+Other/mixed(Mango) + Wheat+ fodder sp., P+ Others/mixed+ wheat	20	2.85
Other/ mixed tree species + vegetable crop species	-	-	-
Other/ mixed tree species + fodder crop species	Other/Mixed (Morus, Tuna) + Chari+Berseem	4	0.57
Other/ mixed tree species alone	-	-	-

Land distribution under these combinations: As far as tree species and land covered under these species, Poplar tree species was planted in 544.68 ha. (86.83%) of total land. Eucalyptus was planted in 57.72 ha. (9.20%) of land and other/mixed species were reported in 24.88 ha. (3.97%) of total land. It shows that Poplar is dominant tree species in agro forestry plantation (land ratio wise). And as compare to this, Eucalyptus and other tree species occupied very less farm lands under their plantation.

Table-5
Total land under different tree species based agro forestry models

Tree species name	Covered land in ha.	percentage
Poplar based models	544.68	86.83
Eucalyptus based models	57.72	9.2
Other/mixed tree species based models	24.88	3.97
Total	627.28	100

Objectives of raising agro forestry models: The main purpose for agro forestry adoption in the studied villages are the prospect of income generation and the income support obtained from commercial selling and domestic consumption of agro forestry produces. The findings showed that except in Other/mixed tree species based models, domestic purpose like fuel wood consumption, fruit/fodder availability etc. was not the main reason behind adoption of Poplar and Eucalyptus based models. The need of raising these models is also favored by commercial conditions like market price for produces, their level of demand, supply chain feasibility etc. Most interviewed farmers were growing agro forestry tree species for commercial purpose especially Poplar (98%) and Eucalyptus (95%) tree species. these tree species have good market demand and hence farmers supply most of the tree produces to the markets. However it is contradictory in for other/mixed tree species (90%) as most of the farmers here, utilized tree produces domestically especially for meeting fuel wood, fruits and fodder requirements.

Table-6
Objective of tree species in agro forestry

Tree species name	Percentage of adopters	objective	percentage
Poplar based models	91	Commercial	98
		Domestic	2
Eucalyptus based models	17	Commercial	95
		Domestic	5
Other/mixed tree species based models	8	Domestic	90
		Commercial	10

Plantation Patterns of these combinations: In the study area, farmers have retained or planted tree species in different patterns. Above table also shows the distribution of farmers in different spatial patterns. Approximately, most of the models (69.05%) were arranged in boundary patterns, while 25.96% were reported block patterns. Usually block pattern usually requires management techniques like pruning to reduce Shade and nutrient depletion. This may be one of the reason behind lesser block plantation in the area. Very less percentage of total tree crop combinations in agro forestry models (4.99%) was reported to be arranged in scattered forms. Again in model wise spatial distribution, maximum models reported in boundary pattern were from Poplar based tree crop combinations (70.61%). In block patterns, Maximum models reported were from Eucalyptus based tree crop combinations (63.09%) while in scattered arrangements, other/ mixed tree species based tree crop combinations were reported mostly with 66.66% of their total percentage. It shows that the farmers are receptive to adopt those tree-crop combinations or models in which trees are arranged along the boundaries. However it is not sole reason behind selection and farmers also planting /retaining tree species in one or more spatial patterns. Poplar based models are preferred in boundary patterns, Eucalyptus based models are preferred in block patterns and Other /mixed tree species based models are preferred by farmers in Scattered forms.

Table-7
different tree species in their spatial distribution in models

Tree species name	Model counts	% of total models	Model % in Boundary	Model % in block	Model % in scattered
			69.05	25.96	4.99
Poplar based models	585	83.57	70.61	28.35	1.04
Eucalyptus based models	84	12	16.66	63.09	20.25
Other/mixed tree sp. models	31	4.43	19.06	14.28	66.66

Conclusion

Different kinds of tree-crop combinations in agroforestry are thriving in all regions of the world. Farmers adopting agroforestry, utilize interspaces between two trees without impairing the growth and development of tree species and hence getting extra income from agroforestry. Depending on the situation and application, trees and other crop species can be included into agro forestry practices in many ways. Agroforestry research has hardly been conducted to explore the tree-crop combinations adopted in this area. This study surely adds an important step towards studies of agroforestry models. This study reports the farmer’s interest and what kind of tree and other crop species they are planting (alone or in combination) in their field. A variety of tree crop combinations (agro forestry models) are significantly adopted and maintained by the farmers in the region. As compare to other tree species, Eucalyptus and Poplar are the main species preferred in these models, due to short rotation, available market, their ability to fulfill domestic and commercial requirements and good economic returns within possible time. Farmers have been raising a number of agricultural crops like Wheat, Paddy, Sugarcane, Millet, Maize and fodder crops like Berseem, Chari, and Maize fodder with these species. However vegetables crops were reported in combination with Poplar tree species only. The most prevalent agro forestry combination found in the study area could be specified as agri-silvi-pastoral, agri-silviculture (food-crop and tree-crop combination) and silvi-pastoral (animals and tree-crop combination). These combination can be arranged in time and space with reference to tree crop species. A wider practice and promotion of different tree-crop combinations in models is important because they have shown an increased level of agro forestry adoption in the region. It is crucial to advance information on characteristics of each adopted model (tree-crop combination). It is also important to describe the growth characteristics and management practices of tree-crops. Periodic assessment on recorded models and farm approach could be solution to it which should be beneficial from the viewpoint of both farmers and the researchers. A remarkable potential of some combination tree-crop combinations are widely recognized by the farmers in the region, and hence, the research done here to study and analyze these combinations

becomes useful. This study would also be helpful as a reference on adopted agro forestry models in the region.

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