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The Potential of Agroforestry in India's Deccan Plateau for Climate Resilience and Carbon Storage

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ABSTRACT

Carbon sequestration is a phenomenon for the storage of atmospheric carbon dioxide and other forms of carbon to mitigate global warming. The Deccan Plateau, covering a significant portion of central and southern India, faces unique environmental challenges exacerbated by climate change. This research delves into the potential of agroforestry as a sustainable solution, aiming to enhance climate resilience and promote carbon storage in this region. By integrating trees with traditional farming systems, this study seeks to present a comprehensive understanding of how agroforestry can address both ecological and socio-economic challenges in the Deccan Plateau. Agroecosystems also contribute to the mitigation of the climate change and are being an adaptation strategy for the farmers.

Keywords: Agroforestry, forestry, carbon storage, climate resilience

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1. INTRODUCTION

Agroforestry is a technique of land use planning to achieve economic, social and environmental sustainability. It helps in reducing poverty, contributes to resilient livelihoods and improves food and nutrition security. Agroforestry can increase microbial activities and reduced soil erosion. Agroforestry practices sequester carbon in vegetation and soil, can make a substantial contribution to global climate change mitigation with potential source of income to poor farmers[1]

The Deccan Plateau, with its distinct topography and climate, has been a bastion of traditional Indian agriculture for centuries. However, with the advent of climate change, the region is witnessing erratic rainfall patterns, prolonged droughts, and soil degradation[2]. These challenges necessitate innovative and sustainable agricultural practices. Agroforestry, the age-old practice of integrating trees into farming systems, offers promise in this context. This research aims to explore the multifaceted benefits of agroforestry in the Deccan Plateau, focusing on its potential for carbon sequestration and enhancing climate resilience.

2. OBJECTIVES OF THE STUDY

a) To assess the current state of agroforestry practices in the Deccan Plateau and their contribution to soil health and carbon storage.

b) To evaluate the potential of different agroforestry systems in enhancing water retention, biodiversity, and overall farm resilience in the region.

c) To understand the socio-economic implications of agroforestry adoption, including its impact on local livelihoods and economic returns.

d) To identify challenges and barriers to the widespread adoption of agroforestry in the Deccan Plateau and provide actionable recommendations.

3. METHODOLOGY

3.1 Literature Review

A literature search was conducted to identify the papers related to carbon sequestration. Agroforestry practices in the Deccan Plateau offer a multifaceted solution to the region's environmental and socio-economic challenges. The literature reviewed here

demonstrates the potential of agroforestry in improving soil health, conserving water resources, enhancing biodiversity, mitigating climate change, and improving farmers' livelihoods. However, addressing the identified challenges and conducting long-term studies will be crucial to fully harness the benefits of agroforestry in this region.

"Agroforestry practices and their role in sustainable land use in the Deccan Plateau, India" (Srinivasarao et al., 2007): This study discusses the adoption and impact of agroforestry systems in the Deccan Plateau, emphasizing soil and water conservation benefits.

"Agroforestry in the Deccan plateau of India: Boundaries, household diversity and drivers of dynamics" (Kumar et al., 2019): This research examines the spatial distribution and drivers of agroforestry systems in the Deccan Plateau, with insights into socioeconomic factors.

"Impact of agroforestry on soil properties: A review" (Naresh et al., 2018): This review discusses the influence of agroforestry on soil properties, including organic matter content, nutrient cycling, and erosion control, which are critical in the context of the Deccan Plateau's fragile soils.

"Hydrological and soil erosion impact of forest and agroforestry systems in the Deccan Plateau of India" (Gebrehiwot et al., 2014): This study evaluates the hydrological and erosion-reducing benefits of forest and agroforestry systems in mitigating soil erosion, a significant concern in the region.

"Assessing the socio-economic impact of agroforestry systems in the Deccan Plateau" (Kulkarni et al., 2016): This research assesses the socio-economic benefits of agroforestry, including income diversification and improved livelihoods for farmers in the Deccan Plateau.

"Agroforestry as a climate-smart agriculture strategy for smallholders in the Deccan Plateau" (Rao et al., 2019): This study explores the role of agroforestry in enhancing smallholder farmers' resilience to climate change and its potential to improve food security in the region.

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3.2 Field Survey

3.2.1 Selection of the Study Area

Deccan Plateau is located in most part of South India. and its states are Karnataka, Andhra Pradesh, Kerala, Tamil Nadu, Maharashtra and Telangana. The plateau has over 43% of India's landmass. The plateau lies between Western and the Eastern Ghats. It forms a triangular shape. Its elevation is 2,000 ft sloping towards eastwards

Figure 1 : Location Map of the study area

3.2.2 Climate in Deccan plateau

Climate in the plateau is usually semi-arid to tropical in most parts of the place. It has rainfall from June to October in the monsoon season. It is very hot in summer and its temperature exceeds 40 degree Celsius. Agriculture is the main profession of the majority people. Pulses, seeds, rice and cotton are of the major crops grown here.

3.2.3 Site selection and sampling procedure

Anantapur district of Andhra Pradesh (Rayalaseema region) was chosen for the study. After that three panchayats of Ananthapur district namely Ingaluru, Venkatapuram and Thummalakuntla Palle were randomly selected for the analysis and from each panchayat 3 villages were selected for the study purpose. So, there are 9 villages and I have collected data from 25 farmers in each village. Thus, the total sample size for the study of 250 farmers were chosen based on the goal of the research on agroforestry systems and intensive farming systems as well as categories representing various, ages, education family size holdings of land, reasons for agroforestry adoption, farmer challenges, and various socioeconomic categories [3] .

3.2.4 Data Collection

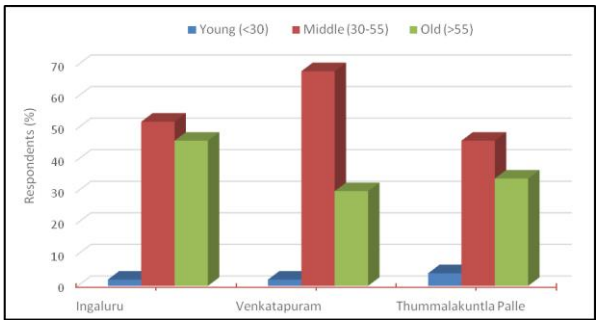
Face-to-face interviews, farm visits, and structured questionnaires were used to collect the data. Information was obtained on agroforestry adoption, socio-demographics of the farmers and the desires of farmers for agroforestry farms, and desires of farmers for integration trees on farms.

4. RESULTS AND DISCUSSION

Socio-economic Information of the respondents were observed from the respondents.

4.1 Age of the respondents under the study area

The results of the socio-economic studies in villages of three panchayats revealed that the age of the majority respondents in (Table 1) were in the middle age group with a high percentage of 68% in Venkatapurum site and the lowest was in Thummalakuntla Palle with 46%. Similarly, the least percentage of young-aged farmers were involved in agricultural operations in the study area with 2 to 4% in the identified sites of the study.



Figore 2 : Age of the respondents under the study area

4.2 Education of the respondents under the study area

Based on a survey of the findings in (Table 2), the education of the respondents was categorized into five categories as Illiterate, Primary school, Middle school, High school, and Graduate. Based on a survey in the Ingaluru panchayat, about 50% of respondents graduated followed by the high school category (34%). But the Primary school and Illiterate categories were very lower in the surveyed area of the study. In Thummalakuntla Palle panchayat majority of the respondents had a high school education and graduated. Also, it had lower number of respondents studied up to middle and primary school education. In the Ingaluru panchayat, it was observed more graduated and high school-educated respondents, but primary school- level educated respondents were the least in number. Education is an important variable for farmers to know about their farming operations, level of technical knowledge on agroforestry systems, and knowledge about tree and crop adaptation.

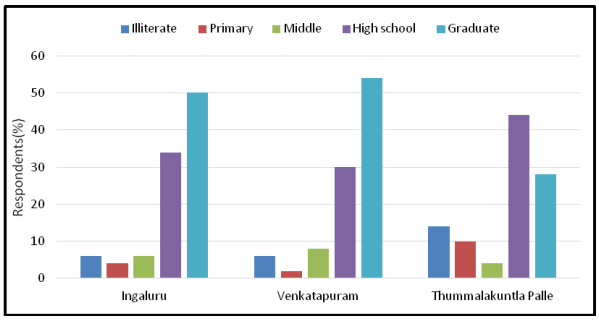


Figure 3 : Level of education of the respondents under the study area

4.3 Land under the Agroforestry System

Results in Table 3 revealed that the land under Agroforestry in three areas having high percent of the land is in a large group and it was present in Ingaluru with 54% followed by Venkatapuram (52%) and Thummalakuntla Palle (50%). The least land-holding farmers were mainly present in the medium category in Ingaluru and Venkatapuram with percent of 2%.

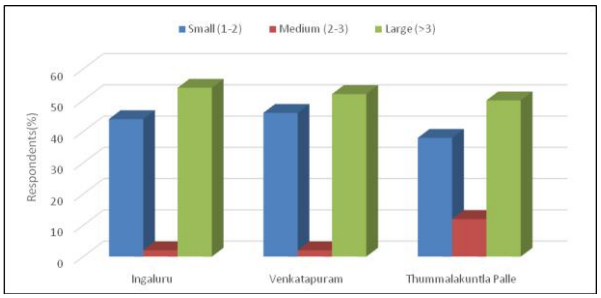


Figure 4 : Land under Agroforestry system in survey area

4.4 Reasons for the adaptation of agroforestry

Combining crops, trees, and cattle is a typical method among farmers to deal with the problem of a severe lack of fuel, fodder, and other supplies. The farmers have few options to choose the tree species, so they settle with whatever is there on their property. Agroforestry is the driving force behind this system's advantages for farmers. While the availability of fuel wood was the main factor in traditional agroforestry systems, commercial agroforestry in Eastern Uttar Pradesh was based on huge revenue. As presented in Table 4, the majority of the farmers adopted trees on

their farmland for traditional purposes in Ingaluru site (72%) and in Venktapuram and Thummalakuntla Palle was 72% and 70% respectively. The adoption of agroforestry systems for commercial purposes was observed highest in Thummalakuntla Palle (18%) followed by Ingaluru (16%) and Venktapuram (12%).

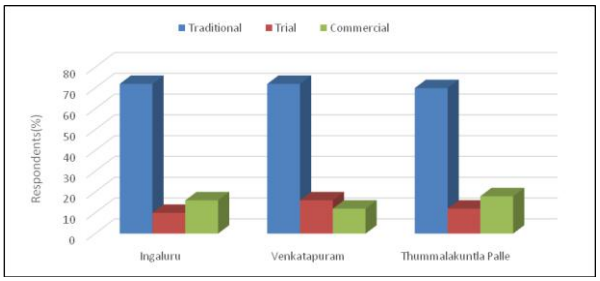


Figure 5 : Reason for adaptation of agroforestry by respondents in the survey area

4.5 Agrisilviculture System Followed by the Farmers

During the survey, a question regarding the preference of the trees for future adoption was also asked from the respondents and the resultant data have been presented in Table 5. It was evident that agrisilviculture is the most widely practiced agroforestry type in the area, while silvipastrol is the least widely practiced agroforestry type. The study conducted by Kumar et al. identified that agri-silviculture, silvopastoral, and agri-silvopastoral are the most common agroforestry types in the study area. Agrisilviculture system is the combination of trees and crops and the farmers are mostly were cultivating crops like paddy, mustard, and wheat in combination with the trees like Teak, Eucalyptus on their land. The results revealed that the Agri-silviculture system was practiced in the three study areas and in Pratapgarh (Teak + Paddy and Eucalyptus + Mustard) both were observed highest: 96%); in Allahabad (Eucalyptus+mustard: 96%) and Kaushambi (Teak+ mustard: 95.6%) were highest.

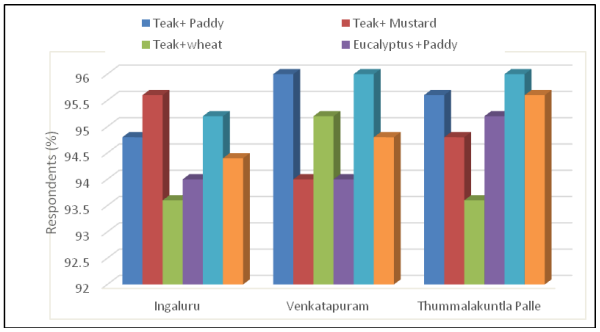


Figure 6 : Agrisilviculture system followed by respondents in survey sites

5. OBSERVATIONS

5.1 During the study the following information on the environmental benefits were observed from the study sites:-

- **Biodiversity Enhancement** - Agroforestry systems in the Deccan Plateau have contributed to increased biodiversity compared to conventional agricultural practices. Enhancing biodiversity in agroforestry systems in the Deccan Plateau not only contributes to ecological conservation but also promotes the resilience and sustainability of agricultural production. Agroforestry practices in the Deccan Plateau have the potential to enhance biodiversity while also providing livelihood opportunities for local communities. Biodiversity was observed through Tree Species Diversity, Insects and Pests, Mammals and Soil Microorganisms. Agroforestry systems can improve soil health and microbial diversity. Beneficial soil microorganisms contribute to nutrient cycling, decomposition of organic matter, and overall soil fertility.

- **Soil Health and Fertility** - Agroforestry practices have shown improvements in soil health, including enhanced nutrient content and reduced erosion. Healthy soils store more carbon. Environmental impacts of storing carbon in soil ensures Improved soil quality and health [4]. Soil carbon is an important factor in improving soil health and agricultural productivity. Trees in agroforestry systems help maintain soil structure and organic matter.

- **Water Management** - Some agroforestry systems have demonstrated improved water management through enhanced groundwater recharge and reduced surface runoff. The trees' deep root systems can help prevent soil erosion and retain moisture.

- **Climate Resilience** - Agroforestry has been recognized for its ability to make farming communities more resilient to climate change. By providing shade and windbreaks, it can help protect crops from extreme weather events.

5.2 Socio-economic benefits of agroforestry – *The Farmers/Public Socio-economic upliftment of farmers was observed*

Agroforestry, as a sustainable land-use practice, demonstrates significant socio-economic advantages, highlighting its potential to enhance local livelihoods and ensure sustainable agricultural returns in various regions, including the Deccan Plateau in India[5]. Here are the key results from studies and observations:-

- **Diversified Income -** Farmers practicing agroforestry reported diversified income sources. In the Deccan Plateau, for instance, they earned income not only from staple crops but also from tree products such as timber, fruits, and nuts. This diversity mitigated income risks associated with crop failures or price fluctuations.
- **Improved Food Security -** Agroforestry systems have contributed to improved food security in the Deccan Plateau. Farmers reported having access to a wider range of food items throughout the year, reducing their dependence on a single crop. This diversification helps safeguard against food shortages during adverse weather conditions.
- **Higher Yields and Productivity -** Studies showed that agroforestry systems resulted in higher agricultural productivity. Shade trees, windbreaks, and improved soil fertility within these systems contributed to increased crop yields. This, in turn, positively impacted farmers' incomes.
- **Sustainable Resource Management -** Agroforestry promoted sustainable land and resource management practices in the Deccan Plateau. Farmers reported reduced soil erosion and improved soil health, which allowed for continuous agricultural production without degrading the land.
- **Resilience to Climate Change -** Local farmers practicing agroforestry demonstrated greater resilience to climate change. The presence of trees helped protect crops from extreme weather events, reducing crop losses during droughts, floods, and storms. This resilience is critical for ensuring long-term agricultural viability.

6. CONCLUSION

The study revealed that agroforestry has great potential of reducing atmospheric carbon-dioxide through carbon sequestration as plant and soil carbon. This paper reviewed agroforestry is an important strategy to sequester carbon from the Deccan Plateau regions. Agroforestry both have equally important roles in reducing carbon emissions and providing food security to the people of the rural areas. Agroforestry has sustainable agricultural methods help to mitigate climate change by sequestering and storing carbon in the trees and in the soil. There is the potentiality of agroforestry in the Deccan Plateau for the climate change adaptation and carbon storage.

Thus, by development of suitable agroforestry system in different agroclimatic regions of the country, not only the green tree cover can be increased but also the level of greenhouse gas in atmosphere can be reduced to a great extent. Hence, agroforestry will prove to be a viable strategy for climate change mitigation if it is promoted for wider adoption by the farmers in the country. This system has a positive impact on conservation of soil and water, restoration of soil organic matter and livelihood support to the farmers in arid and semi-arid region of central India. These systems contribute to increased sustainability of agricultural production.

7. REFERENCES

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APPENDIX

Table 1. Age of the respondents in survey districts

Age of Respondents (year)	Ingaluru		Venkatapuram		Thummalakuntla Palle	
	Frequency	%	Frequency	%	Frequency	%
Young (<30)	05	02	05	02	10	04
Middle (30-55)	130	52	170	68	115	46
Old (>55)	115	46	75	30	85	34
Total	**250**	**100**	**250**	**100**	**250**	**100**

Table 2. Education of the respondents in three survey areas

Education of the Respondents	Ingaluru		Venkatapuram		Thummalakuntla Palle	
	Frequency	%	Frequency	%	Frequency	%
Illiterate	15	06	15	06	35	14
Primary	10	04	05	02	25	10
Middle	15	06	20	08	10	04
High school	85	34	75	30	110	44
Graduate	125	50	135	54	70	28
Total=	**250**	**100**	**250**	**100**	**250**	**100**

Table 3. Land under Agroforestry system in survey area

Land under Agroforestry	Ingaluru		Venkatapuram		Thummalakuntla Palle	
	Frequency	%	Frequency	%	Frequency	%
Small (1-2)	110	44	115	46	95	38
Medium (2-3)	05	02	05	02	30	12
Large (>3)	135	54	130	52	125	50
Total	**250**	**100**	**250**	**100**	**250**	**100**

Table 4. Reason for adaptation of agroforestry by respondents in the survey area

Season for Adaptation of AGF	Ingaluru		Venkatapuram		Thummalakuntla Palle	
	Frequency	%	Frequency	%	Frequency	%
Traditional	185	72	180	72	175	70
Trial	25	10	40	16	30	12
Commercial	40	16	30	12	45	18
Total	**250**	**100**	**250**	**100**	**250**	**100**

Table 5. Agrisilviculture system followed by respondents in survey districts

Agrisilviculture System	Ingaluru		Venkatapuram		Thummalakuntla Palle	
	Frequency	%	Frequency	%	Frequency	%
Teak+ Paddy	237	94.8	240	96	239	95.6
Teak+ Mustard	239	95.6	235	94	237	94.8
Teak+wheat	234	93.6	238	95.2	234	93.6
Eucalyptus +Paddy	235	94	235	94	238	95.2
Eucalyptus + Mustard	238	95.2	240	96	240	96