Agroforestry Practices in Ballia District of Eastern Plain Region of Uttar Pradesh, India

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Abstract— *Agroforestry is an efficient land-use system where trees or shrubs are grown with arable crops, seeking positive interactions in enhancing productivity on the sustainable basis. Agroforestry combines agriculture and forestry technologies to create more integrated, diverse, productive, profitable, healthy and sustainable land-use systems. The study was conducted in selected villages (1%) of Ballia District of Eastern plain region of Uttar Pradesh in India during the year 2018 to record the crop combinations with tree species and their stratified arrangement to identify agroforestry practices. The socio-economic studies based on general village profile, land holding, land use pattern and tree species planting pattern were performed in 1 % villages to collect the data with structured questionnaire and Participatory Rural Appraisal (PRA) tools. The results demonstrated that a total of six different agroforestry practices, agri-silviculture, silvi-horticulture, agri-horticulture, agri-silvi-horticulture, silvi-pastoral, and homestead existed in different villages. Out of different categories, timber, fruits, medicinal, agriculture, flower and other plant species were recorded. It was recorded that out of existing agroforestry practices, scattered near farms and around homestead was found most common (about 37.7 %) followed by agri-silviculture (20.20 %), silvi-horticulture (19.1 %) and agri-horticulture (12.3 %). The pattern of plantation on bunds and blocks was 17.94 % and 16.82 % respectively. The benefits from agro forestry practices in the villages was also assessed and ranked in their order of preferences in respective blocks of district. The different benefits as fruits/vegetables, timber, shade, medicinal, fodder, firewood, protection, and soil erosion were scored from 1 to 8. It was concluded from the results that status of agroforestry in the studied zonal area of the region is in developing stage and needs to be improved by imparting technical knowledge about planting material, methods and sale of end produces of trees to the farmers and tree growers.*

Keywords— Socio-economic studies, agroforestry practices, homestead system, trees benefit scoring.

I. INTRODUCTION

Agroforestry has traditionally been a way of life and livelihood in India for centuries. It is a land use system which involves trees with agricultural crop/grass or animals simultaneously. Agroforestry has attracted the interest of scientists and development planners because it provides variety of products for meeting varied requirements of the people, insurance against risks caused by weather aberrations, controlling erosion hazards and ensuring sustainable production of the intercrops (Nair, 2007). Agroforestry systems in India include trees in farms, community forestry and a variety of local forest management and ethno-forestry practices. In UP, agroforestry practices vary according to different agro-climatic zones, land capability and socio-economic status of farmers. The variation is reflected in terms of diversity in agroforestry practices, and comparative advantage prompted a renewed interest to harness the vivid potential (Verma *et al.* 2017). The survey revealed the wide spectral potential of agroforestry practices in sustenance of agriculture as they provide food, fodder, fruit, vegetables, fuel wood, timber, medicines, fiber etc. from the same piece of land at a time which not only fulfils the demand of people but also elevate their socioeconomic status and standard of life (Pathak et al., 2000).Today, Indian agriculture faces diverse challenges and constraint due to growing demographic pressure, increasing food, feed and fodder needs, natural resource degradation and climate change (Dhyani *et al*., 2013). Therefore, a management system needs to be devised that is capable of producing food from marginal agricultural land and is also capable of maintaining and improving quality of producing environment (Dobriyal, 2014).

Agroforestry system is one of the best known traditional practices and has an important role in reducing vulnerability, increasing resilience of farming systems and buffering households against climate related risks (CAFRI, 2015), but there are

several challenges that reap the benefits of agroforestry in India. There is shortage of superior planting material and improved seed varieties (Verma *et al*. 2017). In India, just as there is a great diversity in climate similarly there exists a large number of agroforestry systems of various forms and types (Dagar *et al*., 2014) .The current area under agroforestry in India is estimated as 25.31 million hectares or 8.2 percent of the total reporting geographical area of the country by Dhyani *et al*. (2013); Dagar *et al*. (2014) and CAFRI (2015). As the population of India is increasing at a very fast rate; the land-holding size of farmers shrink at a very fast rate and agroforestry is the only way to optimize the farm productivity (National Agroforestry Policy, 2014).It is generally well known that status of agroforestry in districts of Eastern plain region of Uttar Pradesh is in developing stage. From Forest survey of India report (2017), it was recorded that forest cover including tree cover is only 0.74 per cent in the district of Ballia. Therefore, a study has been conducted in selected villages (1%) of Ballia district of Eastern plain region of Uttar Pradesh in India during the year 2018 to assess the socio-economic profile of villages for land use pattern, general information about villages, status of tree plantations, crop combinations with tree species and their stratified arrangement to identify agroforestry practices with a view to study existing tree species in different agro forestry systems in the villages and their benefits in day- to- day life of rural livelihood. The choice of species in agroforestry models were also recorded on the basis of their preferences in plantations.

II. EXPERIMENTAL METHODS

2.1 Study area: Ballia district

Ballia is the eastern most part of the Uttar Pradesh state and borders on Bihar State. It comprises an irregularly shaped tract extending westward from the confluence of the Ganga and the Ghaghra, the former separating it from Bihar in the south and the latter from Deoria and Bihar in the north and east respectively. The boundary between Ballia and Bihar is determined by the deep streams of these two rivers. It is bounded on the west by Mau, on the north by Deoria, on the north-east and south-east by Bihar and on the south-west by Ghazipur. The district lies between the parallels of 25º33' and 26º11' North latitudes and 83º38' and 84º39' East longitudes. It has 17 blocks with 2372 number of villages.

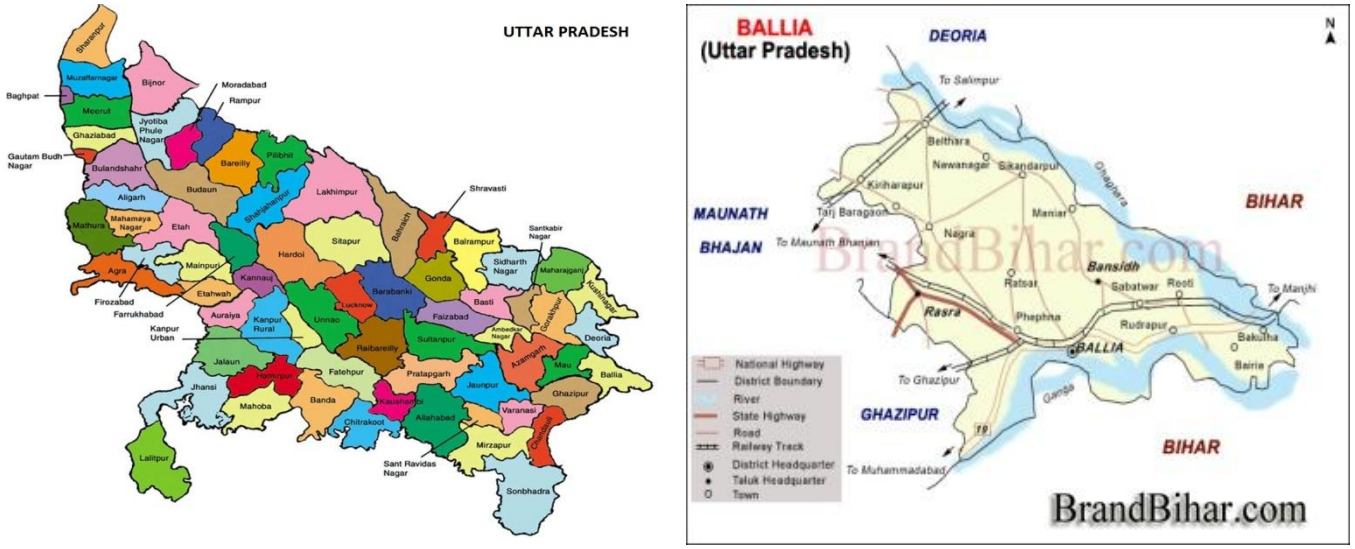

FIGURE 1: Map of Uttar Pradesh, and Ballia district

2.2 Socio-economic study:

The study was carried out in Ballia district of eastern plain region of UP. The socio-economic survey with structured questionnaire and Participatory Rural Appraisal (PRA) technique was used to study the general information of villages, land use pattern, existing status of agroforestry through appraisal of existing farming systems and agroforestry practices and farmers preference for management practices of agroforestry systems such as agri-silviculture, boundary plantation, silvi-pasture, silvi-horticulture, agri-silvi-horticulture, multi-storey, homestead etc. In the region, one representative village in each

developmental block was selected to cover the area. Out of 2372 villages existing in the Ballia, 1% villages were taken for study through stratified random sampling method. A total of 10 per cent households were involved in the survey including farmers of small, medium, large and marginal category, males and females covering age and caste of all groups in selected villages. In each selected village, a random sampling technique was used to select farmers. The primary and secondary data was collected from the selected study area. A semi–structured questionnaire was developed. The pre-test work of questionnaire was done by interviewing farmers in selected villages. Thus, the final questionnaire was prepared on the basis of valid suggestions. Before going to make interview, each respondent was given a brief introduction about the nature and purpose of the study. The collected data was verified through surveying the villages and personal interview with the sample respondents. Interviews were normally conducted in a common place of villages where people of all categories including women may sit collectively.

2.3 Data processing and analysis

After completion of collecting data from all the interview schedules were compiled, tabulated and analyzed in accordance with objectives of the study. The responses to the questions in the interview schedules were transferred to master sheet to facilitate tabulation for describing the different characteristics and their constraint facing, the respondents were classified into several categories. The MS Excel was used for data processing and analysis.

2.4 Experimental Results and Analysis

The results of socio-economic studies in villages of Ballia district revealed that land holding area (Table 1) for majority of farmers are under marginal category (86.88 %) with small, medium and large in 8.24, 3.00 and 1.88 % respectively. The land use pattern (Table 2) showed that agriculture was major land use (78.41 %) followed by agroforestry (11.24 %) and horticulture (4.59 %). The diversity of trees, crops and vegetables in the study area reflected different combination of trees and crops in the study area (Table 3). The results demonstrated that a total of 06 different agroforestry practices, agri-silviculture, silvi-horticulture, agri-horticulture, agri-silvi-horticulture, silvi-pastoral, and homestead existed in different villages. Out of different categories, timber, fruits, medicinal, agriculture, flower and other plant species were recorded. The different agroforestry combinations were recorded namely: eucalyptus-wheat, teak-maize, teak-marigold, teak-vegetables (potato & cabbage) in Dubhad block, teak-wheat / mustard, teak- maize, teak-mango, teak-vegetables (potato) in Belhari block, teak-maize/sorghum, teak- wheat/mustard, teak-marigold, teak/shisham-potato/chilli, Aquaculture in Bairia block, teak- maize, mango-wheat, eucalyptus-vegetable (tomato/chilli) in Murlichhapara block, teak-wheat, teak-chickpea, teak-pigeon pea in Beruarbari block, shisham-wheat, teak-mango/wheat/pigeon pea in Gadwar block, wheat-eucalyptus, teak-chickpea/potato, shisham-black/green gram in Chilkahar block, eucalyptus/shisham-wheat/arhar, teak-wheat/vegetables in Maniar block, eucalyptus/shisham-aquaculture, teak-pigeon pea, mango-mustard/wheat, teak-bajra/maize in Nawanagar block, teak-potato, shisham-onion/garlic, teak-maize/sorghum in Pandah block, shisham-potato/tomato, teak-marigold, mango/guava-wheat/mustard, teak-maize in Bansdih block, teak-wheat, teak/eucalyptus-garlic/onion in Revati block, teak-maize/sorghum, shisham/teak-chick pea, mango-mustard, teak-vegetables(potato/cabbage/chilli) in Sohaon block, teak-wheat/maize/sorghum, shisham-potato/chilli in Hanumangaj block, teak/mango-wheat, eucalyptus-wheat/mustard in Siar block, eucalyptus/shisham-wheat, shisham/mango-mustard/wheat, teak-maize/jowar in Nagra block, teak-wheat/mango, eucalyptus-maize crops in Rasra block of the district Ballia.

It was recorded that out of existing agroforestry practices, scattered near farms and around homestead was found most common (about 37.7 %). The existing agroforestry systems were also quantified in the district (Table 4 and Fig.2) followed by agri-silviculture (20.20 %), silvi-horticulture (19.1 %) and agri-horticulture (12.3 %). The teak, mango, eucalyptus and aonla were most preferred species in plantations (Table 5). The pattern of plantation in agroforestry was also studied and found that systematic tree planting on bunds and blocks was very less with 17.94 % and 16.82 % respectively (Table 6 and Fig.3). The benefits ranking from trees depicted that daily need (fruits and vegetables) was ranked most preferred followed by timber as second and shade was ranked as third benefit. The other benefits were nutrients, protection, soil erosion control and N-fixation (Table 1).

TABLE 1
LAND HOLDING PATTERN IN BALLIA DISTRICT

S. No.	Land holding area (ha)	Dubhar	Belhari	Bairia	Murli Chhapra	Beruarbari	Garwar	Chilkahar	Maniar	Navanagar	Pandah	Bansdih	Rewati	Sohanv	Hanumanga j	Siar	Nagra	Rasra	Average
1	Marginal (<1ha)	92	95	98	99	95	94	95	90	55	99	95	93	95	70	40	92	80	86.88
2	Small (1-2 ha)	5	3	2	1	3	3	4	5	40	1	2	4	3	20	30	4	10	8.24
3	Medium (2-3 ha)	2	1	0	0	1	2	1	3	3	0	2	2	1	6	20	2	5	3.00
4	Large (>3ha)	1	1	0	0	1	1	0	2	2	0	1	1	1	4	10	2	5	1.88

TABLE 2
LAND USE PATTERN IN BALLIA DISTRICT

S. No.	Land use Pattern	Dubhar	Belhari	Bairia	Murli Chhapra	Beruarbari	Garwar	Chilkahar	Maniar	Navanagar	Pandah	Bansdih	Rewati	Sohanv	Hanumangaj	Siar	Nagra	Rasra	Average
1	Agriculture	75	70	75	90	80	85	70	73	75	90	80	80	82	80	75	83	70	78.41
2	Agroforestry	10	18	15	5	12	3	20	18	10	2	10	9	8	10	20	11	10	11.24
3	Horticulture	8	5	7	1	2	2	3	5	2	1	5	5	7	5	2	3	15	4.59
4	Waste Land	2	3	1	1	2	3	1	2	3	2	2	3	1	2	1	2	2	1.94
5	Others	5	4	2	3	4	7	6	2	10	5	3	3	2	3	2	1	3	3.82

TABLE 3
EXISTING TREE CROP COMBINATIONS IN AGROFORESTRY SYSTEMS IN BALLIA

S. No.	Blocks	Existing Agroforesry System	Classes of Agroforestry System
1	Dubhad	Eucalyptus – Wheat Teak – Maize Teak – Marigold Teak – Potato / Cabbage	Agri – Silviculture Agri – Silviculture Silvi – Horticulture Silvi – Horticulture
2	Belhari	Teak – Maize Teak – Wheat / Mustard Teak – Mango Teak – Potato	Agri – Silviculture Agri – Silviculture Silvi – Horticulture Silvi – Horticulture
3	Bairia	Teak – Maize / Sorghum Teak – wheat / Mustard Teak – marigold Teak / Shisham – Potato / Chilli Mango/Mahua – Aquaculture	Silvi – Pastoral Agro – Silviculture Silvi – Horticulture Silvi – Horticulture Aqua – Horticulture
4	Murlichhapara	Teak – Maize Teak – Wheat Mango – Wheat / Mustard Eucalyptus – Tomato / Chilli	Agro – Silviculture Agro – Silviculture Agro – Horticulture Silvi – Horticulture
5	Beruarbari	Teak – Wheat Teak – Chickpea Teak – Pigeon Pea	Agro – Silviculture Agro – Silviculture Agro – Silviculture
6	Gadwar	Shisham – Wheat Teak - Mango Teak – Wheat Teak – pigeon Pea	Agro – Silviculture Silvi – Horticulture Agro – Silviculture Agro – Silviculture

7	Chilkahar	Wheat – Eucalyptus Teak – Chick Pea Teak – Potato Shisham – Black / Green Gram	Agro – Silviculture Agro – Silviculture Silvi – Horticulture Agro – Silviculture
8	Maniar	Eucalyptus – Wheat / Arhar Teak – Wheat Shisham – Wheat / Arhar Teak – Potato / Brinjal Teak – Onion / Cauliflower	Agro – Silviculture Agro – Silviculture Agro – Silviculture Silvi – Horticulture Silvi – Horticulture
9	Nawanagar	Eucalyptus – Wheat Teak – Pigeon Pea Eucalyptus / Shisham – Aquaculture Mango – Mustard / Wheat Teak – Bajra / Maize	Agro – Silviculture Agro – Silviculture Aqua – Silviculture Agro – Horticulture Silvi – Pastoral
10	Pandah	Eucalptus – Wheat / Mustard Teak –Potato Shisham – Onion / Garlic Teak – Maize / Sorgham	Agro – Silviculture Silvi – Horticulture Silvi – Horticulture Silvi – Pastoral
11	Bansdih	Teak – Maize Shisham – Potato / tomato Teak – Marigold Mango / Guava – Wheat / Mustard	Agri – Silviculture Silvi – Horticulture Silvi – Horticulture Agro – Horticulture
12	Revati	Teak – Wheat Teak – Garlic / Onion Eucalyptus – Garlic / Onion	Agro – Silviculture Silvi – Horticulture Silvi – Horticulture
13	Sohaon	Teak – Maize / Sorghum Shisham / Teak – Chick Pea Mango – Mustard Teak – Potato / Cabbage / Chilli	Silvi –Pastoral Agro – Silviculture Agro – Horticulture Silvi – Horticulture
14	Hanumanganj	Teak – Wheat Shisham – Potato / Chilli Teak – Maize / Sorghum	Agro – Silviculture Silvi – Horticulture Silvi – Pastoral
15	Siar	Teak – Wheat Eucalyptus – Wheat / Mustard Mango – Wheat	Agro – Silviculture Agro – Silviculture Silvi – Horticulture
16	Nagra	Eucalyptus - Wheat Shisham – Wheat Shisham – Mustard Mango – Wheat / Mustard Teak – Maize / Jowar	Agro – Silviculture Agro – Silviculture Agro – Silviculture Agro – Horticulture Silvi – Pastoral
17	Rasra	Teak – Wheat Teak – Mango Eucalyptus - Maize	Agro – Silviculture Silvi –Horticulture Agro – Silviculture

TABLE 4
EXISTING AGROFORESTRY SYSTEMS IN BALLIA DISTRICT

S. No.	Classes of agroforestry systems	Status in Ballia district (%)
1	Agri-silvi	20.20
2	Silvi-horti	19.1
3	Agri-horti	12.3
4	Agri-silvi-horti	3.5
5	Silvi-pastoral	7.3
6	Homestead	37.7

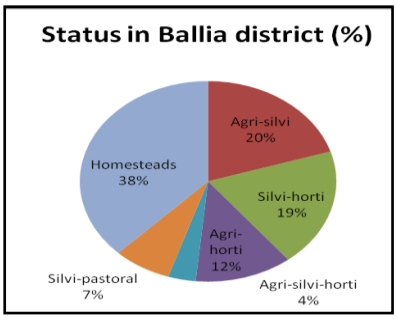

FIGURE 2: Status of Agroforestry systems were also quantified in the district

TABLE 5

PREFERENCE SCORE OF TREES IN BALLIA DISTRICT

S. No.	Tree species	Preference score of trees
1	Teak	1
2	Shisham	8
3	Mango	2
4	Neem	5
5	Babool	7
6	Bamboo	9
7	Mahua	6
8	Eucalyptus	3
9	Aonla	4
10	Others	10

TABLE 6

STATUS OF PATTERN IN AGROFORESTRY PLANTATION IN BALLIA DISTRICT

Pattern of agroforestry plantation	Status in developmental Blocks (%)																	Status in Ballia District (%)
	Dubhar	Belhari	Bairia	Murli Chhapra	Beruarbari	Garwar	Chilkahar	Maniar	Navanagar	Pandah	Bansdih	Rewati	Sohanv	Hanumangaj	Siar	Nagra	Rasra	
Scattered on farms	23	30	28	40	23	28	23	24	31	35	32	24	28	21	28	22	27	27.47
Bunds	17	12	16	8	18	16	22	26	18	12	17	16	16	19	22	30	20	17.94
Block	14	18	12	6	22	12	17	22	21	10	11	12	24	15	26	20	24	16.82
Others	46	40	44	46	37	44	38	28	30	43	40	48	32	45	24	28	29	37.76

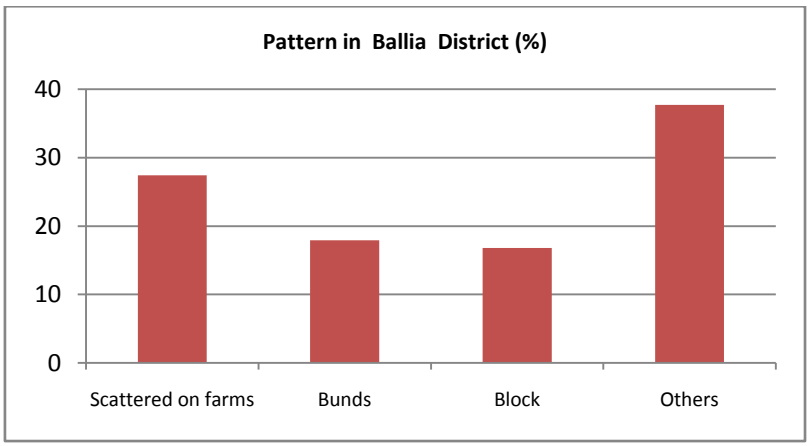

FIGURE 3: Systematic tree planting on bunds and blocks

TABLE 7

BENEFITS FROM AGROFORESTRY IN BALLIA

Benefits	Benefits in developmental Blocks																		Preference score
	Dubhar	Belhari	Bairia	Murli Chhapra	Beruarbari	Garwar	Chilkahar	Maniar	Navanagar	Pandah	Bansdih	Rewati	Sohanv	Hanumangaj	Siar	Nagra	Rasra	Average	
Shade	2	3	3	1	3	2	3	3	3	1	2	3	3	3	3	3	3	2.59	**3**
Fruit/Veg.	1	1	1	2	1	1	1	1	1	3	1	2	1	1	1	2	1	1.29	**1**
Timber	3	2	2	3	2	3	2	2	2	2	3	1	2	2	2	1	2	2.12	**2**
Fire wood	4	4	8	8	5	8	5	4	8	8	4	5	5	5	6	5	5	5.71	**6**
Medicinal	8	6	7	4	6	4	6	5	4	5	5	4	4	6	5	4	6	5.24	**4**
Soil erosion	6	7	5	5	8	6	8	6	7	7	8	8	7	8	8	8	8	7.06	**8**
Protection	7	5	6	7	7	7	7	7	6	6	7	7	8	7	7	7	7	6.76	**7**
Fodder	5	8	4	6	4	5	4	8	5	4	6	6	6	4	4	6	4	5.24	**5**

The farmers have little opportunities to select the tree species and therefore, they accept whatever is available on their land (Bhatt *et al.* 2010). Dadhwal *et al.* (1989) and Toky *et al.* (1989) have recognized three agroforestry systems with their multifarious benefits. The various problems and constraints of agroforestry can be overcome through policy and institutional reforms (Smith *et al.,* 1998). Moreover, there is deficiency in the understanding of biophysical concerns correlated with productivity, water-resource sharing, soil productivity and plant interactions in agroforestry systems, since most of the research is site-specific, observational in nature and not process-oriented (Puri and Nair, 2004). In almost all tropical and subtropical eco zones, agroforestry is represented by the homestead farming, essentially the mixed cropping of annual and perennial crops around the farmer's dwelling houses. Home gardens are recognized worldwide as an epitome of sustainable agroforestry systems (Torquebiau, 1992; Kumar & Nair, 2004). Thus, agroforestry practices can be an important tool to achieve the 4 per cent sustainable growth in agriculture (National Agroforestry Policy, 2014). The promotion of sustainable agroforestry practices on a large scale in future is only possible through amalgamation of proactive farmer policies of government, involvement of the industries, support services from NGOs and willingness of farmers (Verma *et al.* 2017). Extension services are important for smooth dissemination of research results on the different aspect of agroforestry but research results on agroforestry, available in the public and private domain do not regularly reach the farmers due to lack of a proper or dedicated extension system. The Farmers with major land holdings will get more benefit by the agroforestry related schemes than the small and marginal farmers. So, there is need to introduce special programmes on agroforestry models for marginal and small farmers (Verma *et al.* 2017) because 2/3rd farmers of Indian farmers are small and marginal farmers (Kumar *et al.* 2017; Singh & Pandey, 2011) . It is needed to strengthen the agroforestry practices by identifying successful models that can be adopted by the farmers on a wide scale. Advancement of contemporary agricultural technology would also be helpful in increasing the yield of sole crops as well as intercrops (Jain & Singh, 2000). In order to use agroforestry systems as an important option for livelihood improvement, climate change mitigation and sustainable development in India, research, policy and practice will have to progress towards: (i) effective communication with people in order to enhance agroforestry practices with primacy to multifunctional values; (ii) maintenance of the traditional agroforestry systems and strategic creation of new systems; (iii) enhancing the size and diversity of agroforestry systems by selectively growing trees more useful for livelihood improvement; (iv) designing context-specific silvicultural and farming systems to optimize food production, carbon sequestration, biodiversity conservation; (v) maintaining a continuous cycle of regeneration-harvest–regeneration as well as locking the wood in non-emitting uses such as woodcarving and durable furniture; (vi) participatory domestication of useful fruit tree species currently growing in wilderness to provide more options for livelihood improvement, and (vii) strengthening the markets for non-timber forest products. Prevalence of a variety of traditional agroforestry systems in India offers opportunity worth reconsidering for carbon sequestration, livelihood improvement, biodiversity conservation, soil fertility enhancement and poverty reduction (Pandey, 2007).

III. CONCLUSION

The different combinations of agroforestry systems were recorded in the studied areas which were of various benefits for rural livelihood. The systematic pattern in tree planting needs to be improved for the region. The extension and training programmes regarding selection of species, tree planting pattern, nursery raising, quality planting material, maintenance and management of plantations and most importantly, the marketing of trees as end produce. In marketing or sale of trees, transit and felling permit to be issued by forest department is very important. The unawareness of rules and fear of administration discourages farmers for adopting agroforestry widely at large level in this region. It is well known that western part of UP is more flourished than Eastern part for adoption of agroforestrty. It is now urgent need of time to adopt tree plantations in massive way in districts of Eastern Plain zone to achieve our national target of forest policy. Agroforestry is the only way for progress for farmers and rural people, leading to sustainable development, food and nutritional security. Agroforestry adoption with suitable species of economic value will improve country's forest and tree cover to the 33 per cent as desired in national forest policy. The foresters, researches, NGOs and tree growers and traders are needed to coordinate on a common platform for successful implementation of agroforestry programme on massive level. Further, to enhance the efforts of farmers, sale of end products should be strengthened with the involvement of project planners and wood based industries.

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Existing agroforestry systems in Ballia

Socio economic studies in villages of Ballia

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