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Research Article

Assessment of Factors Affecting for Adoption of Agroforestry by Local Communities of Vaishali, Bihar, India

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Abstract

Agroforestry is considered one way to avoid deforestation to reduce CO_2 emissions into the atmosphere and mitigate climate change. Deforestation is a serious problem in many developing countries, mainly due to subsistence and commercial agriculture. The present study complemented the secondary data related to Agroforestry schemes adoption with household surveys and key informant interviews to obtain evidence from farmers and promoters of the schemes on the factors affecting adoption the of agroforestry by the local community of Vaishali, Bihar. Based on data analysis and parameter estimates value, the three most important factors as Socio-Economic Level (Livestock, Income Level); External Unforeseen Factors (Protection from Wild Animals, Insects, Climate), and Economics of Business (Market Availability) impacting the Adoption of Agro-forestry Schemes (AAS) in Vaishali, Bihar.

Keywords: Agroforestry; Factors; Vaishali; Bihar

Introduction

Agroforestry is considered one way to avoid deforestation to reduce CO_2 emissions into the atmosphere and mitigate Climate Change [1,6,10]. Deforestation is a serious problem in many developing countries, mainly due to subsistence and commercial agriculture [3,11]. About 17% of global CO_2 emissions come from deforestation [4], significantly contributing to Climate Change (Van der Werf et al. 2009) [4]. Therefore, it is important to adopt agroforestry practices to address the continuous depletion of forest resources and improve the livelihood of forest communities. Among them, agroforestry is a land use system that integrates pasture, trees, and animals, allowing ecological and economic interactions. The environmental and productive benefits of agroforestry are well known from the recovery of degraded land and water to adaptation to Climate Change; however, the rate of adoption of such production strategies is still low. The large body of literature on farming technology adoption, summarized in Patnaik et al. 1984 and Knowler and Bradshaw, 2007 gives an overview of the complexity of the adoption process, which is influenced by social, economic, financial, and natural factors. Farmers have practiced agroforestry since ancient times. Agroforestry focuses on the wide range of trees grown on farms and other rural areas. Among these are fertilizer trees for land regeneration, soil health, and food security; fruit trees for nutrition; fodder trees for livestock; timber and energy trees for shelter and fuel wood; medicinal trees to cure diseases and trees for minor products viz. gums, resins or latex products. Many of these trees are multipurpose, providing a range of benefits. According to the 2001 report of the Forest Survey of India, the forest cover in the country is 675,538 sq. km, constituting 20.55% of its total geographical area. The National Agriculture Policy (2000) emphasized the role of agroforestry for efficient nutrient cycling, nitrogen fixation, and organic matter addition and for improving drainage and underlining the need for diversification by promoting integrated and holistic development of rainfed areas on a watershed basis through the involvement of the community to augment biomass production through agroforestry and farm forestry. The Task Force on Greening India for Livelihood Security and Sustainable Development of Planning Commission (2001) has also recommended that for sustainable agriculture, agroforestry may be introduced over an area of 14 million ha out of 46 m ha irrigated areas that are degrading due to soil erosion, water-logging, and salinization. For integrated and holistic development of rainfed areas, agroforestry is to be practiced over an area of 14 million ha out of 96 m ha. Besides ensuring ecological and economic development, this will provide livelihood support to about 350

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million people. The practice of agroforestry can help in achieving these targets. Therefore, in the quest to optimize productivity, the multitier system came into existence. The gap of the demand and supply of forest produce in India is widening and forests are unable to fulfill the demand. Agroforestry can play an important role in filling this gap and conservation of natural resources. Agroforestry combines agriculture and forestry technologies to create more integrated, diverse, productive, profitable, healthy, and sustainable land use systems. The most important agroforestry practices are windbreaks, riparian forest buffers, alley cropping, silvipasture, and forest farming. Agroforestry is a set of practices that provide strong economic and conservation incentives for landowner adoption. Incorporated into watersheds and landscapes, agroforestry practices help to attain community/society goals for more diverse, healthy, and sustainable land-use systems.

Study Area

The study area was chosen on the basis of agroforestry project implementing district, Vaishali, Bihar. It is located in 25°41'N 85°13'E and 25.68°N 85.22°E. The district has a geographical area of 2,036 square kilometers with a population of 3,495,021. of which male and female were 1,844,535 and 1,650,486 respectively as per Census 2011. This district has 3 sub-divisions but is administratively divided into 16 blocks and comprises of 2 forest ranges namely Hajipur and Lalganj.

Materials and Methods

The primary data has been collected from beneficiaries using a structured questionnaire technique. Data for each respondent has been further verified by visiting their farmland and physically inspecting it. The data has been collected using 16 factors (Identified using FGD) classified under 6 criteria namely, Socio-economic Level, Support from the Forest Department (Government Support), Economics of Business (sustainability in Income Generation), Land, External Unforeseen Factors, Beneficiaries Attitude for Adoption of Scheme. The 16 factors, covered under the study using a structured questionnaire are listed as, 1. Education Level of the Beneficiary; 2. Social Class; 3. Income Level; 4. Livestock (in Number); 5. Size of the land (Marginal, Small, Medium, or Large Farmer); 6. Level of training imparted (Duration and total number of instances); 7. Occupation (Farming/ Non-Farming); 8. Irrigation facility; 9. Types of species planted and their Mortality Status (Poplar ETP/Other);10. Market availability; 11.Protection of sapling (Protection Guard/ Unprotected); 12.Extent of wild animals; 13.Quality of samplings (Condition, as received from Nursery); 14.Input cost (Other than procurement); 15.Subsidy from Government (Release of payment);16. Soil fertility levels (Fertile/Non-fertile).

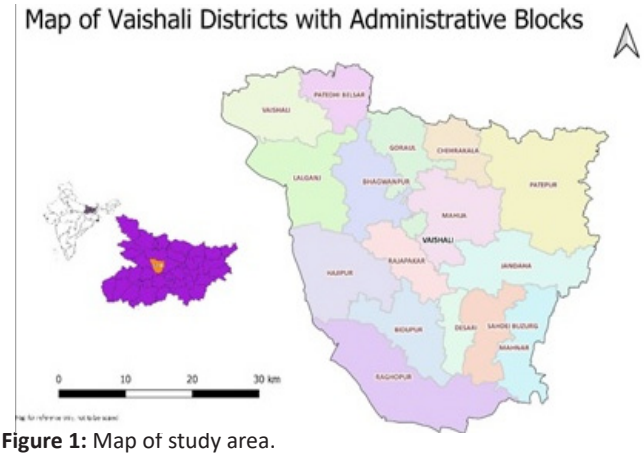

Figure 1: Map of study area.

Data Interpretation

Further, to identify the most influential factors affecting Agro-forestry adoption Factor Analysis has been administered using IBM SPSS 22.0v.

Result and Discussion

Socio-Demographic Profile

With respect to various socioeconomic characteristics like the occupation of the household members, there may be some variations between "adopters" and "non-adopters". This study has assessed the major occupations of household heads as public/government employees, subsistence farmers, Businessmen, and others which include self-employed or a combination of these occupations (Table 1).

Size of the Land (marginal, small, medium, or large farmers)

One of the critical factors that have been given consideration in determining the potential acceptability and viability of agroforestry is land fragmentation. Land fragmentation at generational transfers has become a more important tendency in nearly all types of holdings. Rules of inheritance of land by all sons in a family and a larger family size inevitably imply a rapid fragmentation of family land. In areas already heavily populated with average land holdings of less than 2 acres such as parts of Urban Hajipur, the land fragmentation continues much below the limits of capacity to reproduce a family. This has reduced land sizes among families leaving only small pieces of land for food production. In the study of Agroforestry adoption and risk perception by farmers in different parts of the world, it is established that land ownership is one of the two predominant factors affecting the adoption of agroforestry practices. This study has quantified the factor "Size of the land" by identifying the respondents as marginal, small, medium, or large farmers (Table 2).

Table 1: Distribution of Respondents profile as per their occupation in the study area.

Characteristics	Percentage	Characteristics	Percentage	Characteristics	Percentage
Educational level		**Major Occupation**		**Social Caste**	
No formal Education	7.0%	Agriculture	97.0%	SC	3.5%
Primary School	11.0%	Business	0.5%	ST	0.5%
Middle School	11.0%	Service	1.5%	General	84.5%
Matriculation (10th Standard)	45.0%	Other	1.0%	Others	11.5%
Graduate	26.0%				

Table 2: Distribution of Respondents from Vaishali as per type of farmers.

Type of Farmers	Number	Percent
Marginal Farmer	14	7.0%
Small Farmer	65	32.5%
Middle Farmer	78	39.0%
Big Farmer	13	6.5%
No Response	30	15.0%
Grand Total	**200**	**100.0%**

Livestock (In Number)

Besides, fodder and fuel wood, there is a considerable dependence of farmers on common property and public forests for litter for livestock, with its quantity collected varying considerably by location, season, and the accessibility to the forest. However, "adopters" and "non-adopters" may differ considerably in terms of livestock owned by farmers. For this reason, this study has assessed the interplay between the number of livestock and the adoption of Agroforestry. The Livestock status of respondents of this study has been assessed in Vaishali.

Annual Income

Level of Training Imparted (duration and number of instances)

This study supports the notion that appropriate training may increase the adoption of agroforestry among farmers as cited in different studies. This study bases its argument on the fact that formal and informal training has the potential to increase the rate of adoption by directly increasing awareness and imparting skills and knowledge of the agroforestry schemes. The impact of exposure to information about agroforestry and the level of training provided on the decision to adopt agroforestry will reveal some interesting trends crucial for policy interventions (Tables 4 & 5).

Table 3: Annual Income of respondent in the study area.

Annual Income	Percentage in the sample population
INR 10,000 to 50,000	35.5%
INR 50,000 to 1,00,000	52.0%
INR 1,00,000 to 3,00,000	10.0%
INR 3,00,000 to 5,00,000	2.5%

Table 4: Distribution of Respondents from Vaishali as per status of Training.

Training	Number	Percent
Trained	122	61.0%
Need training	76	38.0%
No Response	2	1.0%
Grand Total	**200**	**100.0%**

Table 5: Assessment of Frequency of Training of Beneficiaries from Vaishali.

Response	Number	Percent
Less than 5 times	199	99.5%
5 to 10 times	1	0.5%
More than 15 times	0	0.0%

Table 6: Status of total plantation in sampled households in Vaishali.

Number of Trees	Farm Plantation (on all land)	Agriculture Plantation (with Crops/Block or on Boundary)
Total no. of Trees	139056	40661
Average No. of Trees	869	635

Table 7: Types of Species Planted in Sampled Households in Vaishali.

Name of Tree	Number	Percentage	Name of Tree	Number	Percentage
Poplar	107	53.5%	Neem	3	1.5%
Gamhar	38	19.0%	Eucalyptus	3	1.5%
Kadamb	7	3.5%	Mango	28	14.0%
Semal	78	39.0%	Litchi	12	6.0%
Arjun	76	38.0%	Amrood	25	12.5%
Sagwan	68	34.0%	Babul	1	0.5%
Shisham	71	35.5%	Bamboo	4	2.0%
Jamun	30	15.0%	Kadamb	3	1.5%
Karanj	19	9.5%	Others*	12	6.0%
Mahogany	75	37.5%			

Table 8: Assessing reasons for Non-survival of Plants in Sampled Households (respondents view).

Respone	Yes		No		No Response		Total	
	Number	%	No.	%	No.	%	No.	%
Damage from Wild Animal	176	88.0%	15	7.5%	9	4.5%	200	100.0%
Lack of Irrigation	29	7.3%	129	32.3%	42	10.5%	200	50.0%
Lack of Quality Saplings	4	1.0%	143	35.8%	53	13.3%	200	50.0%
Human caused Damage	1	0.3%	146	36.5%	53	13.3%	200	50.0%

Table 9: Assessment of Soil Fertility Levels in Vaishali.

Status	Number	Percent
Unsatisfactory	1	0.5%
Satisfactory	170	85.0%
Very Good	25	12.5%
General	4	2.0%
Grand Total	**200**	**100.0%**

Types of Species Planted (Poplar ETP or other)

This combination of species planted should not only meet the fodder needs of the cattle and timber needs for agricultural implements but also add organic matter to the soil. Therefore, the majority of the farmers usually adopt the tree species mainly for a reason to meet their fuel and cattle fodder demand. Assorted species of trees and shrubs grown on farms are an integral component of local economies. In the past, farmers gave little or no priority to planting trees on their private lands due mainly to easy access to community and public forests for fodder, fuel wood, and timber collection as well as the availability of some naturally grown trees on agricultural lands. Because of widespread deforestation and the transfer of ownership and management of forests to their users under the recent community forestry programs, access to forest resources has been severely curtailed forcing farmers to seek alternatives. One such alternative is agroforestry involving both indigenous and exotic fodder tree species in private farmlands. Thus, the adoption of agroforestry, which can combine the production of crops, livestock, and forest on a sustainable basis is crucial. It is observed that Poplar, Semal, Gamhar, Sagwan, Shisham, Mahogany, and Arjun are major species which is planted in Vaishali.

Survival of Agroforestry Plantations: Assessment of Mortality Rate of the Saplings

Interestingly, Mortality Status (Poplar ETP/Other) across various FYs such as 2012-13, 2013-14, and 2014-15 as responded to by Adopters has a significant impact on the perception of Non Adopters for availing the given scheme. Based on the data survival rate of Poplar ETP and other planted Species such as, Gamhar (*Gmelina arborea*), Sheesham (*Dalbergia sissoo*), Sagwan (*Tectona grandis*), Arjun (*Terminalia arjuna*), Neem (*Azadirachta indica*), Banana, Babul (*Acacia nilotica*), Kadamb (*Neolamarckia cadamba*), Eucalyptus (*E. Tereticornis*), Mango, Guava and Mahogani (*Swietenia humilis/ mahagoni*) varies across Plantation Years for the District. Data suggest that for Poplar ETP and Other Species (Gamhar, Shisham, Sagwan, Arjun, Neem, Banana, Babul, Kadamb, Eucalyptus, Mango, Guava, and Mahogani) Planted for the FY 2012-13, the mortality rates were highest for the first year of plantation (i.e., FY 2013-14) and later decreased significantly for FY 2014-15. Findings suggest that if a plant (sapling) survives for its first year of planta-

Table 10: Extraction of various factors.

	Component					
	1	2	3	4	5	6
Education	.722	.313	.180	.112	.311.	.112
Social class	.452	-.639	-.107	.233	.221	.114
Level of training imparted	-.116	.914	.594	.222	.221	-.153
Income	.731	-.064	-.006	.443	.043	.177
Occupation	.595	.131	.063	.211	.131	.045
Extent of wildlife animals	.245	-.140	.030	.112	.546	.078
Size of the land	.171	.024	.106	.950	.339	.341
Livestock	.945	.148	.101	.022	-.632	.219
Soil fertility levels	.010	.481	-.044	.864	-.332	.178
Protection of saplings	.063	-.149	.274	-.224	.733	-.078
Subsidy from government	.542	.674	.442	.438	.166	-.045
Quality of saplings	.422	.743	.111	.319	.167	.045
Motivation for species planted	-.542	.332	.122	.289	.225	.777
Irrigation facility	.211	.441	.331	.799	.332	.234
Market availability	.121	.112	.789	.476	.087	.123
Input cost	.114	.341	.456	.211	.034	-.076
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.						
a. Rotation converged in 6 iterations.						

tion, it has a high probability of its survival. The highest threat to survival includes Wild Animals like Neelgai (Boselaphus tragocamelus). Protecting trees from animal damage is necessary for the survival of agroforestry plants. Animals like Hare, Mice, Nelgai (Boselaphus tragocamelus), and other cattle can cause a great deal of damage to small tree plantings. Fencing is a common control method that is particularly useful when small areas such as orchards or shelterbelts are being damaged. But still, the extent of wild animals is surely a significant factor that affects the adoption of agroforestry schemes. When this study assessed the reasons for the Non-survival of Plants in Sampled Households from Vaishali, it was confirmed that wild animals are a big problem for adopters. The assessment of reasons for the Non-survival of Plants is given below.

Soil Fertility Levels

Soil fertility refers to the ability of a soil to sustain plant growth, i.e. to provide plant habitat and result in lasting constant yields of high quality. Fertile soil is rich in nutrients necessary for basic plant nutrition, including nitrogen, phosphorus, and potassium. The Bihar state lies in the eastern part of the Indo-Gangetic plain. It occupies the fertile alluvial land stretching from the foothills of the Himalayas in the north to a few miles south of the river Ganges which crosses the state from west to east. The Indo-Gangetic plain is one of the world's major food-grain-producing regions. The Soil Fertility Maps of Bihar indicate that the study area Vaishali falls under the low Potassium region. In this study, we have assessed Soil fertility levels based on the perception of adopters which ranges from very good to unsatisfactory.

Factors Affecting Agroforestry Adoption

Factors have been extracted using the Principal Component Analysis (PCA) technique and rotation methods such as Rotation Method: Varimax with Kaiser Normalization. A total of 6 factors have been extracted with Eigen Value more than 1. The total 5 factors identified using the Rotated Component Matrix are as, 1) Socioeconomic Level; 2) Support from Forest Department (Government Support); 3) Economics of Business (sustainability in Income Generation); 4) Land Size; 5) External Unforeseen Factors (Wild Animals and in turn survival of Samplings).

Conclusion

This study examines the factors that affect the adoption of agroforestry in the Vaishali region of Bihar. Agroforestry schemes, especially evergreen agriculture and conservation agriculture with trees have emerged as sustainable measures of addressing land degradation and loss of soil fertility. Although agroforestry is known to be beneficial to farmers and the environment, its adoption rate falls far behind the projected goals. The study also highlights that the intervention was not especially pro-poor with the adoption of Agro-forestry schemes occurring disproportionately among relatively wealthier households with larger landholdings. This in turn suggests the need for various policy interventions and recommendations focusing forest department. This study concludes that by adopting agroforestry practices, livelihood and income generation can be improved. The marketing of agroforestry by-products is very important for the success and sustainability of this initiative. The training programs in this area may be helpful for improving livelihood and helping farmers to address marketing issues.

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