

**ECONOMIC APPRAISAL OF CULTIVATING  
KHAIR (*Acacia catechu*) ON FARM LANDS IN  
JAMMU REGION OF JAMMU AND KASHMIR**

by  
**RAMANPREET KOUR**  
**(J-20-M-713)**

**A Thesis submitted to  
Faculty of Agriculture  
in partial fulfillment of the requirements  
for the degree of**

**MASTER OF SCIENCE IN AGRICULTURE  
AGRICULTURAL ECONOMICS**



**DIVISION OF AGRICULTURAL ECONOMICS AND ABM**  
Sher-e-Kashmir University of Agricultural Sciences & Technology of Jammu

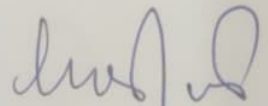
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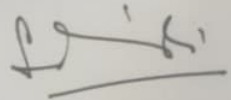
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The work has been carried out by **Miss Ramanpreet Kour**, Registration No. **J-20-M-713** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma. It is further certified that help and assistance received during the course of thesis investigation have been duly acknowledged.



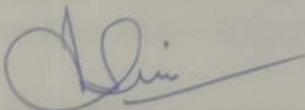
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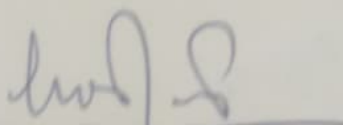


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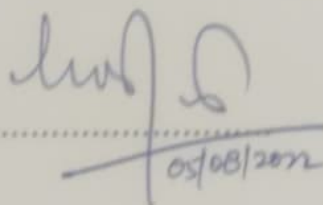
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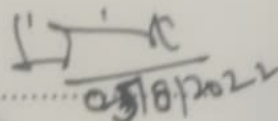
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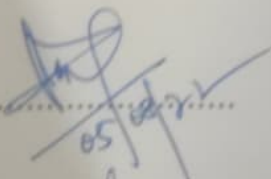
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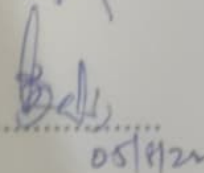
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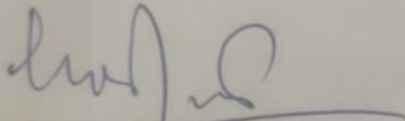
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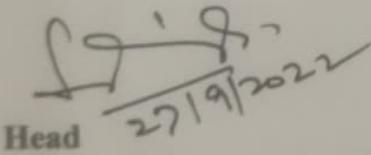
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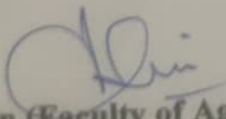
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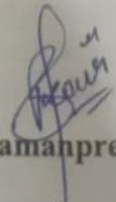
Heartfelt gratitude is due towards my respectable Papa **Mr. Jatinder Pal Singh**, my beloved mumma **Mrs. Kulwant Kour**, my bhaiya **Mr. Manjot Singh**, my didi **Mrs. Amanpreet Kour** and my jiju **Mr. Jagjyot Singh** for being my best guides, friends and my everything. Neither verbally nor materialistically can I repay for the unconditional love, support and unparalleled affection you have provided me with throughout my life. With heartiest reverence, I admire the confidence bestowed on me by my parents. Whatever I am today, I owe it to them.

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Date: 22-08-2022

  
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## ABSTRACT

Title of the Thesis	: Economic Appraisal of cultivating Khair (Acacia catechu) on farm lands in Jammu region of Jammu and Kashmir
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### Abstract

The present study was conducted in the Jammu and Kashmir UT. Two districts were selected for the study i.e. Kathua and Samba. The economics of agroforestry system involving *Acacia catechu* was assessed keeping in view the modification of government policy. Both primary as well as secondary data were used in the proposed study. The secondary data was collected from the Forest Department of selected districts in J&K. The list of areas / forest range having high concentration under of *Acacia catechu* was procured from Forest Department, J&K and one zone was purposively selected for appraisal of its economics. 100 farmers were selected randomly from the list procured from the Forest department to collect the data on production, management and marketing of *Acacia catechu*. 30 farmers from neighboring areas were interviewed to assess the comparative economics of cropping system. The study was conducted with the objectives to map the concentration of commercially exploitable Khair in Jammu region of J&K, to assess the economics of farming systems associated with cultivation of Khair, to compare the economics of alternative cropping systems, excluding agroforestry and to perform profitability analysis of growing Khair on farm lands under new policy framework. The methodology used for the study involve CACP for cost and return, cobb douglas production function for resource use efficiency. Kathua district was found to be highly concentrated of Khair trees followed by Samba district in Jammu region of J&K UT. The cropping pattern followed by the respondents in kharif season involve crops such as maize, paddy, blackgram and in Rabi season wheat, mustard and toria. Analysis of data revealed that the total cost when taken as an average for maize, paddy, wheat, blackgram, mustard and toria is ₹52979.25, ₹58795.21, ₹46367.06, ₹41232.21, ₹44787.77, ₹60002.85 with net return of ₹17102.28, ₹53329.96, ₹5000.38, ₹40352.79, ₹73794.10, ₹68103.80 having cost benefit ratio of 1:1.32, 1:1.90, 1:1.07, 1:1.97, 1:2.64, 1:2.13 respectively. The assessment of comparative economics revealed that agroforestry intervention yields higher B.C ratio i.e. 1:6.14 compared to normal cropping system i.e. 1:1.88. The result of Cobb Douglas regression model revealed that the coefficient of cost of Khair and quantity of DAP was significant at 1% level of significance. The value of R square was calculated to be 0.781 which shows 78 per cent variability of dependent variable is explained by independent variables under study.

Keywords: CACP, Resource use efficiency, *Acacia catechu*, Agroforestry, Khair

Signature of Major Advisor

Signature of the Student

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### INTRODUCTION

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#### 1.1 Overview

Agriculture has been one of the basic occupations since ancient times. In India it dates back during the time of Indus Valley or Harappan civilization. But in modern era, agriculture is being developed, not just as a mean to feed oneself but as an enterprise. Thus, one needs to view agriculture as an industry to earn profit, instead of a nominal occupation. With such an approach, allied sectors such as animal husbandry, fishery, forestry etc. assumes great importance. Recently, agroforestry has been gaining popularity and considered as a shining approach as it merges century's old knowledge with modern sciences.

“Agroforestry is a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos etc.) are deliberately used on the same land-management units as agricultural crops and/ or animals, in the form of spatial arrangement or temporal sequence (FAO, 2015)”. India has adopted national agroforestry policy in Feb., 2014 with an objective to maximize agricultural productivity for mitigating climate change. With its implementation India became the first country in the world to do so (Chavan *et al.*, 2014).

India has 80.7 million hectares of forest and tree cover which accounts to 24.56 per cent of total geographical area in the country (Forest survey of India, 2019). In Jammu and Kashmir, total area under forest cover is about 53,258 sq. km. that is about 39.96 per cent of total geographical area. As of particular to Jammu, total area under forest is 21,122 sq.km. i.e. about 56 per cent (Indian State of Forest Report, 2019).

There are several types of agroforestry system practised in India, Agrisilvicultural system which involves combination of trees and crops, silvopastoral system combines forestry and grazing of domesticated animals on pastures, rangeland or on-farms and agrosilvopastoral system involves integration of trees, animals and crops (FAO, 2015).

Agroforestry has many important economic and commercial uses. It provides woods, medicines, fuel wood and many other agricultural produces. Trees mainly

considered in agroforestry are Poplar, Acacia, Pine, Eucalyptus, Sandal, Terminalia etc.

Khair (*Acacia catechu* Willd), in agroforestry has been considered to provide various products such as catechu, tannin, firewood, dye etc. It is a deciduous tree having light feathery crown and dark brown, smooth, slender, thorny, shining branchlets, usually twisted (Orwa *et al.*, 2009). Catechu is widely distributed from North-West plain to East ward in Assam and throughout the country, particularly in drier and deciduous region.

Acacia is the botanical name of this tree and it has different varieties; such as *Acacia sundara* found mostly in Indian Peninsula, *Acacia catechuoides* found mostly in Sikkim terai, West Bengal and Assam, *Acacia catechu* found chiefly in Punjab, Garhwal and Kumaon, Bihar and Orissa (Orwa *et al.*, 2009). These trees are mainly concentrated in Uttar Pradesh, Jammu and Kashmir, Bihar, Gujarat, Rajasthan, and Himachal Pradesh. The tree can be propagated by planting its seeds, which are soaked in hot water first. After about six months in a nursery, the seedlings can be planted in the field ([www.fao.org](http://www.fao.org)). The maximum temperature required for the tree growth ranges from 37.5 °C to 43.5°C and the minimum from 1°C to 2.1°C (ICFRE, 2015). The tree is generally grown in dry regions though in its alluvial form, it is also found in the region with rainfall as high as 3800 mm. It thrives best on porous alluvium, composed of sand and shingle and on well drained sandstone. Height of Khair tree is generally small or medium i.e. about 12-15m with 60-90cm girth and a bole of 2 to 3 metres (CRC Weed Management, 2003). The bark of the tree is reported to be beneficial in treatment of snake bites and the flowers when mixed with cumic, milk, sugar is beneficial in treatment of gonorrhoea.

The heartwood, bark, and wood extract (called *catechu*) are useful for preparation of traditional medicine (Goodwin, 1982). The concentrated aqueous extracted from the tree is cutch or khayer gum, is astringent (British Pharmacopoeia, Department of Health, British Pharmacopoeia Commission, London. The Stationery Office, 1999). The use of heartwood extract is in dyeing and leather tanning, as a preservative for fishing nets and as a viscosity regulator for oil drilling (Valli Herman, 2003). The flowers are good source of nectar and pollen for bees. The tree is generally used as firewood and charcoal and its wood is highly beneficial for furniture and tools. The wood has a density of about 0.88 g/cm cube. Branches of the tree are quite

often cut to use for goat fodder and are sometimes used fed to cattle. The seeds of the tree are a good source of protein. The gum obtained from Khair is of very good characteristics and is regarded as best substitute for true gum arabic.

Manufacturing of *Katha* is an important forest wood traditional industry in India. The Central Forest Research Institute, Dehradun has developed and improved process of manufacturing *Katha* and products. Catechu is obtained by crystallization in cold from water extractives of the heartwood of *Acacia catechu* commonly known as Khair tree. It is an ingredient of pan preparations as in combination with lime; it gives red coloration resulting from chewing of pan.

According to the section 51 A in the Indian Forest Act, 1927, union government transferred the power to regulate, manufacture, etc. of articles based on forest produce to the state government. This gave state government the authority to provide for establishment and regulation by licences, permits or otherwise (any payment of fees therefore) of saw mills and units including factories engaged in manufacture of *Katha* out of Khair tree.

The Government of J&K adopted “The Jammu and Kashmir Non- Forest Land Khair Trees ‘*Acacia catechu*’ (Management Plan) Rules, 2016” by virtue of SRO 111 of 2016.

In this law, it was stated that permission regarding growing of Khair tree in private land and later felling, marking, conversion, transportation and disposal of Khair tree can be given to private ownership after seeking permission from state government via proper inspection by related officers. It also provides for setting up of manufacturing units of *Katha* after acquiring permission from state authority (“The Jammu and Kashmir non forest land Khair tree *Acacia catechu*” (Management Plan) Rules, 2016). Therefore, the present study is proposed to mainly evaluate the returns of Khair tree plantation under changed rules and regulations.

## **1.2 Benefits of Agroforestry**

In India, agroforestry systems comprise both traditional and modern land use methods, and they have tremendous potential and application in many areas, such as provision of employment to rural and urban populations through production, processing, and value addition. According to estimates, one hectare of plantation in wood-based enterprises employs about 450 people; hence, 30 million hectare has the

capacity to employ almost 15,000 million people in addition to providing employment options in the wood-based value chain (Singh and Dhyani, 2014).

According to the Forest Survey of India (2017), the country's present forest and tree cover is 79.42 million hectares, or 24.39 per cent of the total geographical area, however the National Forest Policy (1988) mandates that one third of the country's geographical area should be covered by forest and trees. Unfortunately, there is still a 9 per cent shortfall, and substantial afforestation initiatives in non-forest regions are desperately needed, but this is a difficult challenge for developing countries like India.

Agroforestry may be the only practical alternative for achieving a forest and tree cover of 33 per cent of the country's overall geographical area. According to CAFRI (2015) by 2050, an additional 28.0 mha of agroforestry might be added, bringing the total to 53.23 mha, or 17.5 percent of the country's reported agroforestry area. The majority of this land will come from fallows, cultivable fallows, orchards, deteriorated and wasteland, and has the power to reshape the fortunes of small and marginal farmers and rural people in the region by providing resources to support livelihood and food security while also contributing to regional economic growth (Singh and Dhyani, 2014).

Besides that, according to Chavan et al. (2015), agroforestry systems have the capability to produce 100 million cubic metres of timber/pulpwood for industrial and domestic use, which would meet 65 per cent of the nation's timber demand, 2/3 of small timber demand, 70–80 per cent of plywood demand, and 60 per cent of raw material demand for paper pulp. It also produces 150 million tonnes of firewood, which is enough to meet half of the nation's demand. Similarly, agroforestry provides 9–11 per cent of green fodder requirements (Singh and Pandey 2011, CAFRI 2015).

According to IPCC reports, agroforestry is one of the most important tools for combating climate change and increasing farmer endurance to threats of climate change and natural catastrophes because it provides services such as microclimate control, conservation of natural resources, carbon sequestration, water resource protection, soil erosion, and pollution (Chavon *et al.*, 2015). Agroforestry systems can sequester up to 10 tonnes of carbon per hectare per year (Chavon *et al.*, 2015), with an

average sequestration potential of 25 tonnes of carbon per hectare (Singh and Pandey, 2011).

### **1.3 Limitations of Agroforestry**

The agroforestry system is one of the most well-known traditional techniques, and it plays a critical role in lowering vulnerability, boosting farming system resilience, and protecting households from climate-related risks (CAFRI, 2015). However, there are a number of obstacles to reaping the benefits of agroforestry in India. Superior planting material and enhanced seed varieties are in scarce supply (Verma *et al.*, 2017). Only around 10 per cent of planting material is of good quality, with the rest without any assurance of quality.

There is a lack of study on agroforestry models suitable for a variety of agroclimatic areas; indigenous and multipurpose species (e.g. *Prosopis cineraria*); and species domestication, resulting in an over-emphasis on a few species such as Poplar, Eucalyptus, Kadam, and others (National Agroforestry Policy, 2014). Another concerning element is that agroforestry research in India has traditionally been undertaken on research stations with tiny plots or in laboratories. On an ecosystem or landscape level, little or no study has been done, and the majority of studies are of a relatively short duration (Puri and Nair, 2004).

Except in a few states, there are no marketing infrastructures for agroforestry products in the country. As a result, it's mostly a buyer's market, with middlemen reaping the majority of the profit. Due to a lack of awareness of technical and economic data on various agroforestry models, institutional finance and insurance coverage in agroforestry has fallen short of its potential (National Agroforestry Policy, 2014; Planning Commission, 2001).

In addition, there is complicated, expensive, and inconvenient regulations governing tree cutting, timber transportation, processing, and marketing (Planning Commission, 2001), all of which play a part in the thoughts of farmers considering agroforestry (Chavan *et al.*, 2014). Similarly, several authorities impose tax at different phases of the processing. As a result, native agroforestry products are gradually losing ground to imported goods. As a result, these regulatory constraints must be removed as soon as possible.

#### **1.4 Government Initiatives to promote Agroforestry**

In 2016-17, the Sub-Mission on Agroforestry (Har Medh Par Ped) Scheme was implemented to promote tree planting on fields in combination with crops/cropping systems in order to enable farmers earn additional revenue while also making their agricultural systems more climate responsive and flexible. The scheme is being implemented in 20 states, including Andhra Pradesh, Bihar, Chhattisgarh, Gujarat, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Kerala, M.P., Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, U.P., Mizoram, Meghalaya, Nagaland, and two union territories, namely J&K and Ladakh, with a funding pattern of 60:40 between state and centre government for all states except NE and Hilly states, where it is 90:10, and 100 per cent for UTs and National Level Agencies.

Farmers are given assistance through the State Government for nursery development, boundary plantation, and block plantation of notable species of trees to promote, fruits bearing tree borne oilseeds, medicinal and aromatic plants, silk & lac nurturing host plants, and wood species, so that producers receive early returns. (Ministry of Agriculture and Farmers Welfare, 2021)

#### **1.5 Policy and legal issues**

Khair has been designated as an industrial species in Jammu and Kashmir, and its felling and export was governed by the Jammu and Kashmir Preservation of Specified Trees Act 1969 (J&K Forest Law Compendium, 2008).

The Government of Jammu and Kashmir passed an Act in 1969 to do more for the protection of particular tree species as well as the restriction of their felling and export for industrial purposes. Initially, this legislation was enacted to protect walnut trees, but in 1978, the government issued SR0-320, dated June 10, 1978, declaring the Khair tree as a specified tree, and in 1981, Willow trees were added to the list of specified trees.

Therefore, from 1978 onwards the Preservation of Specified Trees Act regulated all felling and export of Khair trees from private estates.

The Jammu and Kashmir Forest Act 1987, the Jammu and Kashmir Forest Conservation Act 1997, and the Wildlife Protection Act and its guidelines govern the management of Khair trees on Forest Lands.

## 1.6 Objectives

Keeping in view the facts discussed above, the present proposed investigation entitled, “**Economic Appraisal of cultivating Khair (*Acacia catechu*) on farm lands in Jammu region of Jammu and Kashmir**” was carried out with the following objectives:

1. To map the concentration of commercially exploitable *Acacia catechu* in Jammu region of J&K
2. To assess the economics of farming systems associated with cultivation of *Acacia catechu*
3. To compare the economics of alternative cropping systems, excluding agroforestry
4. To perform profitability analysis of growing *Acacia catechu* on farm lands under new policy framework

### REVIEW OF LITERATURE

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In order to develop a deeper understanding of concept, research design, and methods of analysis used in any research study, a thorough reading of the literature is required. An attempt has been made to discuss briefly the relevant and pertinent literature that has a direct or indirect influence on the present's stated objectives. As a result, relevant literature has been examined and organised into the following sub headings:

- 2.1 Economics of Agroforestry based systems
- 2.2 Cultivation and Economics of *Acacia catechu*

#### **2.1 Economics of Agroforestry based systems**

Etherington and Matthews (1983) studied the approaches to the economic evaluation of agroforestry farming system in purely analytical way using mathematical equations and diagrams to describe the concept of analysis. This study urges that although such an approach may be valuable in classroom, but it is not practicable. A realistic instrument for assessing agroforestry system by multi-disciplinary team is urgently needed. Budgeting is one of the basic and widely used method for analysing the economics of farm management issues.

Bettors (1988) analysed the planning optimal economic strategies for agroforestry systems and suggested that in terms of net present value, Benefit cost ratios and Internal rate of return, production economics combined with capital theory and valuation methodologies can provide assessment of economic indicators. These indicators can be used to evaluate the appropriate amount of joint output for a certain agroforestry technique.

Monteith *et al.* (1991) observed microclimatic interactions in agroforestry systems and described it in terms of solar energy and rainfall intercepted by foliage as well as the temperature, humidity and widespread of air surrounding the foliage. The alley's system key advantage in term of microclimate was that it intercepted more light throughout the year, resulting in increased biomass production. The system's

greatest disadvantage in terms of pearl millet output was competition below ground rather than above ground.

Szott and Kass (1993) included in his review the finding of fertilizing trails on agroforestry system-alley cropping, perennial shade systems and home gardens. Fertilizer application is a likely management option in these systems. Alley cropping had the largest fertilizer response, perennial shade system had the most variability and the home gardens had the fewest. The level of nutrient removal in harvested products is likely the most important factor in determining the fertilizer response, however, greater accumulation of organic residues, slower growth under shade, longer period of nutrient uptake are likely also factors in perennial shade system and home garden's lower fertilizer response.

Oliveira *et al.* (2000) studied economic analysis of agroforestry system with implanted Eucalypt in area of Cerrade with a goal to determine the economic feasibility of establishing a Eucalypt based agroforestry system in Savanna regions. Net present value was employed as the economic indicator. The finding revealed that the agroforestry system is viable if at least 5 per cent of the wood produced is given to the saw mills and remaining wood is used for energy or other purpose with a market value equal to higher than the wood produced.

Knapp and Sadorsky (2000) made a critical and extensive assessment of economics of agroforestry production in irrigated agriculture by developing a dynamic optimization model for the management of agroforestry and applied it in San Joaquin valley of California. They concluded that in saline soil, ideal water requirement is first increasing and then decreasing whereas the decision of harvesting is tough to change in physical and economical parameters.

Alavalapati *et al.* (2004), in his paper, studied the agroforestry development and develops an environmental economic logic for establishing incentive policies to localize environmental services, particularly in industrialized countries, using the notion of externality as a conceptual framework. When environmental services are factored in, the profitability of silvopasture is found to be higher than that of conventional ranching. Assessment of public readiness to pay for environmental services connected with silvopasture as well as rancher's readiness to adopt silvopasture, will provide a scientific foundation for policy formulation.

Pandey (2007) conducted a study on multifunctional agroforestry systems in India and found out that as a traditional land use adoption, agroforestry has the ability to improve livelihoods by simultaneously producing food, fodder and firewood while mitigating the effects of climate change. He critically reviewed the contribution of agroforestry in India to: - (i) Conservation of Biodiversity (ii) Output of goods and services to society (iii) Augmentation of carbon storage in ecosystem (iv) Improving soil fertility (v) Offering economics and social well-being to people, based on representative literature.

Dwivedi *et al.* (2007) in his study on socio-economic analysis of agroforestry system in western Uttar Pradesh presented the outcome of the diagnosis of traditional and commercial agroforestry practices. In traditional system, dominant tree species were *Azadirachta indica*, *Acacia nilotica*, *Dalbergia sissoo*, *Eucalyptus spp* where as in commercial agroforestry, dominant spp, were *Populus deltoides* and *Eucalyptus spp*. Fuelwood, additional income and shade were the major driving forces in the traditional agroforestry while additional income was the major driving force in commercial agroforestry.

Rao *et al.* (2007) conducted a study on adaptation to climate change through sustainable management and development of agroforestry system and in their paper they describe the potential impact of agroforestry systems in small holder farmer's adaption to predict climate change in tropical region and sub-Saharan Africa. Although agroforestry system exactly provides economic and environmental benefits, our inadequate understanding of trade-offs between subsistence demands, tolerable hazards and the cost associated limits the establishment of strong system that meet stakeholder needs and expectations.

Sharma and Choudhary (2008) on analysing the land productivity and site suitability assessment for crop diversification using remotely sensed data and GIS techniques identified that in Shiwalik hills of Himachal Pradesh a watershed was delineated into 3 major physiographic units viz Shiwalik foot hills, piedmonts and flood plains comprise of eighteen soil mapping units. Entisol, Inceptisol and Alfisol were the three main orders from where these eighteen soils belonged to. Store's index showed that 4.45 per cent of total geographical area of watershed under four land productivity class, 8.29 per cent under poor and 15.45 per cent under very poor and 13.18 per cent under non-agricultural class.

Rai *et al.* (2009) discussed biomass production in multipurpose tree species in natural grassland under semi-arid conditions for 25 years to select the most suitable tree species among *Albizia lebbek*, *Albizia procera*, *Dalbergia sissoo*, *Emblia officinallis*, *Eucalyptus tereticornis*, *Hardhikika binate*, *Madhuca latifolia* and *terminalia arjuna* for the introduction in natural grasslands and found out that *A. procera* followed by *E. tereticornis*, *A. lebbek*, *E. officinallis* and *D. sissoo* are the most suitable one.

Patel *et al.* (2010) conducted a survey on *Moringa oleifera* which is known for its medicinal value and is highly distributed in tropics and sub-tropics region. Protein, vitamins,  $\beta$ -carotene, amino acids, essential minerals, and phenolic compounds are all found in various portions of this plant. It has a significant nutritional value as well as therapeutic properties. Various parts of this plant, such as the leaves, roots, seed, bark, fruit, flowers, and immature pods, have antitumor, anti-inflammatory, antiulcer, antihypertensive, cholesterol-lowering, antioxidant, antidiabetic, antibacterial, cardiac, and antifungal activities and are used in the indigenous system of medicine to treat a variety of ailments. The existing scientific evidence on phytochemical composition, medicinal applications, and pharmacological activities of diverse parts of this versatile tree is the topic of this review.

Khullar and Gill (2010) examined economic evaluation of poplar-based forestry and agro-forestry models in Punjab and recommended block plantation for large farmers having more than 10 hectares farm size while boundary plantation for small and marginal farmers.

Chandra (2011) in his paper analysed the development of Poplar based agroforestry system and concluded that farmers adopted it on large scale when ban on falling and transportation was removed. Poplar cultivation yield higher returns than field crops because of set up of markets and huge demand by industries.

Gracia *et al.* (2013) describe the economic assessment and socio-economic evaluation of water use efficiency in Artichoke cultivation in his paper and evaluated that drip irrigation system is most profitable and feasible method. However, traditional method which require less investment is not an optimum solution. With reference to water use efficiency, drip irrigation is most effective.

Murthy *et al.* (2013) attempted to examine the carbon sequestration potential of agroforestry systems in India and concluded that agroforestry offers a one-of-a kind opportunity to combine climate resilience and mitigation goal. It provides valuable prospects for achieving synergy between adaptation and mitigation efforts. By overcoming many technological, financial and institutional constraints, the significance of agroforestry methods in climate change mitigation in India can be fully realized.

Alao and Shuaibu (2013) attempted to describe agroforestry practices and concepts in sustainable land use systems in Nigeria in his paper by highlighting the immense benefit from the interaction of forest trees and agricultural crops. They included the most efficient use of land for agriculture and forestry production on long term basis as well as the enhancement of soil quality. Indeed, the benefits of agroforestry are numerous and relevant to a long-term production system and way of life.

Silesh *et al.* (2014) conducted a research on agroforestry fertilizer trees and reviewed that diversification of agro-ecosystems with fertilizers trees can enhance domestic soil nitrogen supply and increase productivity of land. Fertilizer trees also provide a multifunctional agriculture by supplying timber, fodder, shade, soil enhancement and watershed management. As a result, by reducing external inputs, notably nitrogen fertilizers enhance resource and land use efficiency and delaying erosion, they can make a significant contribution to sustainable agriculture.

Luedeling *et al.* (2014) conducted a study on agroforestry system in changing climate. The development of process- based models, climate analogue analysis and field testing in climate analogue locations bare all approaches explored in his paper for estimating climate change implications on agroforestry system. Each approach's challenges and opportunities are examined.

Kumar and Singh (2014) attempted to examine the climate change and its impact on wheat production through agroforestry technologies and presented an analysis of crop-climate relationship by applying historic production statistic for wheat crop. The result showed that if simple strategies are adopted like change in planting time and varieties used than increase in 1 ° mean temperature along with carbon-dioxide concentration would not cause harm to wheat production.

Mera and Xu (2014) analysed bamboos as a valuable and adaptable resource found all over the world. Bamboo items are used by many Asian, African, and South American people for housing and farming tools. In East and South-East Asian countries, however, the shoots of these plants are considered vegetables. China has the largest bamboo forest area and the highest number of bamboo species. Bamboo forest management has received extraordinary attention in China in recent decades. The substantial economic profits gained from forestry have made a significant contribution to rural development and poverty reduction. In hilly areas, the bamboo industry has become a foundation of the economy.

Mishra (2015) evaluated bamboo as an essential forest commodity that has a lot of potential as a source of income for forest-dependent communities in India. This study quantified the resource and provide an impartial assessment of bamboo's contribution to poverty alleviation and subsistence income generation for the rural poor. Bamboo farming and processing generate a substantial amount of employment, which contributes significantly to people's wages. The large disparity between demand and supply of bamboo as a result of the rising national and international market indicates the enormous possibility for the development of bamboo resources on both public and private property, as well as an improvement in the economic situation of bamboo-dependent people.

Sharma *et al.* (2015) attempted to examine the changes in some physico-chemical characteristics of soil under poplar-based agroforestry in the alluvial soil of Punjab region. The findings demonstrate that under poplar cultivation, the physical and chemical properties of soil improved overall. Higher age plants showed a fall in soil pH and an increase in electrical conductivity. There was no discernible effect of poplar cutting cycles on soil bulk density or particle density.

SgROI *et al.* (2015) assessed the economics of Eucalyptus for biomass production as alternative crop in southern Italy and aimed at analysing the economic feasibility of Eucalyptus as compared to the traditional crop rotation. The result highlighted that introduction of eucalyptus is less profitable when compared to the traditional crops with special reference to incompressibility of output cost and selling price of woodchips.

Newaj *et al.* (2016) surveyed on recent development in agroforestry research and its role in climate change adaptation and mitigation and found that agroforestry has the potential to improve the system's resilience to deal with negative effect of climate change. Beside this, it has indirect benefit in that it helps to reduce burden in natural forests, which are greatest sink of carbon on plant by sequestering carbon in the trees.

Abbas *et al.* (2017) discussed agroforestry as a sustainable environmental practice for carbon sequestration under climate change scenarios in his paper and presented agroforestry capacity to mitigate the carbon-dioxide concentration in atmosphere by storing it in above and below ground biomass.

Gupta *et al.* (2017) in his paper on carbon sequestration potential through agroforestry concluded that this system show there are significant chances to create synergy between adaptation and mitigation strategies. As a result, agroforestry system appears to have a high potential for carbon sequestration, realistically measuring the degree of this potential requires significant efforts. In order to achieve the potential of agroforestry techniques in climate change reduction and adaptation, they must first overcome many components of present and future international climate mitigation policies.

Toppo and Toppo (2018) discussed the tree interaction in Agroforestry system and their result revealed that this system maintains enhanced yield on the same portion of land by adding crops, trees and livestock. This system can be adopted in the form of boundaries, bunds, wastelands etc. Global warming can be reduced by adopting this system especially by tree component. Its other positive impact is that fertility of soil can be enhanced which further increase the productivity and its negative impact is that it creates tough competition between crop and trees for light, water and nutrients.

Puran *et al.* (2018) conducted an experiment in a randomised block design with seven treatments, including bamboo intercropping with Sudan, Napier, and Guinea grass, as well as sole bamboo, Sudan, Napier, and Guinea grass, to evaluate the growth of bamboo with forage intercrops under the silvipasture system of agroforestry. Plant height and crude protein percent of all forage in the intercrops were higher than in solo bamboo plantations, and T1 treatment (Bamboo + Sudan)

was considerably higher than the other treatments. Treatment T1 had a much larger overall yield of forage intercrops than the other treatments. In comparison to solitary sudan T5, the net return of *Bambusa vulgaris* with intercrops of forage crop was found to be greatest at ₹ 1,22,405 per hectare in treatment T1.

Dhillon *et al.* (2018) on analysing the economics of Eucalyptus based agroforestry system in North western India under semi- arid conditions and suggested that Eucalyptus has large acceptance because it provides huge income and has stable market price. To get higher yield of annual crop, large spacing between rows is the favourable condition till harvesting of trees. The spacing of 6×1m and paired spacing of 17×1m results better.

Chavan and Dhillon (2019) conducted a study on economics of *Populus deltoids* based agroforestry that recommended the spacing of 10×2m of popular with Sorghum-Barseem crop rotation gives ₹1,191,241 per hectare of highest net returns, B:C ratio of 1:2.22, IR of 70 per cent, NPV@12 per cent discount i.e ₹409,637 per hectare, highest land equivalent ratio of 2.28 and land expectation value of ₹ 2,242,372 per hectare. Thus, spacing of 10×2m gives more profit and helps in doubling farmer's income.

Singh *et al.* (2020) investigated the importance of *Terminalia chebula* known as 'Harar,' is a member of the Combretaceae family. It can be found in deciduous woods. Except in the dry zones of India, it is found across the country. The fruits are a common component of 'Triphala' capable of adding youthful vitality and receptivity of mind and sense, and are widely used in clinical research, tanning, and furniture. They also contain 1.73 per cent nitrogen and 2.75 per cent calcium, and contain 1.73 per cent nitrogen and 2.75 per cent calcium. Because of its medical properties, demand for its fruit has skyrocketed; its fruits sell for between \$10 and \$60 per kilogram. However, its adoption is limited by its weak germination capacity, lack of natural regeneration, and lack of understanding about how to propagate it.

Devkota and Bhusal (2020) studied *Moringa oleifera*, a miracle multipurpose tree for agroforestry in the Nepal region and concluded that it as one of the best tree for agroforestry. Studies also suggested that the shade of the tree is highly beneficial for crops under multi-storied cropping pattern. Monocropping can be considered best

for the tree because of its less sensitivity to price change. For the conservation of soil and water, tree is considered as optimum one.

Raj *et al.* (2020) in his paper discussed agroforestry system in the tropic is gaining popularity due to profitable and healthy combination of trees, crops and livestock. Improved fallow, alley planting, versatile trees on farms and rangelands, home gardens, windbreaks, shelterbelts, silvopastoral grazing system, Taungya farming etc. are some of the most common frequent methods in tropics. The main impediments to the development of agroforestry system are poor policy, inadequate governance and Farmer's lack of adoption of system owing to ignorance.

## **2.2 Cultivation and Economics of *Acacia catechu***

Karnik *et al.* (1973) carried out the investigation to see if the exhausted heartwood of *Acacia catechu* might be used commercially. The exhausted heartwood is a Katha industrial waste product. The principal chemical elements of exhausted heartwood were investigated and the best conditions for isolating cellulose suitable for cellulose based industries, both from exhausted heartwood alone and from a mixture of exhausted heart and sap wood were outlined.

Shukla *et al.* (1985) proposed the study on development of hardboards from spent chips of *Acacia catechu* and reported that Khair chips can serve as excellent material for manufacturing hardboards. The results show that satisfactory boards can be manufactured by mixing spent chips of Khair and Su-babul in 70:30.

Todaria *et al.* (2004) after observing the effect of seed source, temperature and light on the germination of seeds of *Acacia catechu* summed - up that there is variation in germination of seeds collected from 20 different sources and no significant relationship between seed origin and its germination. The most suitable temperature for seed germination is 30/20°C.

Nandeshwar *et al.* (2004) reported that potting media of soil: compost in the ratio of 1:1:2 was best for the production of catechu seedlings in root trainer to overcome the coiling problem of roots in polythene bags.

Singh and Lal (2006) in their paper, discussed the traditional uses of Khair by inhabitants of Shiwalik range in western Himalayas by highlighting the importance of Khair tree in the existence of rural and tribal communities residing in western

Himalayas. Being a multi-purpose tree it is used widely for fodder, fuel, construction and treatment of disease by the local inhabitants.

Singh *et al.* (2006) on investigating the effect of agroforestry tree spp. and allelopathic effects of *Acacia catechu*, *D. sisso* and *B. ceiba* on the germination, growth and dry matter production of crops concluded that *D. sisso* was most depressive while *Acacia catechu* display least effect on growth, germination and dry matter production of crops.

Gera and Gera (2006) on estimating the genetic variability and character association in case of *Acacia catechu* showed that the value of genotypic variation and genotypic coefficient are higher than the environmental variation and environmental coefficient of variation in germination and growth character. The expected genetic gain as well as heritability were also observed to be high.

Sharma and Tripathi (2006) conducted a study on the growth assessment of *Acacia catechu* under resource constraints (nutrient and moisture) in mid hill condition of Himachal Pradesh and concluded that the combined application of fertilizers, irrigation and mulch resulted in an increase of 162 per cent in biomass production and 123 per cent in CAI. With application of all resources the per cent increase in foliar micronutrients content- N, P, K, Ca, Mg and S was recorded as 26, 79, 12, 13, 17 and 15 per cent. The study also showed that the important factor that govern the growth performance and nutrient content of tree species is sub-surface nutrient status.

Luna and Kumar (2007) observed the effect of pruning on young plantation of *Acacia catechu*, *Acacia nilotica* and *Acacia tortilis* and found out that when 1,2 and 3 years old plants of *Acacia catechu*, *Acacia nilotica* and *Acacia tortilis* were subjected to no pruning, 1/3 pruning, 1/2 pruning of total total height of plant then the maximum diameter and height increment was found in one year old plant in comparison to 2 and 3 years old plants. The study also indicates that clear bole formation and maximum diameter increment per cent was attained in *Acacia nilotica* in comparison to *Acacia tortilis* and *Acacia catechu*. The study suggests no pruning in one year old plant of *Acacia catechu*, 1/3 pruning in *Acacia tortilis* and 1/2 pruning in *Acacia nilotica* for 1 and 2 years old plant.

Nath *et al.* (2011) attempted to study the indigenous practices and socio-economics of *Areca catechu* L. and *Piper betel* L. based innovative agroforestry in northern rural Bangladesh. Their investigations showed that because of the profitability and sustainability of Areca and betel based agroforestry, farmer set aside a portion of their land for these crops. They also noticed difference among farmers regarding allocation of land, density of trees, income earnings and product marketing.

Alambayan *et al.* (2014) on analyzing the evaluation of anti-ulcer activity of roots of *Acacia catechu* found that aqueous extract from root of *Acacia catechu* show anti-ulcer activity, as verified by their inhibition of formation of ulcer induced by different models viz. aspirin +pylorus ligated ulcer model, NSAID's induced ulcer model and ethanol induced ulcer model.

Verma and Pandey (2014) observed the anti-oxidant potential of young pods of *Acacia catechu* and concluded that young pods exhibit sufficient peroxide and DPPH free radical *scavenging activity*. Young pods serve as a source of anti-oxidant as well as food.

Verma *et al.* (2014) on analysing the nutritional assessment of different parts of *Acacia catechu* found that young legumes of *Acacia catechu* can serve as rich source of nutrition for both animals and plants. The most commonly used part of *Acacia catechu* is bark that is strong anti-oxidant, antibacterial, antifungal, astringent, anti-inflammatory in nature

Kabir *et al.* (2016) investigated a study on *Acacia catechu* Trees in Rice fields and explored the farming system with complete information on farm operations and cropping calendar. The investigation shows that under rainfed condition growth of trees is remarkable and in unirrigated fields the density of trees is higher. Management of trees in small plots were good. It was also found that in small holdings, i.e less than two hactare, higher density of Khair trees were available.

Thakur *et al.* (2018) on observing the effect of growth regulators on sprouting and rooting behaviour of *Acacia catechu* and *Toona ciliate* found that when both the auxin i.e IBA and NAA in different concentration of 2000ppm, 4000ppm, 6000ppm and 8000ppm were used as eight different treatment, the maximum sprouting per cent i.e. 52.22 per cent and rooting per cent i.e 36.61 per cent recorded in *Toona ciliate* treated with 8000ppm IBA whereas no rooting in *Acacia catechu* was observed

however sprouting per cent was maximum i.e. 77.79 per cent in cutting treated with 2000ppm. Thus, IBA give better result than NAA in both spp.

Samant *et al.* (2020) on studying the anti- microbial and UV protection properties of cotton fabric using enzymatic pre-treatment and dyeing with *Acacia catechu* reported that when three enzymes viz. acid cellulose, neutral cellulose and xylanase; and conventional chemical applied on fabric then the colour uptake was better in enzyme treated fabric then chemically treated fabric. The result of dyed fabric showed excellent UPF as well as anti-microbial properties against gram positive and gram-negative bacteria. The enzyme xylanase found to be superior than other.

Pandey *et al.* (2020) proposed the study on evaluation of catechu for anti-diabetic activity and the results showed that extract was rich source of tannin. The migration of glucose was slower across semi- permeable membrane and slower the accumulation of starch by inhibiting 67.8 per cent activity of  $\alpha$ -amylase.

Huong *et al.* (2020) attempted to analyse the sustainable management of *Acacia auriculiformis* plantation for wood production over four successive rotations in South Vietnam. Their finding showed that it is feasible in long term to enhance and sustain the production of wood by adopting simple integrated management practices. Moreover, these practices also enhance understory development and variation in the stand.

Nigussie *et al.* (2020) conducted a study on financial and economic suitability of an *Acacia decurrens*- based Taungya system for farmers in Upper Blue Nile Basin, Ethiopia and suggested that rise in discount rate have more harmful effect than fluctuation in price on the profitability in case of *Acacia* based taungya system, however sharp fluctuation in price could influence profitability and tend farmers to move back to an annual crop system.

Rout *et al.* (2021) evaluated a study on an overview of *Acacia catechu* and reported that tree is in significant demand because of its medicinal properties in Asia and other parts of the world. In dermatology and sore throat, *Acacia catechu* have excellent benefits. Antimycotic and hypoglycaemic activities were also found in this tree. For the treatment of many diseases like conjunctivitis, Asthma, Constipation, etc. the tree proved to be a good source of medicine.

Cochard *et al.* (2021) surveyed in Vietnam on Acacia plantation development and the configuration of tree farmer's agriculture assets and land management by interviewing 180 farmers in three districts of Thua Thien Hue province. According to the findings, in barren land the cultivation of Acacia was started first in low and mid lands in 1990s and in uplands in 2010s. The forest land tenure was given to farmers who are producing Forest Stewardship council sawlogs.

### MATERIAL AND METHODS

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Scientific investigation requires sound methodology that is in accordance with the objectives. The methodology used to achieve the study's specific objectives is discussed in this chapter. It includes the description of study area, sampling procedures applied, survey method, data type and sources, and the numerous tools and techniques used in analysis of data and problem evaluation. Methodology used to carry out the study entitled '**Economic Appraisal of cultivating Khair (*Acacia catechu*) on farm lands in Jammu region of Jammu and Kashmir**' is discussed under the following headings:

- 3.1 Locale of the study
  - 3.2 Construction of interview schedule
  - 3.3 Collection of Data
  - 3.4 Selection of respondents
  - 3.5 Analytical tools
- 3.1 Locale of the study**

In order to achieve the stipulated objectives, present study was conducted in the Jammu and Kashmir state. Two districts were selected for the study i.e. Kathua and Samba because from the secondary data it was found that the concentration of Khair is maximum in these two districts. Agroforestry plantation of *Acacia catechu* at the farm level was considered under the investigation.

**3.2 Construction of interview schedule**

Comprehensive schedule was prepared for the collection of information from the farmers growing *Acacia catechu* on farm lands, keeping in view the objective of proposed study's objectives. Pre-testing was done among the farmers before starting the data collection work. Undesirable, vague, and difficult-to-answer questions were simplified or eliminated. Several questions that arose during pre-testing and were deemed relevant were also incorporated into the final schedule.

### 3.3 Collection of data

Both primary as well as secondary data were used in the proposed study. The secondary data was collected from the Forest Department of selected districts in J&K. The list of areas / forest range having high concentration under of *Acacia catechu* was procured from Forest Department, J&K and one zone was randomly selected for appraisal of its economics. The list of farmers who have trees on their registered land holdings was collected for selected forest range from the department. The primary data was acquired from the respondent farmers by personal interview using specially designed and pre-tested schedule.

#### Selection of respondents:

100 farmers were selected randomly from the list procured from the Forest department to collect the data on production, management and marketing of *Acacia catechu*.

### 3.4 Analytical tools

The economics of farming system involving *Acacia catechu* will be assessed using cost concepts given by Commission for Agricultural Costs and Prices (CACP).

**Cost A<sub>1</sub>:** Wage of hired human labour, Charges for bullock labour, hired labour charges of implements and machinery, Cost incurred on manures and fertilizers, Seeds, Plant protection chemicals, Irrigation charges, Land revenue, Depreciation, and Repair charges on farm assets

**Cost A<sub>2</sub>:** Cost A<sub>1</sub> + rent paid for leased in land

**Cost B<sub>1</sub>:** Cost A<sub>2</sub> + interest on value of owned fixed capital assets.

**Cost B<sub>2</sub>:** Cost B<sub>1</sub> + rental value of owned land

**Cost C<sub>1</sub>:** Cost B<sub>1</sub> + imputed value of family labour.

**Cost C<sub>2</sub>:** Cost B<sub>2</sub> + imputed value of family labour.

**Cost C<sub>3</sub>:** Cost C<sub>2</sub> + 10 per cent of Cost C<sub>2</sub> (as managerial cost)

**Gross income:** Value of total output

**Net Income:** It is computed by deducting cost C<sub>3</sub> from gross income

### Profitability analysis

Profitability analysis of agroforestry system shall be assessed using the following concepts:

#### Net Present Value

$$\sum_{t=1}^n \frac{R_t}{(1+i)^t}$$

Where,

$R_t$  = Net cash inflow-outflows during a single period t

i = Discount rate or return that could be earned in alternative investments

t = Number of time periods

#### Internal rate of return

$$0 = \text{NPV} = \sum_{t=1}^n \frac{C_t}{(1+IRR)^t} - C_0$$

Where,

$C_t$  = Net cash inflow during the period t

$C_0$  = Total initial investment costs

IRR = The internal rate of return

t = Number of time periods

#### Resource Use Efficiency of cropping system

The marginal physical product (MPP) of inputs will be obtained by taking derivatives of production function. The estimated production function underlying crop production will be used to assess the efficiency of factor proportions.

The MVP will be computed by multiplying the coefficients of the given resource with the ratio of the geometric means of the output to the geometric mean of given resource.

$$\text{MVP}(X_i) = b_i \frac{\text{Geometric Mean } \bar{Y}}{\text{Geometric Mean } \bar{X}_i}$$

Where,

MVP = Marginal Value of Product

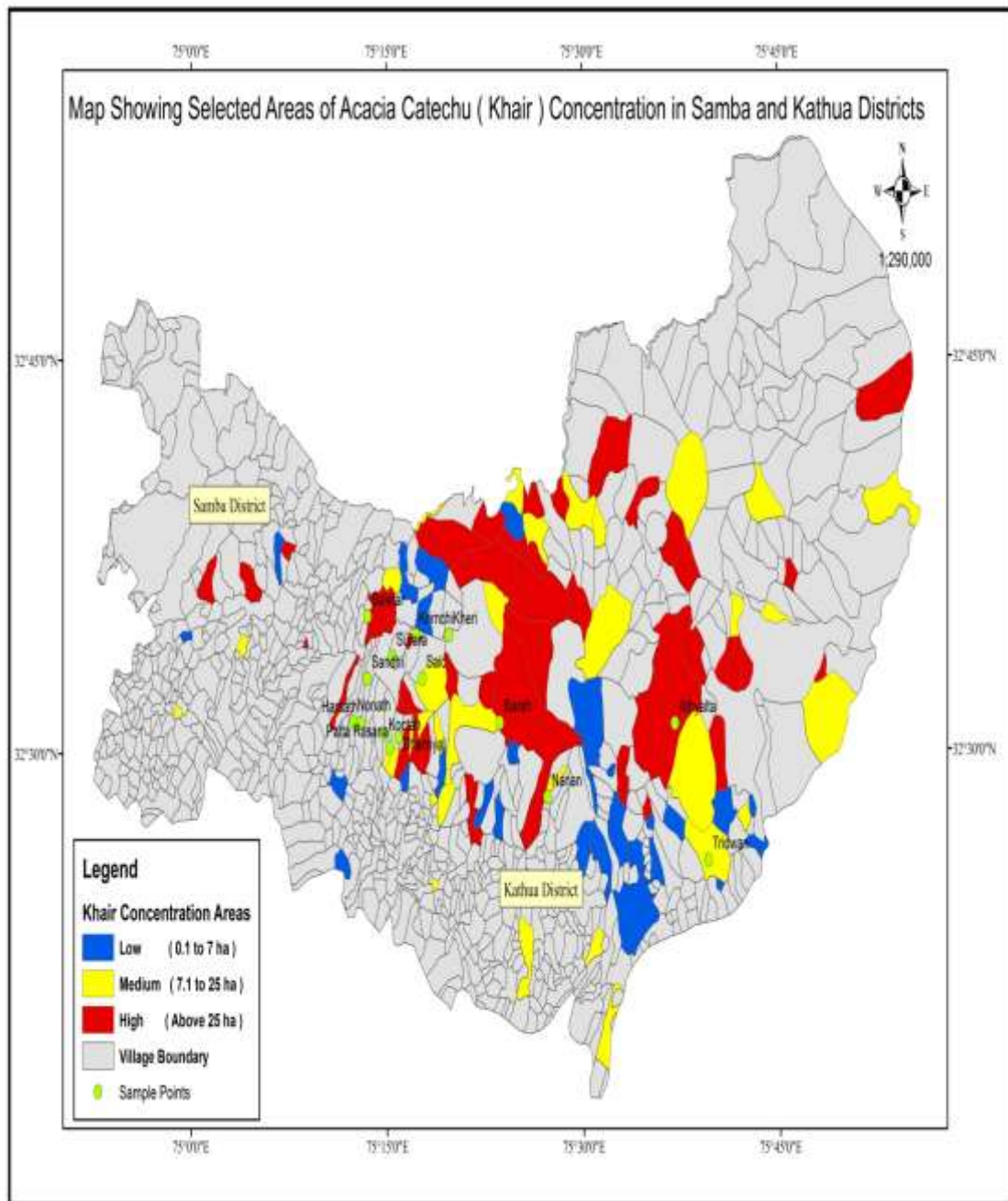
$b_i$  = Corresponding elasticity of  $\bar{X}_i$

$\bar{X}_i$  (G.M.) = G.M. of  $i$ th resource

$\bar{Y}$ (G.M.) = Computed value of Y at G.M. levels of resources.

**Table 3.1: Description of variables used in the study**

Variable	Unit	Description
1. Cost of Khair	₹	Cost of Khair is the rental value of land as no cost is involved in the cultivation of Khair
2. Urea	Q	The quantity of urea used during the complete cultivation of land in two seasons i.e. kharif and rabi
3. DAP	Q	The amount of urea used during the entire two-season, or kharif and rabi for the entire cultivation of land
4. MOP	Q	The quantity of MOP annually used during the cultivation of land during kharif and rabi season
5. Seed	Q	The total amount of seed applied during the two seasons of kharif and rabi for the entire land cultivation
6. Labour	Man-days	The amount of labour used to fully cultivate a hectare of land during two seasons, kharif and rabi
7. Age of respondent	Years	The age of household farmer is considered.
8. Farming experience	Years	Farming experience of farmer is considered.
9. Family Size	Numbers	The family size of farmers is considered
10. Education	Years	The formal education level of farmer is considered
11. KCC	0 or 1	Kisan Credit Card of farmer is considered
12. Soil Health Card	0 or 1	Soil Health Card of farmer is considered



**Fig 3.1: Maps Showing the concentration of *Acacia catechu* (Khair) in the study area of Samba and Kathua district**

**RESULTS**

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The present study entitled, “**Economic Appraisal of cultivating Khair (*Acacia catechu*) on farm lands in Jammu region of Jammu and Kashmir**” was designed to examine the costs and returns structure of agro-forestry system vis-à-vis crop farming in Samba and Kathua district of Jammu and Kashmir UT. The results pertaining to the present study have been presented in this chapter under the following headings:

- 4.1. Map showing the concentration of khair (*Acacia catechu*) in Jammu province**
- 4.2. Socio-economic profile of farmers**
- 4.3. Cropping pattern followed by farmers**
- 4.4. Level of input used by farmers**
- 4.5. Concept-wise cost of cultivation of kharif crop under agroforestry system with Khair tree (₹/ha)**
- 4.6. Concept-wise cost of cultivation of rabi crop under agroforestry system with Khair tree (₹/ha)**
- 4.7. Economic returns of kharif crop under agroforestry system with Khair tree (₹/ha)**
- 4.8. Economic returns of rabi crop under agroforestry system with Khair tree (₹/ha)**
- 4.9. Descriptive statistics of variables related to the Khair tree**
- 4.10. Economics of cropping system under agroforestry intervention with Khair**
- 4.11. Economics of cropping system without agroforestry intervention**
- 4.12. Comparative economics of cropping system with & without agroforestry intervention**
- 4.13. Feasibility analysis of Khair under agroforestry system**

#### **4.14. Descriptive statistics of variables related to agroforestry system (Khair).**

#### **4.15. Estimates of cobb-douglas regression model**

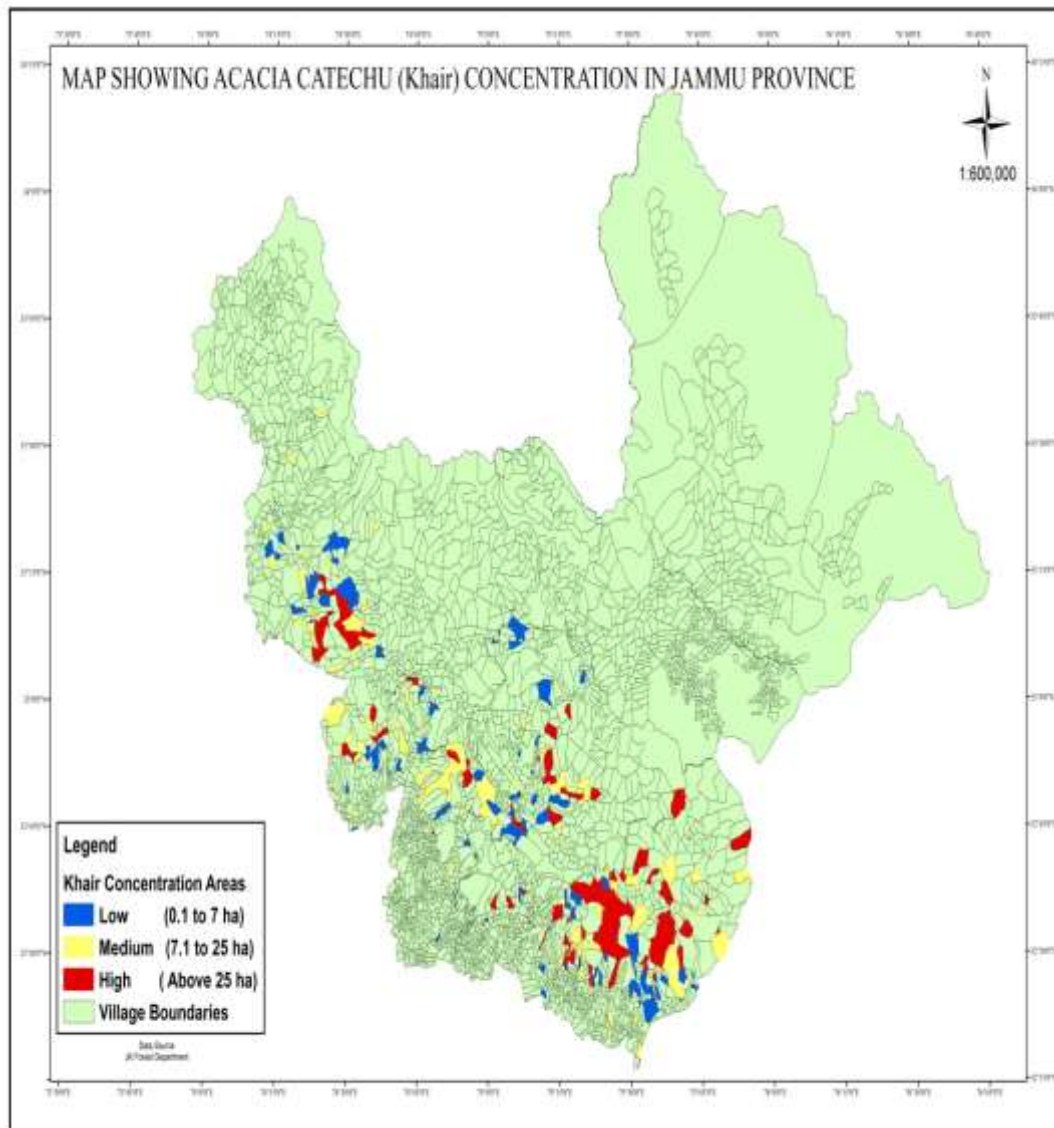
#### **4.1 Map showing the concentration of khair (*Acacia catechu*) in Jammu province**

The map (Figure 4.1) showing concentration of commercially exploitable Khair (*Acacia catechu*) in Jammu province has been prepared with the help of J&K Forest department. The blue color in the map represents the low Khair concentration area i.e. between 0.1 to 7 ha, the yellow color depicts the medium Khair concentration area i.e. between 7.1 to 25 ha and the red color represents the high Khair concentration area i.e. above 25 ha. The green color shows the village boundaries of Jammu province.

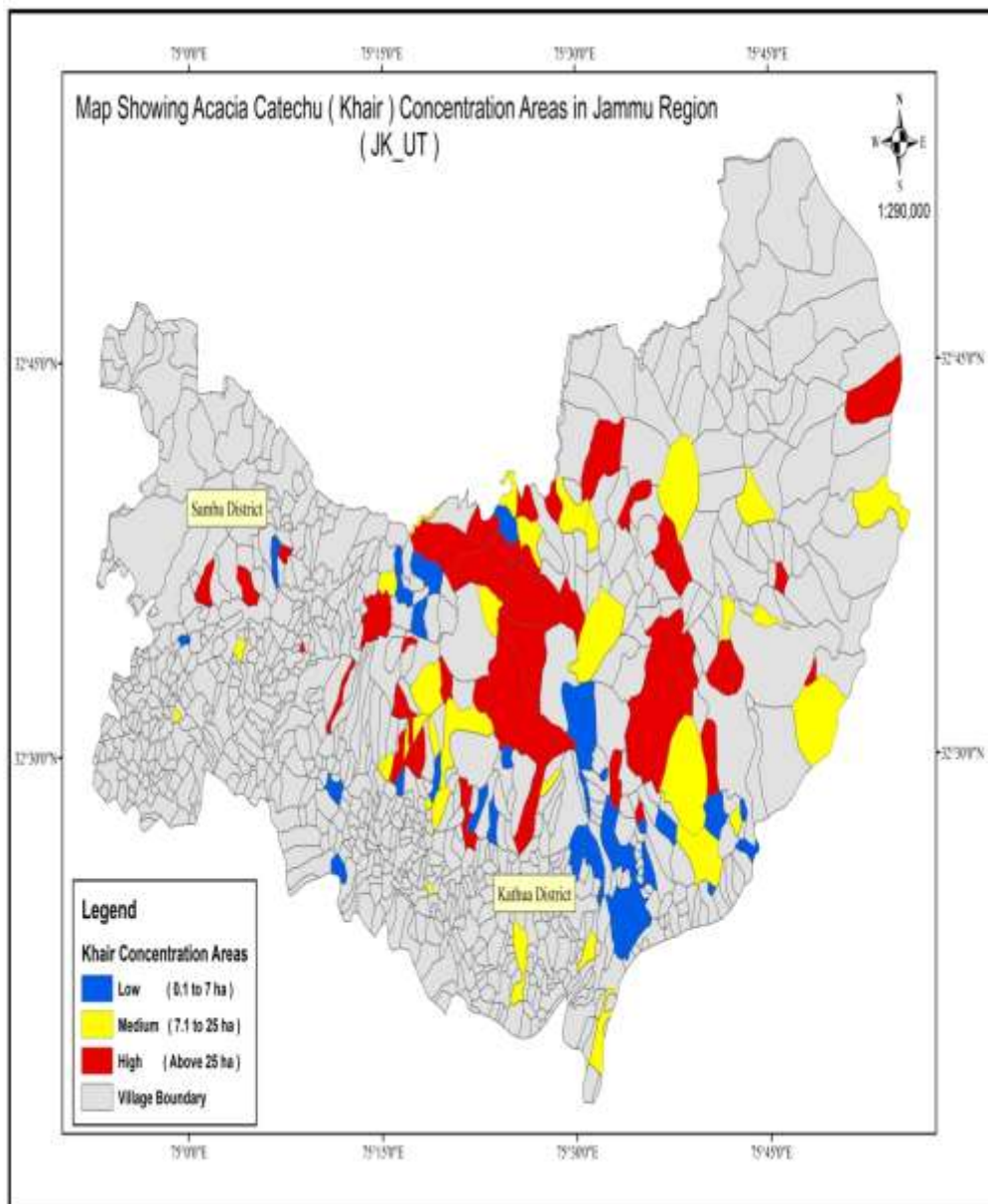
The map (Figure 4.2) showing concentration of (*Acacia catechu*) Khair in study areas (Samba and Kathua district) has been extracted from the Jammu province map. Low concentration area of Khair i.e. between 0.1 to 7 ha is depicted by the blue color, medium concentration area of Khair i.e. between 7.1 to 25 ha is highlighted by yellow color and high concentration area of Khair i.e. above 25 ha is shown by red color. The village boundaries of Samba and Kathua district are depicted by grey color. The map also reveals that most of the high Khair concentration area falls in the Kathua district.

#### **4.2 Socio-economic profile of farmers**

Age, family size, education level, farming experience and other socio-economic characteristics of the sampled respondents are the most relevant indicators determining decision-making power in various aspects of the agriculture production process. In comparison to other competing crops such as Maize, Wheat, Paddy, Blackgram, Mustard, and Toria, socio-economic characteristics may have a direct or indirect impact on the decision-making process in *Acacia catechu*. As a result, it is important to have an overview of the socio-economic characteristics of *Acacia catechu*-based agroforestry system adopters, and the results have been addressed as:



**Fig 4.1:** Map showing the concentration of Khair (*Acacia catechu*) in Jammu province of J&K



**Fig 4.2: Map showing the concentration of commercially exploitable Khair in Jammu region ( Samba and Kathua ) of J&K.**

#### **4.2.1 Age**

The socio-economic characteristics revealed that the average age of respondents is 60.12 with standard deviation of 12.24 and standard error of 1.22. The maximum age of respondent is 85 and minimum is 38 (Table 4.1).

#### **4.2.2 Family size**

The overall average family size of the respondent is 6.38 with standard deviation and standard error of 2.85 and 0.29 respectively. The maximum family size is 2 and the minimum size is 17 (Table 4.1).

#### **4.2.3 Education**

The Formal education of household head (in years) has a mean of 11.761 with standard deviation of 3.13 and standard error of 0.31. The maximum education of respondent is 20 and minimum is 7. The kurtosis is -0.26 (Table 4.1) indicating that the distribution is flatter than a normal curve.

#### **4.2.4 Farming experience**

The mean of the respondents farming experience is 39.23 with standard deviation of 11.53 and standard error of 1.15. The maximum farming experience is 65 and the minimum is 1 (Table 4.1).

#### **4.2.5 KCC holder**

The average of the respondents having KCC is 0.68 with standard deviation of 0.47 and standard error of 0.05. The kurtosis and skewness is -1.41 and -0.78, respectively (Table 4.1) indicating flatten distribution than normal curve and data is skewed left.

#### **4.2.6 Soil health card holders**

Respondents having soil health card has mean of 0.46 with standard deviation and standard error of 0.46 and 0.05 respectively. The skewness and kurtosis is -1.24 and 0.89 respectively, (Table 4.1) indicating distribution is flatter than a normal curve and data is skewed right.

#### 4.2.7 Distance of farm from market (in Km)

The average distance of respondent's farm from Market (in km) is 6.65 with standard deviation and standard error of 5.93 and 0.59 respectively. The maximum distance is 25 and minimum is 0.2 (Table 4.1).

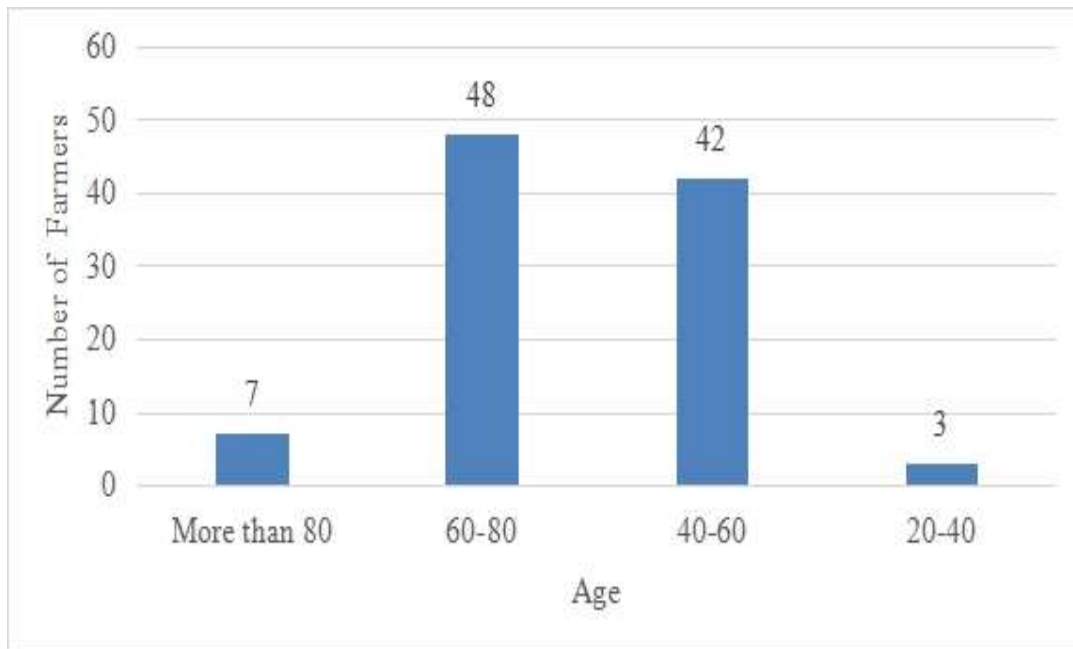
**Table 4.1: Descriptive statistics of respondents' socio-economic characteristics**

Variables	Mean	Standard deviation	Standard Error	Kurtosis	Skewness	Minimum	Maximum
Age (years)	60.14	12.24	1.22	-0.84	0.16	38.00	85.00
Family size	6.38	2.85	0.29	2.28	1.50	2.00	17.00
Formal education of household head (in years)	11.76	3.13	0.31	-0.26	0.36	7.00	20.00
Farming experience (years)	39.23	11.53	1.15	0.74	-0.35	1.00	65.00
KCC holders	0.68	0.47	0.05	-1.41	-0.78	0.00	1.00
Soil health card holders	0.30	0.46	0.05	-1.24	0.89	0.00	1.00
Distance of farm from Market (in km)	6.65	5.93	0.59	1.39	1.42	0.20	25.00

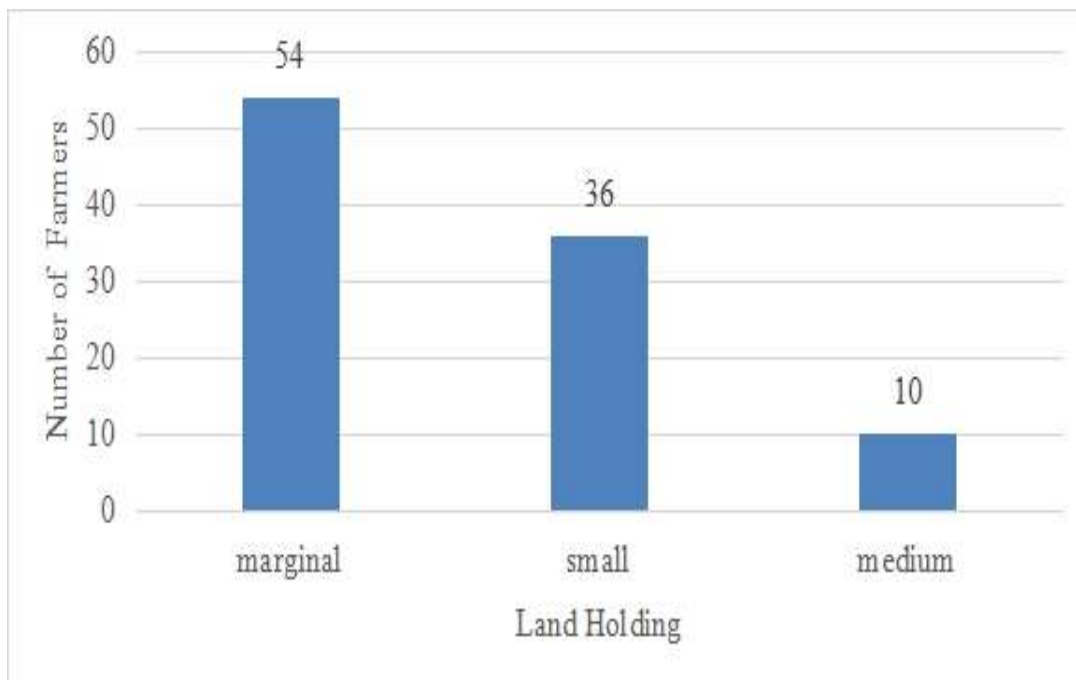
**Source: Primary data collected through survey**

#### 4.3 Cropping pattern followed by the farmers

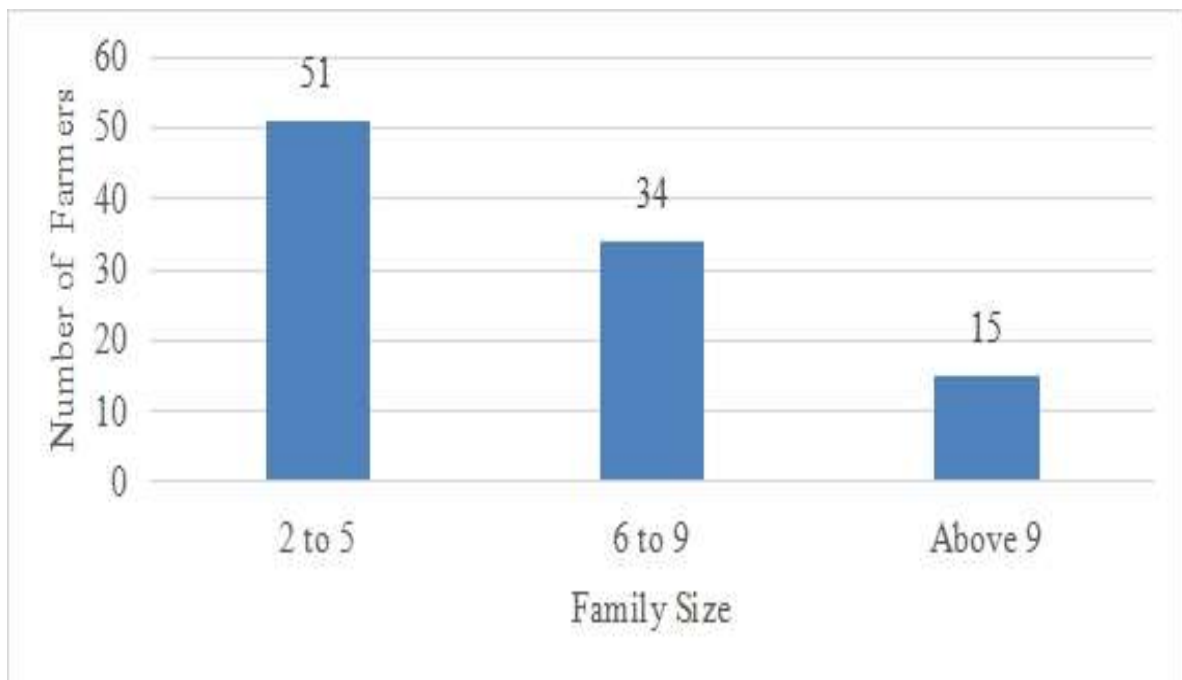
It is observed that the cropping pattern followed by the respondents of the sampled areas in the kharif season is maize, paddy, blackgram and in the rabi season is wheat, mustard and toria (Table 4.2). The number of farmers who cultivate maize crop are 79 with a total area of 42.2 ha. The number of farmers who cultivate paddy are 63 having a total area of 29.2 ha whereas the blackgram growers are 4 with a total area of 2.0 ha. In the Rabi season, the number of farmers who cultivate wheat crop are 89 having total area of 57.6 ha. The number of farmers who grow mustard crop are 25



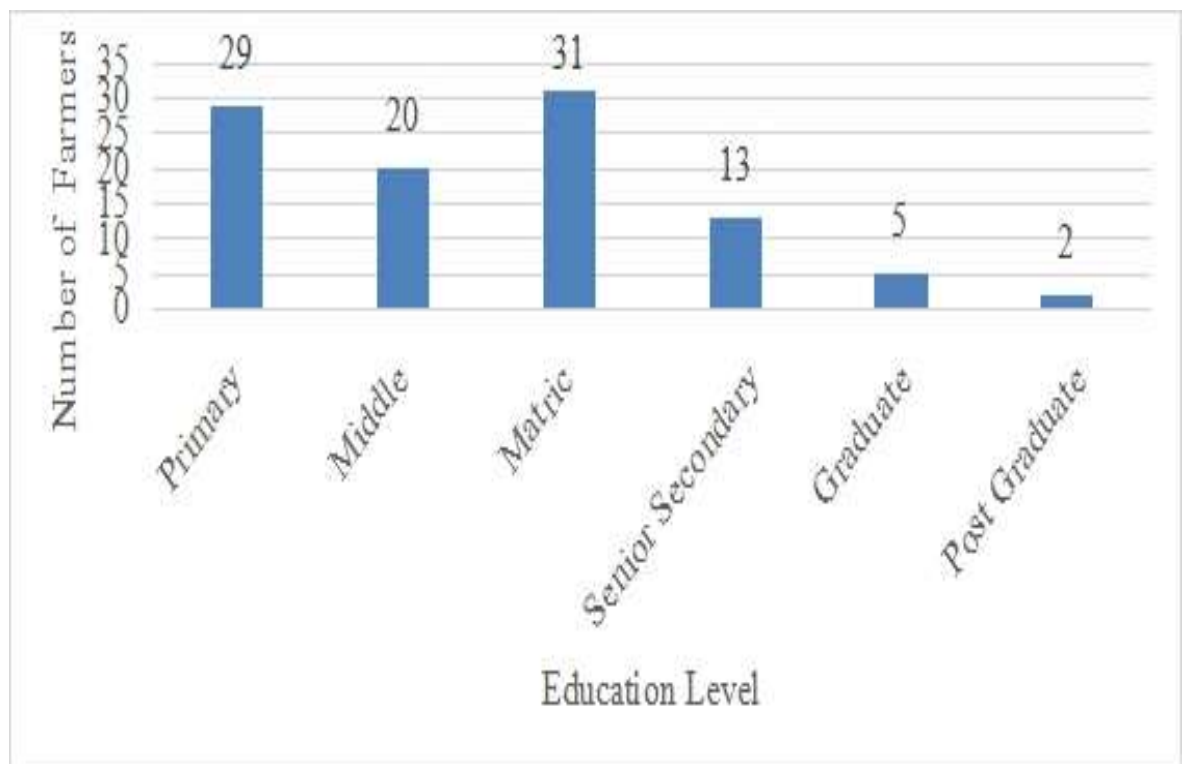
**Figure 4.3: Age-wise distribution of the farmer**



**Figure 4.4: Number of farmers in the study area on the basis of Land holding**



**Figure 4.5: Family size of the sample farmers**



**Figure 4.6: Education level of the sample farmer**

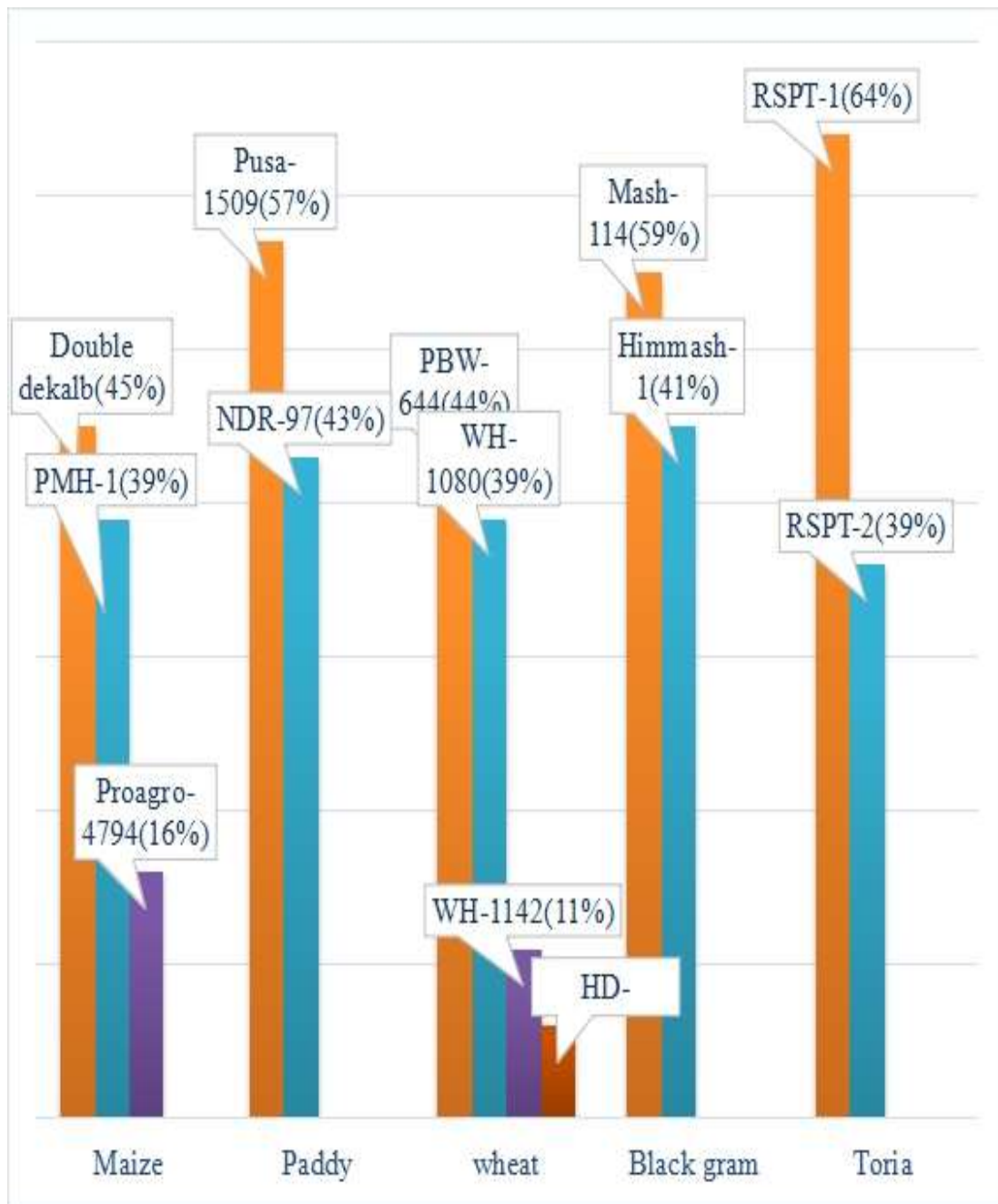
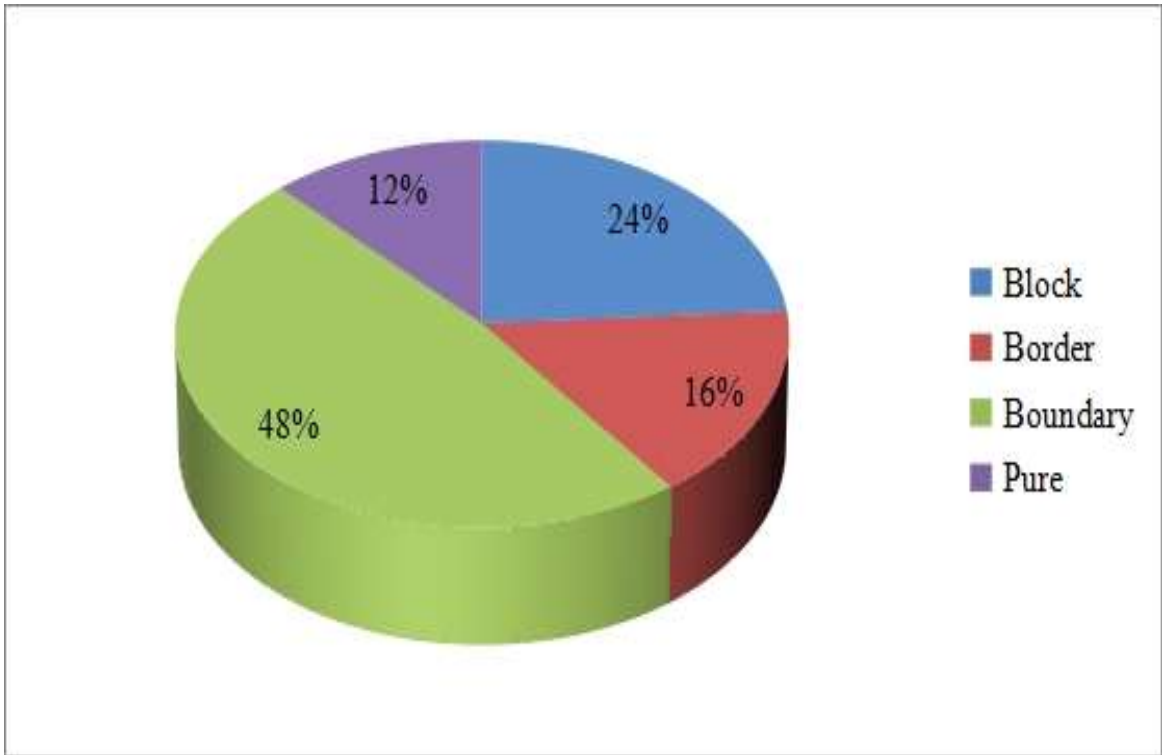


Figure 4.7: Variety of different crops grown in the study area



**Figure 4.8: Type of Plantation adopted by farmers under study area**

with the total area of 9.35 ha whereas the number of toria growers are 11 having total area of 2.30 ha.

**Table 4.2: Cropping pattern followed by the farmers under the study area**

Crops	Total area (ha)	No. of farmers
<b>Kharif</b>		
Maize	42.20	79
Paddy	29.20	63
Blackgram	2.00	04
<b>Rabi</b>		
Wheat	57.60	89
Mustard	9.35	25
Toria	2.30	11

**Source: Primary data collected through survey**

#### **4.4 Level of Input used by farmers (kg/ha)**

The use of inputs, which in turn influences the productivity of farm and income in maize, paddy, wheat, blackgram, mustard and toria is presented (Table 4.3). It has been seen from the results that on an average per hectare utilization of seed in the cultivation of maize is 33.37 kg, paddy is 24.61 kg, wheat is 130.01 kg, blackgram is 20.50 kg, mustard is 9.35 kg and toria is 9.78 kg. The results also reveal that on an average per hectare use of manure is 273.08 kg in maize, 167.74 kg in paddy, 24.74 kg in wheat, 155.00 kg in blackgram, 38.5 kg in mustard and 434.78 kg in toria. The per hectare application of Urea in maize is 81.79 kg, paddy is 120.32 kg, wheat is 24.74 kg, blackgram is 21 kg, mustard is 9.35 kg and in toria is 26.52 kg. It is also found that on average the per hectare application of DAP in maize is 74.62 kg, paddy is 99.73 kg, wheat is 78.20 kg, blackgram is 21.00 kg, mustard is 11.55 kg and in toria is 37.17 kg. The results also show that on an average per hectare application of MOP in maize is 31.79 kg, paddy is 31.13 kg, wheat is 26.52 kg, blackgram is 21.00 kg, mustard is 7.48 kg and in toria is 12.60 kg. The data also shows that on an average per hectare utilization of human labour in maize is 9.9 man-days, paddy is 24.2 man-days,

wheat is 15.45 man-days, blackgram is 13.00 man-days, mustard is 9.19 man-days and in toria is 17.39 man-days. It is also found from table (4.3) that on an average per hectare utilization of family labour in maize is 23.45 man-days, paddy is 54.67 man-days, wheat is 35.00 man-days, blackgram is 29.99 man -days, mustard is 29.51 man-days and in toria is 38.26 man-days. Moreover, the data also reveals that the per hectare utilization of total labour in maize is 33.35 man-days, paddy is 78.87 man-days, wheat is 50.45 man-days, blackgram is 42.00 man-days, mustard is 29.51 man-days and in toria is 38.26 man-days.

**Table 4.3: Level of Input used by farmers under the study area (kg/ha)**

<b>Particulars</b>	<b>Maize</b>	<b>Paddy</b>	<b>Wheat</b>	<b>Blackgram</b>	<b>Mustard</b>	<b>Toria</b>
<b>Seed (kg)</b>	33.37	24.61	130.01	20.50	9.35	9.78
<b>Manure (kg)</b>	273.08	167.74	24.74	155.00	38.50	434.78
<b>Urea (kg)</b>	81.79	120.32	128.99	21.00	9.35	26.52
<b>DAP (kg)</b>	74.62	99.73	78.20	21.00	11.55	37.17
<b>MOP (kg)</b>	31.79	31.13	26.52	21.00	7.48	12.60
<b>Hired labour (man-day)</b>	9.90	24.20	15.45	13.00	9.19	17.39
<b>Family labour (man-day)</b>	23.45	54.67	35.00	29.00	29.51	38.26
<b>Total labour (man-day)</b>	33.35	78.87	50.45	42.00	38.71	55.65

**Source: Primary data collected through survey**

#### **4.5 Concept-wise cost of cultivation of Kharif crops under agroforestry system with Khair tree (₹/ha)**

##### **4.5.1 Concept-wise cost of cultivation of Maize crop (₹/ha)**

In order to understand, the detailed views of the cost of cultivation of maize, various concepts are worked out on per hectare basis which are presented in (Table 4.4). The result reveals that per hectare cost  $A_1$  in maize is ₹27100.14. Seed, manure, urea, DAP, MOP, herbicide, hired labour, depreciation, rental value, and interest on working capital @3.5% are the components of cost  $A_1$ . Cost  $A_2$  is also ₹27100.14 as the rent paid for leased in/ land revenue is 0.00. Similarly, per hectare cost  $B_1$  is ₹29767.25 whereas cost  $B_2$  is found to be ₹ 44767.25. The per hectare cost  $C_1$  is ₹37979.25 and cost  $C_2$  is found out to be ₹52979.25. After working out the management cost, i.e. 10 per cent of cost  $C_2$ , per hectare cost  $C_3$  is found out to be ₹58277.18.

##### **4.5.2 Concept-wise cost of cultivation of Paddy crop (₹/ha)**

To understand the detailed views of the cost of cultivation of paddy, various concepts are worked out on per hectare basis which are presented in (Table 4.4). The result shows that per hectare cost  $A_1$  in paddy is ₹22966.61. Seed, manure, urea, DAP, MOP, herbicide, hired labour, depreciation, rental value, and interest on working capital @3.5% are the components of cost  $A_1$ . Cost  $A_2$  is also ₹22966.61 as the rent paid for leased in/ land revenue is 0.00. Similarly, per hectare cost  $B_1$  is ₹24658.14 whereas cost  $B_2$  is ₹39658.14. The per hectare cost  $C_1$  is ₹43795.21 and cost  $C_2$  is found out to be ₹58795.21. After working out the management cost, i.e. 10 per cent of cost  $C_2$ , per hectare cost  $C_3$  is found to be ₹64674.73.

##### **4.5.3 Concept-wise cost of cultivation of Blackgram crop (₹/ha)**

To acknowledge the detailed views of the cost of cultivation of blackgram, various concepts are worked out on per hectare basis are presented in (Table 4.4). The results intimate that per hectare cost  $A_1$  in blackgram is ₹13847.21. Seed, manure, urea, DAP, MOP, herbicide, hired labour, depreciation, rental value, and interest on working capital @3.5% are the components of cost  $A_1$ . Cost  $A_2$  is also ₹13847.21 as the rent paid for leased in/ land revenue is 0.00. Similarly, per hectare cost  $B_1$  is ₹16082.21 whereas cost  $B_2$  is ₹31082.21. The per hectare cost  $C_1$  is ₹ 26232.21 and cost  $C_2$  is found out to be ₹41232.21. After working out the management cost, i.e. 10 per cent of cost  $C_2$ , per hectare cost  $C_3$  is calculated to be ₹45355.43.

**Table 4.4: Concept-wise cost of cultivation of kharif crop under agroforestry system with Khair tree (₹/ha)**

Particulars	Maize	Paddy	Blackgram
Cost-A1			
Seed	4171.47	3183.06	405.00
Manure	2680.77	2012.90	450.00
Urea	3326.92	529.41	62.50
DAP	289.62	1017.20	0.00
MOP	596.92	264.59	160.00
Plant protection	381.54	4864.51	650.00
Hired labour	3460.00	8467.74	4550.00
Interest on working capital @3.5%	521.7534	711.8794	219.71.00
Depreciation	11671.15	1915.32	7350.00
<b>Total cost-A1</b>	27100.14	22966.61	13847.21
Cost- A1	27100.14	22966.61	13847.21
Rent paid for leased in land	0.00	0.00	0.00
<b>Total cost -A2</b>	27100.14	22966.61	13847.21
Cost- A1	27100.14	22966.61	13847.21
Interest on fixed capital @10%	2667.11	1691.53	2235.00
<b>Total cost- B1</b>	29767.25	24658.14	16082.21
Cost-B1	29767.25	24658.14	16082.21
Rental value of owned land	15000.00	15000.00	15000.00
Rental value of leased in	0.00	0.00	0.00
<b>Total cost- B2</b>	44767.25	39658.14	31082.21
Cost B1	29767.25	24658.14	16082.21
Family labour	8212.00	19137.07	10150.00
<b>Total Cost-C1</b>	37979.25	43795.21	26232.21
Cost-B2	44767.25	39658.14	31082.21
Family labour	8212.00	19137.07	10150.00
<b>Total cost-C2</b>	52979.25	58795.21	41232.21
Cost C2	52979.25	58795.21	41232.21
Cost of management (10% of Cost-C2)	5297.92	5879.52	4123.22
<b>Total cost- C3</b>	58277.18	64674.73	45355.43

Source: Primary data collected through survey

#### **4.6 Concept-wise cost of cultivation of Rabi crops under agroforestry system with Khair tree (₹/ha)**

##### **4.6.1 Concept-wise cost of cultivation of Wheat crop (₹/ha)**

To figure out the detailed views of the cost of cultivation of wheat, various concepts are worked out on per hectare basis are presented in (Table 4.5). The results signify that the per hectare cost  $A_1$  in wheat is ₹17538.81. Seed, manure, urea, DAP, MOP, herbicide, hired labour, depreciation, rental value, and interest on working capital @3.5% are the components of cost  $A_1$ . Cost  $A_2$  is also ₹17538.81 as the rent paid for leased in/ land revenue is 0.00. Similarly, per hectare cost  $B_1$  is ₹19227.18 whereas cost  $B_2$  is ₹34227.18. The per hectare cost  $C_1$  is ₹31367.06 and cost  $C_2$  is found out to be ₹46367.06. After working out the management cost, i.e. 10 per cent of cost  $C_2$ , per hectare cost  $C_3$  is calculated to be ₹51003.77.

##### **4.6.2 Concept-wise cost of cultivation of Mustard crop (₹/ha)**

To acknowledge the detailed views of the cost of cultivation of mustard, various concepts are worked out on per hectare basis which are presented in (Table 4.5). The result reveals that per hectare cost  $A_1$  in mustard is ₹17301.67. Seed, manure, urea, DAP, MOP, herbicide, hired labour, depreciation, rental value, and interest on working capital @3.5% were the components of cost  $A_1$ . Cost  $A_2$  is also ₹17301.67 as the rent paid for leased in/ land revenue is 0.00. Similarly, per hectare cost  $B_1$  is ₹19456.22 whereas cost  $B_2$  is ₹34456.22. The per hectare cost  $C_1$  is ₹29787.77 and cost  $C_2$  is found out to be ₹44787.77. After working out the management cost, i.e. 10 per cent of cost  $C_2$ , per hectare cost  $C_3$  is found to be ₹49266.54.

##### **4.6.3 Concept-wise cost of cultivation of Toria crop (₹/ha)**

To apprehend the detailed views of the cost of cultivation of toria, various concepts are worked out on per hectare basis which are presented in (Table 4.5). The table shows that per hectare cost  $A_1$  in toria is ₹29263.72. Seed, manure, urea, DAP, MOP, herbicide, hired labour, depreciation, rental value, and interest on working capital @3.5% are the components of cost  $A_1$ . Cost  $A_2$  is also ₹29263.72 as the rent paid for leased in/ land revenue is 0.00. Similarly, per hectare cost  $B_1$  is ₹31611.54 whereas cost  $B_2$  is ₹46611.54. The per hectare cost  $C_1$  is ₹45002.84 and cost  $C_2$  is found out to be ₹60002.84. After working out the management cost, i.e. 10 per cent of cost  $C_2$ , per hectare cost  $C_3$  is found out to be ₹66003.13.

**Table 4.5: Concept-wise cost of cultivation of rabi crops under agroforestry system with Khair tree (₹/ha)**

Particulars	Wheat	Mustard	Toria
Cost-A1			
Seed	4940.53	1124.92	4317.39
Manure	247.35	545.45	86.95
Urea	709.43	599.67	1108.69
DAP	821.12	2267.38	5269.56
MOP	265.16	1874.33	2652.17
Plant protection	2624.71	761.49	560.86
Hired labour	5517.41	3219.25	6086.95
Interest on working capital @3.5%	529.39	363.73	702.89
Depreciation	1883.70	6545.45	8478.26
<b>Total cost-A1</b>	<b>17538.81</b>	<b>17301.67</b>	<b>29263.72</b>
Cost- A1	17538.81	17301.67	29263.72
Rent paid for leased in land	0.00	0.00	0.00
<b>Total cost -A2</b>	<b>17538.81</b>	<b>17301.67</b>	<b>29263.72</b>
Cost- A1	17538.81	17301.67	29263.72
Interest on fixed capital @10%	1688.37	2154.54	2347.82
<b>Total cost- B1</b>	<b>19227.18</b>	<b>19456.22</b>	<b>31611.54</b>
Cost-B1	19227.18	19456.22	31611.54
Rental value of owned land	15000.00	15000.00	15000.00
Rental value of leased in	0.00	0.00	0.00
<b>Total cost- B2</b>	<b>34227.18</b>	<b>34456.22</b>	<b>46611.54</b>
Cost B1	19227.18	19456.22	31611.54
Family labour	12139.88	10331.55	13391.30
<b>Total Cost-C1</b>	<b>31367.06</b>	<b>29787.77</b>	<b>45002.84</b>
Cost-B2	34227.18	34456.22	46611.54
Family labour	12139.88	10331.55	13391.30
<b>Total cost-C2</b>	<b>46367.06</b>	<b>44787.77</b>	<b>60002.84</b>
Cost C2	46367.06	44787.77	60002.84
Cost of management (10% of Cost-C2)	4636.70	4478.77	6000.28
<b>Total cost- C3</b>	<b>51003.77</b>	<b>49266.54</b>	<b>66003.13</b>

**Source: Primary data collected through survey**

#### **4.7 Economic return of kharif crops under agroforestry system with Khair tree (₹/ha)**

##### **4.7.1 Cost and Returns of Maize (₹/ha)**

Cost and return analysis of maize on a per hectare basis in all sample farms were analyzed and presented in (Table 4.6) which reveals that, the total cost of cultivation in maize is ₹52979.25. The gross return is found to be ₹70081.53 and the net return realized is ₹17102.28. The cost-benefit ratio per hectare is calculated to be 1:1.32.

##### **4.7.2 Cost and Returns of Paddy (₹/ha)**

Cost and return analysis of paddy on per hectare basis on all sample farms were analyzed and presented in (Table 4.6) which shows that, the total cost of cultivation in paddy is ₹58795.21. The gross return is found out to be ₹112125.31 and the net return realized is ₹53329.96. The cost-benefit ratio per hectare is calculated to be 1:1.90.

##### **4.7.3 Cost and Returns of Blackgram (₹/ha)**

Cost and return analysis of blackgram on a per hectare basis on all sample farms were analyzed and presented in (Table 4.6) which evidently shows that, the total cost of cultivation in blackgram is ₹41232.21. The gross return is found to be ₹81585.00 and the net return realized is ₹40352.79. The cost-benefit ratio per hectare is calculated to be 1:1.97.

**Table 4.6: Economic return of Kharif crops under Agroforestry system with Khair tree (₹/ha)**

<b>Particulars</b>	<b>Maize</b>	<b>Paddy</b>	<b>Blackgram</b>
Seed (Rs.)	4171.47	3183.06	405.00
Manure (Rs.)	2680.77	2012.90	450.00
Urea (Rs.)	3326.92	529.41	62.50
DAP (Rs.)	289.62	1017.20	0.00
MOP(Rs.)	596.92	264.59	160.00
Herbicide (Rs.)	381.54	4864.51	650.00
Hired Labour (Rs.)	3460.00	8467.74	4550.00
Family Labour (Rs.)	8212.00	19137.07	10150.00
Interest on working capital	521.75	711.87	219.71
Depreciation (Rs.)	11671.15	1915.32	7350.00
Rental Value (Rs.)	15000.00	15000.00	15000.00
Interest on fixed capital	2667.11	1691.53	2235.00
Total cost	52979.25	58795.21	41232.21
Yield of main product (in q)	36.78	27.58	12.95
Price of main product/q	1870.00	2889.62	6300.00
Returns from main product	68778.60	79695.80	81585.00
Returns from by-product	1302.93	32429.46	0.00
Gross return/ha	70081.53	112125.31	81585.00
Net return/ha	17102.28	53329.96	40352.79
Cost-benefit ratio	1:1.32	1:1.90	1:1.97

**Source: Primary data collected through survey**

#### **4.8 Economic return of Rabi crops under Agroforestry system with Khair tree (₹/ha)**

##### **4.8.1 Cost and Returns of Wheat (₹/ha)**

Cost and return analysis of wheat on a per hectare basis on all sample farms were analyzed and presented in (Table 4.7) which signifies that, the total cost of cultivation in wheat is ₹46367.06. The gross return is found to be ₹51367.44 and the net return realized is ₹5000.38. The cost-benefit ratio per hectare is calculated to be 1:1.07.

##### **4.8.2 Cost and Returns of Mustard (₹/ha)**

Cost and return analysis of mustard on a per hectare basis on all sample farms were analyzed and presented in (Table 4.7) which intimates that, the total cost of cultivation in mustard is ₹44787.77. The gross return is found to be ₹118581.87 and the net return realized is ₹73794.10. The cost-benefit ratio per hectare is calculated to be 1:2.64.

##### **4.8.3 Cost and Returns of Toria (₹/ha)**

Cost and return analysis of toria on a per hectare basis on all sample farms were analyzed and presented in (Table 4.7) which shows that, the total cost of cultivation in toria is ₹60002.85. The gross return is found to be ₹128106.65 and the net return realized is ₹68103.80. The cost-benefit ratio per hectare is calculated to be 1:2.13.

**Table 4.7: Economic return of Rabi crops under Agroforestry system with Khair tree**

Particulars	Wheat	Mustard	Toria
Seed (Rs.)	4940.53	1124.92	4317.39
Manure (Rs.)	247.35	545.45	86.95
Urea (Rs.)	709.43	599.67	1108.69
DAP (Rs.)	821.12	2267.38	5269.56
MOP(Rs.)	265.16	1874.33	2652.17
Herbicide (Rs.)	2624.71	761.49	560.86
Hired Labour (Rs.)	5517.41	3219.25	6086.95
Family Labour (Rs.)	12139.88	10331.55	13391.30
Interest on working capital	529.39	363.73	702.89
Depreciation (Rs.)	1883.70	6545.45	8478.26
Rental Value (Rs.)	15000.00	15000.00	15000.00
Interest on fixed capital	1688.37	2154.54	2347.82
Total cost	46367.06	44787.77	60002.85
Yield of main product	18.39	23.31	26.54
Price of main product/q	1975.00	4650.00	4650.00
Returns from main product	36320.25	108391.50	123411.00
Returns from by-product	15047.19	10190.37	4695.652
Gross return/ha	51367.44	118581.87	128106.652
Net return/ha	5000.38	73794.10	68103.802
Cost-benefit ratio	1:1.07	1:2.64	1:2.13

**Source: Primary data collected through survey**

#### **4.9 Descriptive statistics of variables related to the Khair tree**

The descriptive statistics of the number and age of Khair trees (Table 4.8) reveals that the average number of Khair tree per farm is 41.21 with standard error and standard deviation of 4.47 and 37.39 respectively. The maximum number of Khair trees in the study area was 206 and the minimum number of Khair trees was 3 on the farm. The average age of the Khair tree is 45.93 years with standard error and standard deviation of 1.08 and 9.02. The maximum age of the Khair tree is 80 years and the minimum age is 30 years.

**Table 4.8: Descriptive statistics of variables related to Khair tree**

Particulars	Number of Khair trees	Age of Khair trees (years)
Mean	41.21	45.93
Standard Error	4.47	1.08
Median	31.00	45.00
Mode	20.00	50.00
Standard Deviation	37.39	9.02
Sample Variance	1397.65	81.31
Kurtosis	6.90	1.56
Skewness	2.41	0.72
Range	203.00	50.00
Minimum	3.00	30.00
Maximum	206.00	80.00
Sum	2885.00	3215.00
Count	100.00	1000.00

**Source: Primary data collected through survey**

#### **4.10 Economics of cropping system under agroforestry intervention with Khair**

Under agroforestry intervention, the economics of cropping system is calculated and presented in (Table 4.9). It is observed that the maximum cost of cultivation is incurred in toria with net return of ₹68103.80 having B.C. ratio of 1:2.13. The minimum cost of cultivation is incurred in Blackgram with the net return of ₹40352.79 having B.C. ratio of 1:1.97. The maximum B.C. ratio is found in the mustard crop i.e. 1:2.64 and minimum in the wheat crop i.e. 1:1.07.

**Table 4.9: Economics of cropping system under agroforestry intervention with Khair (n=100)**

Crops	Cost of Cultivation (₹/ha)	Gross Return (₹/ha)	Net Return (₹/ha)	B:C
Maize	52979.25	70081.53	17102.28	1:1.32
Paddy	58795.21	112125.31	53329.96	1:1.90
Wheat	46367.06	51367.44	5000.38	1:1.07
Blackgram	41232.21	81585.00	40352.79	1:1.97
Mustard	44787.77	118581.87	73794.10	1:2.64
Toria	60002.85	128106.65	68103.80	1:2.13

Source: Primary data collected through survey

#### 4.11 Economics of cropping system without agroforestry intervention

Excluding agroforestry intervention, the economics of the cropping system is calculated and presented (Table 4.10). The results show that the maximum cost of cultivation is incurred in toria with a net return of ₹76455.00 having B.C. ratio of 1:2.22 and the minimum cost is incurred in Blackgram with a net return of ₹43572.50 having B.C. ratio of 1:1.99. The maximum B.C. ratio is found in the mustard crop i.e. 1:2.68 and minimum in the wheat crop i.e. 1:1.14.

**Table 4.10: Economics of cropping system without agroforestry intervention (n=30)**

Crops	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B.C ratio
Maize	53638.40	72081.53	18443.13	1:1.34
Paddy	59422.09	115992.00	55569.91	1:1.95
Wheat	47195.64	54200.08	7005.16	1:1.14
Blackgram	43877.50	87450.00	43572.50	1:1.99
Mustard	47644.90	128122.00	80477.1	1:2.68
Toria	62565.00	139020.00	76455.00	1:2.22

Source: Primary data collected through survey

#### 4.12 Comparative economics of cropping system with & without agroforestry intervention

The economics of cropping system with and without agroforestry intervention is calculated and compared (Table 4.11). The results show that with agroforestry intervention, the yield of maize, paddy, wheat, blackgram, mustard and toria is 28.58, 27.58, 18.39, 12.95, 23.31, 26.54 q/ha respectively and of Khair tree is 1000. The total net return with agroforestry intervention is found to be ₹5121168.31 and the average B.C. ratio is 1:6.14. Without agroforestry system, the yield of maize, paddy, wheat, blackgram, mustard and toria is 30.20, 28.64, 20.60, 13.42, 24.15, 27.10 q/ha which is slightly higher than the cropping system with agroforestry intervention. The total net return is found to be ₹281522.80 and the average B.C. ratio is 1:1.88.

**Table 4.11: Comparative economics of cropping system with & without agroforestry intervention**

Crops	With agroforestry intervention			Without agroforestry intervention		
	Yield (q/ha)	Net return (₹/ha)	B.C ratio	Yield (q/ha)	Net return (₹/ha)	B.C ratio
Maize	28.58	17102.28	1:1.32	30.20	18443.13	1:1.34
Paddy	27.58	53329.96	1:1.90	28.64	55569.91	1:1.95
Wheat	18.39	5000.38	1:1.07	20.60	7005.16	1:1.14
Blackgram	12.95	40352.79	1:1.97	13.42	43572.50	1:1.99
Mustard	23.31	73794.10	1:2.64	24.15	80477.1	1:2.68
Toria	26.54	68103.80	1:2.13	27.10	76455.00	1:2.22
Tree	1000	4863485	1:32	-	-	-
<b>Total</b>	-	5121168.31	1:6.14	-	281522.80	1:1.88

**Source: Primary data collected through survey**

#### 4.13 Feasibility analysis of Khair under agroforestry system

Feasibility analysis of Khair shows that at the age of 22, the NPV@8 per cent, 10 per cent and 12 per cent is ₹9,18,956.40, ₹5,41,450.97 and ₹2,96,702.52 respectively and IRR is 13 per cent (Table 4.12). When the tree is of 32 years, the NPV@8 per cent, 10 per cent and 12 per cent is ₹3,16,296.19, ₹1,02,637.05 and ₹-5,277.03 respectively and IRR is 8 per cent (Table 4.12). When the tree is of 42 years,

the NPV@8 per cent, 10 per cent and 12 per cent is ₹-3,35,663.60, ₹-3,53,899.57 and ₹-3,30,187.69 respectively and IRR is 5 per cent. When the tree is of 52 years, the NPV@8 per cent, 10 per cent and 12 per cent is ₹5,35,371.70, ₹-4,57,493.20 and ₹-3,87,370.45 and IRR is 2 per cent.

**Table 4.12: Feasibility analysis of Khair under agroforestry system**

Particulars	Age of trees: 22 years	Age of trees: 32 years	Age of trees: 42 years	Age of trees: 52 years
NPV@8%	₹ 9,18,956.40	₹ 3,16,296.19	₹ -3,35,663.60	₹ -5,35,371.70
NPV@10%	₹ 5,41,450.97	₹ 1,02,637.05	₹ -3,53,899.57	₹ -4,57,493.20
NPV@12%	₹ 2,96,702.52	₹ -5,277.03	₹ -3,30,187.69	₹ -3,87,370.45
IRR	13%	8%	5%	2%

**Source: Primary data collected through survey**

#### 4.14 Descriptive statistics of variables related to agroforestry system

The descriptive statistics of variables related to agroforestry system reveals that the average gross profit is ₹366170.40 with standard error and standard deviation of 17042.75 and 170427.50 respectively (Table 4.13). The maximum gross profit is ₹1109759 and the minimum gross profit is ₹18000. The overall average cost of Khair is ₹41800.50 with standard error and standard deviation of ₹3903.67 and ₹39036.79 respectively. The maximum cost of Khair is ₹216300 and the minimum cost of Khair is ₹18000. The average quantity of urea applied is 7.61 with the maximum and minimum of 260 and 0 respectively. The overall average quantity of seed is 2.09 with maximum and minimum of 5.5 and 1 respectively. The mean of the labour used is 128.52 with standard error of 5.97 and standard deviation of 59.78. The average quantity of DAP applied is 7.21 with maximum and minimum of 300 and 0 respectively. The mean of MOP utilized is 60.14 with standard error of 0.98 and standard deviation of 9.84. The overall average age of respondent was 60.14 with maximum and minimum of 85 and 38 respectively. The average farming experience of respondents was 39.23 with maximum and minimum of 65 and 1 respectively.

**Table 4.13: Descriptive statistics of variables related to agroforestry system**

<b>Particulars</b>	<b>Gross profit</b>	<b>Cost of Khair</b>	<b>Urea (q)</b>	<b>Seed (q)</b>	<b>Labour (man days)</b>	<b>DAP (q)</b>	<b>MOP(q)</b>	<b>Age of respondent (years)</b>	<b>Farming experience (years)</b>
<b>Mean</b>	366170.40	41800.50	7.67	2.09	128.52	7.21	2.20	60.14	39.23
<b>Standard Error</b>	17042.75	3903.67	3.22	0.09	5.97	3.45	0.98	1.22	1.15
<b>Median</b>	361303.10	31500.00	3.00	1.71	149.00	2.35	0.80	60.00	40.00
<b>Mode</b>	#N/A	21000.00	2.40	1.50	0.00	2.00	0.40	60.00	35.00
<b>Standard Deviation</b>	170427.50	39036.79	32.25	0.91	59.78	34.52	9.84	12.24	11.53
<b>Sample Variance</b>	2.9E+10	1.52E+09	1040.23	0.83	3574.33	1192.00	96.99	149.80	133.05
<b>Kurtosis</b>	3.10	6.45	50.68	2.84	0.21	59.14	51.43	-0.84	0.74
<b>Skewness</b>	1.00	2.38	7.11	1.58	-0.57	7.57	7.16	0.16	-0.35
<b>Range</b>	1091759.00	213150.00	260.00	4.50	301.00	300.00	80.00	47.00	64.00
<b>Minimum</b>	18000.00	3150.00	0.00	1.00	0.00	0.00	0.00	38.00	1.00
<b>Maximum</b>	1109759.00	216300.00	260.00	5.50	301.00	300.00	80.00	85.00	65.00
<b>Sum</b>	36617040.00	4180050.00	767.10	186.33	12852.00	721.20	220.00	6014.00	3923.00

**Source: Primary data collected through survey**

#### 4.15 Estimates of Cobb Douglas regression model

To explain the relationship between input and output, Cobb-Douglas production function was applied. The result of Cobb-Douglas production function are presented (Table 4.14) which shows the resource use efficiency and it reveals that regression coefficients for cost of Khair and quantity of urea is found to be significant at 1 per cent level of significance, which means that 1 per cent increase in the cost of seed and quantity of DAP will increase the gross profit by 0.30 and 0.23 per cent, respectively keeping all other inputs constant at their geometric mean levels. Quantity of seed and labour is also found to be significant at 5 per cent level of significance, which means that 1 per cent increase in the quantity of seed and labour will increase the gross profit by 0.18 and 0.33 respectively. The value of  $R^2$  is calculated to be 0.78 which means that the independent variables explained 78 per cent of the dependent variable.

**Table 4.14: Estimates of Cobb Douglas regression model**

Dependent variable: Gross profit (Rs.)

Variables	Regression coefficients	Standard error	MVP
Constant	2.849*	0.419	-
Cost of Khair (Rs.)	0.30*	0.09	3.28
Quantity of urea (q)	-0.05	0.93	-5999.81
Quantity of seed (q)	0.18**	0.07	299.59
Quantity of labour (q)	0.33**	0.13	838.83
Quantity of MOP (q)	0.008	0.04	2847.02
Quantity of DAP (q)	0.23*	0.48	31924.70
Age of respondent (year)	0.03	0.17	168.79
Farming experience (year)	0.05	0.12	441.85

Coefficient of determination ( $R^2$ ) = 0.78

\*Significant at 1 % level of significance

\*\* Significant at 5% level of significance.



**Plate 4.1:Glimpses of data collection in Samba and Kathua district**

### DISCUSSION

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**The results of the study were obtained are being discussed below in this chapter and are presented as follows:**

The result pertaining to the socio-economic profile of the respondents in Samba and Kathua district revealed that the average age of respondent was 60.14 years with standard deviation and standard error of 12.24 and 1.22 respectively. The family size of respondent has mean of 6.38 with standard deviation of 2.85. The average distance of farm from market was 6.65 km with standard deviation of 5.93. The findings are in line with the earlier study conducted by Shode and Amanuel (2016) who concluded that the mean of age of respondent was 39.30 years with standard deviation of 6.11. The mean of family size was found to be 7.3 with standard deviation of 3.217. The average distance of farm from market was found to be 7.4 with standard deviation of 2.17 which was in line with the results found in this study.

The cost of cultivation of maize was found in Samba and Kathua district of Jammu and Kashmir UT. The cost of cultivation was ₹52979.25 for maize crop. Out of all the inputs that were used the maximum expenditure was incurred on the human labour with an overall average of ₹11671.15/ha followed by the expenditure on seeds with an overall average of ₹4171.47/ha. This showed that the crop was highly labour intensive with high seed rate. The findings are in line with the earlier studies conducted by Rana *et al.* (2018) who concluded that maize is a labour intensive crop. Also, in their study they mentioned that the maximum share among these crops was of rental value of land which is in line with the result that have been found in the study. Elahi *et al.* (2022) reported the gross return of maize crop was ₹690000 per acre and the benefit cost ratio was found to be 1.66. Monlruzzaman *et al.* (2009) concluded that B.C. ratio of 1.58, 2.10 and 2.85 on total cost, variable cost and cash cost from economic analysis in Bangladesh which was in line with the results found in this study. Similar results were also seen in the study of H N and Yogish (2020) where it was found that ₹45000 and ₹26345 were the average gross return and average net return. Jamakhandi *et al.* (2020) concluded that B.C. ratio of 1.43 from the economic analysis in north Karnataka indicating it a profitable crop enterprise which was in line with the result found in this study.

The cost of cultivation of paddy crop was also found in Samba and Kathua district of Jammu and Kashmir UT. The cost was ₹58795.21. Among all the inputs that were applied, the maximum expenditure was incurred on the human labour with an overall average of ₹27604.81/ha followed by expenditure on herbicide with an overall average of ₹4864.52/ha. This concludes that crop is highly labour intensive with high herbicide rate. The findings are in line with the earlier studies conducted by Srinivasan (2012) where it is found that labour input is twice the average labour use which is 176 human days. Sangma and Kalita (2019) reported that benefit-cost ratio to be 1:1.93 from the economic analysis in Meghalaya which was in line with the result found in this study. Rangunath and Rajesh (2021) reported the average gross income of maize crop was ₹92,077 per hectare and the net income was found to be ₹29,712 per hectare in Cuddalore district. Pal *et al.* (2020) concluded that B.C. ratio of 1.55 from the economic analysis in Uttar Pradesh which was in line with the results found in this study.

Another cost of cultivation of Wheat was also calculated in the sample area of Samba and Kathua district of Jammu and Kashmir UT. The cost was ₹46367.06. The maximum expenditure among all the inputs that were used is on the labour with an overall average of ₹17657.30/ha which is followed by the seed with an overall average of ₹4940.53/ha. This showed that the wheat crop is highly labour intensive with high seed rate. The findings are in line with the earlier study conducted by the Khare *et al.* (2021) reported that the wheat is a labour intensive crop. Also, in their study they mentioned that the benefit-cost ratio of wheat production was 1.87 which was in line with the results found in this study. Gaikwad and Changule (2013) reported the economic analysis in Aurangabad district of Maharashtra and found that net profit was ₹18741.55/ha and output-input ratio was 1.46 which was in line with the findings of this study.

Cost of cultivation of Blackgram was also calculated in the study area of Samba and Kathua district of Jammu and Kashmir UT. The cost was ₹41232.21. The labour is the most expensive input among all with an overall average of ₹ 14700.00/ha followed by herbicide with an overall average of ₹ 650.00/ha. This revealed that the blackgram is a labour intensive crop. The findings are in line with the earlier study conducted by the Mohiuddin *et al.* (2018) that blackgram is labour intensive crop. They also mentioned in their study that the net return was Tk. 26990

and Tk. 19845 in Sherpur and Jamalpur districts of Bangladesh which was also in line with the results found in this study. Sunandinet *al.* (2020) reported that total cost of cultivation was ₹27884.97/ha and revealed positive returns indicating that blackgram cultivation is profitable which was in line with the findings of this study. Shyamsundaret *al.* (2019) concluded the economic analysis in Villupuram district of Tamil Nadu and found that the average cost of cultivation in large farms was ₹53887/ha with net return of ₹7550/ha which was in line with the results of this study. Similarly, Lahreet *al.* (2017) reported the average cost of cultivation was ₹23586.48/ha with benefit cost ratio of 1:1.65 which was in line with the findings of this study.

In mustard, the cost of cultivation was calculated in the study area of Samba and Kathua district of Jammu and Kashmir UT. The cost of cultivation was ₹44787.77. The labour is the most expensive input out of all the inputs applied for the cultivation of maize with an overall average of ₹13550.8 /ha which is followed by the DAP with an overall average of ₹2267.38. This concluded that mustard is a labour intensive crop with high DAP rate. The findings are in line with the earlier study conducted by the Sonvane and Pathak (2016) that the average cost of cultivation was ₹11030.14/ha and the benefit cost ratio was 1:1.23 which was in line with the result found in this study. Agrawal *et al.* (2015) reported the cost of cultivation in Kabirdham district of Chhatisgarh was ₹16617.50/ha with net income of ₹18579.49/ha having input-output ratio of 1:2.12 and benefit of ₹1.12 in per rupee investment which was in line with the findings of this study. Similarly, Rathouret *al.* (2022) concluded that average cost of cultivation of Rapseed-Mustard in Begusaraidistrict of Bihar was ₹63873/ha with average gross income of ₹83746.92/ha having return to cost ratio of 1:1.39 which was in line with the findings of this study.

The cost of cultivation was also calculated in the Samba and Kathua study area of Jammu and Kashmir UT. The cost of cultivation of Toria was ₹60002.85. Out of all the inputs that were used the maximum expenditure was incurred on the human labour with an overall average of ₹19478.2/ha followed by the expenditure on DAP with an overall average of ₹5269.56/ha. This showed that the crop was highly labour intensive with high DAP rate. The findings are in line with the earlier study conducted by Kalitkaet *al.* (2019) that benefit cost ratio was 2.07 which was in line with the result found in this study. Similarly, Samant (2015) on assessment of toria concluded

net return of ₹11006/ha with B:C ratio of 1.80 which was in line with the findings of this study.

Economics of cropping system with and without agroforestry system was calculated and then compared. It was found that yield was slightly higher in the cropping system without agroforestry but the average B.C. ratio of the farm with agroforestry was found to be 1:6.14 and the B.C. ratio of farm without agroforestry was found to be 1:1.88, clearly indicating that the cropping system with agroforestry intervention is most profitable. The findings are in line with the study conducted by Shode and Amanuel (2016) who reported that net benefit in mono-cropping was 7,895.93 ETB and in Moringa-tree based agroforestry was 25,466.01 ETB indicating that Moringa-tree based agroforestry is more profitable than the mono-cropping.

The results pertaining to the feasibility analysis of *Acacia catechu* in Samba and Kathua district revealed that when the age of trees was 22 years, the NPV@8 per cent is ₹9,18,956.40, at 10 per cent is ₹5,41,450.97 and at 12 per cent is ₹2,96,702.52. The IRR is found to be 13 per cent. When the age of trees exceeds 22, the NPV was found to be negative and IRR was found to be decreasing. The findings are in line with the earlier study conducted by Pitigala and Gunatilake (2002) that NPV of Mahogany, Teak, Jak and Eucalyptus was positive at 10 per cent discount rate but when the discount rate increases the NPV was found to be negative which was in line with the result found in this study. The result of the study was also in confirmation with the findings of Paul *et al.* (2014) where NPV of agrisilvicultural systems was found to be 50 per cent higher than pure forestry at 6 per cent interest rate, whereas NPV of pure agriculture was found to be less than the tree-crop combination.

The results relating to the overall resource use efficiency of farm in Samba and Kathua district revealed that various factors like cost of khair, quantity of urea, quantity of seed, quantity of labour, quantity of MOP, quantity of DAP, age of respondent and farming experience were affecting the gross profit significantly as the explanatory variables explained 78 per cent of the dependent variable, which was shown by the value of  $R^2$ . Positively significant values obtained for the regression coefficients of cost of khair, quantity of seed, quantity of labour, quantity of MOP, quantity of DAP, age of respondent and farming experience depicted that one per cent increase in these independent variables will increase the gross profit by 0.30 per cent, 0.18 per cent, 0.33 per cent, 0.008 per cent, 0.23 per cent, 0.03 per cent and 0.05 per

cent respectively. This was in line with the study conducted by Phugeet *et al.* (2020) where human labour and fertilizer were seen to have a positive impact on income. The regression coefficient of human labour and fertilizer were 0.33 and 0.45 respectively. The result of the study was also in confirmation with the findings of Awe *et al.* (2020) where seeds were found to be over-utilized whereas farm size and labour were found to be significant.

### SUMMARY AND CONCLUSIONS

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A study entitled “**Economic Appraisal of cultivating Khair (*Acacia catechu*) on farm lands in Jammu region of Jammu and Kashmir**” was conducted in Jammu region of UT of Jammu and Kashmir during the year 2021-22. District Samba and Kathua were selected purposively on the basis of the highest area under *Acacia catechu* concentration during the year 2021-22. The secondary data was collected from the Forest Department of selected districts in J&K. The primary data was acquired from the respondent farmers by personal interview using specially designed and pre-tested schedule. 100 farmers were selected randomly from the list procured from the Forest department to collect the data on production, management and marketing of *Acacia catechu*. 30 farmers from neighbouring areas were interviewed to assess the comparative economics of cropping system.

The collected data was subjected to the analysis for examining the objectives of the study which were costs and returns with and without agroforestry intervention, comparative economics of cropping system and profitability analysis of growing Khair on farm lands under new policy framework. The following is the summary of the findings of the present study:

#### **Economics of cropping system under agroforestry intervention (with *Acacia catechu*)**

The per hectare cost of cultivation in maize was ₹52979.25, in paddy was ₹58795.21, in blackgram was ₹41232.21, in wheat was ₹46367.06, in mustard was ₹44787.77 and in toria was ₹60002.85. Cost concept wise calculation of the cost was done and cost A<sub>1</sub> per hectare was found to be ₹27100.14 in maize, ₹22966.61 in paddy, ₹13847.21 in blackgram, ₹17538.81 in wheat, ₹17301.67 in mustard and ₹29263.72 in toria. In maize, paddy, blackgram, wheat, mustard and toria, the cost A<sub>2</sub> was found to be ₹27100.14, ₹22966.61, ₹13847.21, ₹17538.81, ₹17301.67 and ₹29263.72 respectively. The cost B<sub>1</sub> was ₹29767.25 in maize, ₹24658.14 in paddy, ₹16082.21 in blackgram, ₹19227.18 in wheat, ₹19456.22 in mustard, ₹31611.54 in toria. Cost B<sub>2</sub> stood at ₹44767.25 for maize, ₹39658.14 for paddy, ₹31082.21 for blackgram, ₹34227.18 for wheat, ₹34456.22 for mustard, ₹46611.54 for toria. In

maize, paddy, blackgram, wheat, mustard and toria, the cost  $C_1$  was found to be ₹37979.25, ₹43795.21, ₹26232.21, ₹31367.06, ₹29787.77, ₹45002.84. Cost  $C_2$  was revealed to be ₹52979.25 in maize, ₹58795.21 in paddy, ₹41232.21 in blackgram, ₹46367.06 in wheat, ₹44787.77 in mustard, ₹60002.84 in toria. Cost  $C_3$  was calculated to be ₹58277.18 in maize, ₹64674.73 in paddy, ₹45355.43 in blackgram, ₹51003.77 in wheat, ₹49266.54 in mustard and ₹66003.13 in toria.

The overall average per hectare yield of maize, paddy, blackgram, wheat, mustard, toria and khair tree was found to be 28.58q, 27.58q, 12.95q, 18.39q, 23.31q, 26.54q, 1000q and the net returns stood at ₹17102.28, ₹53329.96, ₹40352.79, ₹5000.38, ₹73794.10, ₹68103.802 and ₹4863485 respectively. The total net return was found to be ₹5121168.31. The B.C. ratio of maize, paddy, blackgram, wheat, mustard, toria and Khair tree was calculated to be 1:1.32, 1:1.90, 1:1.97, 1:1.07, 1:2.64, 1:2.13 and 1:32. The overall average B.C. ratio was found to be 1:6.14.

### **Economics of cropping system without agroforestry intervention**

The overall average per hectare cost of cultivation in maize crop was found to be ₹53638.40 with gross return and net return of ₹72081.53 and ₹18443.13 respectively having B.C. ratio of 1:1.34. The average per hectare cost of cultivation in paddy was calculated to be ₹59422.09 with gross return and net return of ₹115992.00 and ₹55569.91 respectively having B.C. ratio of 1:1.95. In blackgram, the average per hectare cost of cultivation was found to be ₹43877.50 with gross return and net return of ₹87450.00 and ₹43572.50 respectively having B.C. ratio of 1:1.99. In wheat, the average per hectare cost of cultivation was found to be ₹47195.64 with gross return and net return of ₹54200.08 and ₹7005.16 respectively having B.C. ratio of 1:1.14. The average cost of cultivation in mustard was found to be ₹47644.90 with gross return and net return of ₹128122.00 and ₹80477.1 respectively having B.C. ratio of 1:2.68. The average per hectare cost of cultivation in toria was calculated to be ₹62565.00 with gross return and net return of ₹139020.00 and ₹76455.00 respectively having B.C. ratio of 1:2.22.

The overall average per hectare yield of maize, paddy, blackgram, wheat, mustard and toria was found to be 30.20q, 28.64q, 13.42q, 20.60q, 24.15q and 27.10q respectively. The total net return per hectare of maize, paddy, blackgram, wheat,

mustard and toria was ₹281522.80 and the overall average B.C. ratio of maize, paddy, blackgram, wheat, mustard and toria was found to be 1:1.88.

### **Comparative economics of cropping system with & without agroforestry intervention**

Economics of cropping system with and without agroforestry intervention was calculated and compared which showed that with agroforestry intervention, total net return was ₹5121168.31 and average B.C. ratio is 1:6.14 and without agroforestry system, the total net return was found to be ₹281522.80 and average B.C. ratio is 1:1.88, clearly indicating that cropping system with agroforestry is more profitable enterprise for the farmers to increase their income manifolds.

### **Feasibility analysis of *Acacia catechu* under agroforestry system**

Net present value and Internal rate of return was used to find out the economic feasibility of *Acacia catechu* under agroforestry system, which revealed that when the age of tree was 32 years, the NPV@8 per cent, 10 per cent and 12 per cent was found to be ₹ 9,18,956.40, ₹ 5,41,450.97 and ₹ 2,96,702.52 respectively and IRR was found to be 13 per cent. When the age of tree was 32 years, the NPV@8 per cent, 10 per cent and 12 per cent was found to be ₹ 3,16,296.19, ₹ 1,02,637.05 and ₹ -5,277.03 respectively and IRR was found to be 8 per cent. When the age of tree was 42 years, the NPV@8 per cent, 10 per cent and 12 per cent was found to be ₹ -3,35,663.60, ₹ -3,53,899.57 and ₹ -3,30,187.69 respectively and IRR was found to be 5 per cent. When the age of tree was 52 years, the NPV@8 per cent, 10 per cent and 12 per cent was found to be ₹ -5,35,371.70, ₹ -4,57,493.20 and ₹ -3,87,370.45 respectively and IRR was found to be 2 per cent.

### **Estimates of Cobb-Douglas Production Function**

The Cobb- Douglas production function was used to find out the resource use efficiency of the farms under study, which revealed that the independent variables were able to explain 78 per cent of the dependent variable where cost of khair and quantity of DAP was found to be significant at 1 per cent level of significance and one per cent increase in these leads to 0.30 per cent and 0.23 per cent increase in the gross profit. The quantity of seed and quantity of labour was found to be significant at 5 per cent level of significance and one per cent increase in these leads to 0.18 per cent and 0.33 per cent increase in the gross profit.

## CONCLUSION

It was found from the map that the commercially exploitable concentration of Khair is highest in the Kathua district followed by Samba district in Jammu region of Jammu and Kashmir UT.

Under agroforestry intervention the overall average net return per hectare was observed to be ₹5121168.3, out of which the overall average net return from 1000 Khair trees was ₹4863485 per hectare and without agroforestry intervention, the overall average net return per hectare was found to be ₹281522.80.

By comparing the economics of cropping system with agroforestry intervention (*Acacia catechu*) with the economics of cropping system without agroforestry intervention, it was found that farmers who adopt agroforestry (*Acacia catechu*) have overall average B.C. ratio of 1:6.14 and the farmers who do not adopt agroforestry have overall average B.C. ratio of 1:1.88, which clearly indicates that cropping system along with agroforestry system is the most profitable enterprise.

It was found from the profitability analysis of *Acacia catechu* (Khair) on farm lands under new policy framework that NPV is positive only upto the age of 22 years and IRR is found to be 13% at the age of 22 years and after that it starts decreasing. Hence the present study suggests that the foremost marketable age of Khair tree should be 22 years having diameter of 30 cm as after that the tree will not remain profitable for the farmers.

The utilization of the resources was also analyzed and it was observed that with one per cent increase in the cost of Khair, quantity of seed, quantity of labour, quantity of MOP, quantity of DAP, age of respondent and farming experience will increase the gross profit by 0.30 per cent, 0.18 per cent, 0.33 per cent, 0.008 per cent, 0.23 per cent, 0.03 per cent and 0.05 per cent respectively with the explanatory variables explaining 78 per cent of the dependent variable.

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Sher-e-Kashmir University of Agricultural Sciences and Technology  
of Jammu

Survey Schedule for Data Collection of M.Sc. Research Problem

Economic Appraisal of cultivating Khair (Acacia catechu) on farm lands in Jammu region of  
Jammu and Kashmir

S.No. \_\_\_\_\_

Village : \_\_\_\_\_

Block : \_\_\_\_\_

**SECTION A: SOCIO PERSONAL AND ECONOMIC PROFILE OF THE RESPONDENT**

1. Name of respondent :
2. Father's name :
3. Age of respondent (years) :
4. Marital Status : Married/ Un-married/ Widow/ Widower
5. Sex : Male/Female
6. Telephone/ Mobile no. :
7. No of family members : Male: \_\_\_\_\_ Female: \_\_\_\_\_ Total \_\_\_\_\_
8. Socio-economic characteristics :

Particulars					Value
Formal education of Household Head (in years)					
Farming experience (years)					
Maximum education of a family member					
Off-farm income (Yes/No)					
Working people in family					
Land possesses (kanals)	Total		Irrigated	Unirrigated	
Do you have Kisan Credit Card					
Do you have MGNREGA Card (Yes/No)					
Do you have Soil Health Card (Yes/No)					
Distance of farm from					
House (in km)					
Main Road					
Forest office					
Agriculture Office					
Market					

**SECTION B. AGRICULTURE PROFILE OF FARMERS**

**1. CROPPING INTENSITY AND CROP DIVERSIFICATION**

S. No.	Crops/ season	Area (ha)	Variety
1.	<b>Kharif</b>		
A.			
B.			
C.			
2.	<b>Rabi</b>		
A.			
B.			
C.			
3.	<b>Zaid / Summer</b>		
A.			
B.			
C.			
		Gross Cropped area	
		Net cultivated area	

**2. Other Enterprises**

S. No.	Enterprises					
1.	<b>Mushroom</b>	Qty. of compost	Qty. of mushroom	Cost	Gross Return	Net Return
2.	<b>Bee-keeping</b>	Qty. of Beehives	Qty. of honey	Cost	Gross Return	Net Return
3.	<b>Vermicompost</b>	No. of units	Qty. of vermicompost	Cost	Gross Return	Net Return
4.	<b>Dairy</b>	No. of cattle/ Buffaloes	Milk production	Cost	Gross Return	Net Return
5.	<b>Sheep/ Goat</b>	No.	Milk/Meat/Wool production	Cost	Gross Return	Net Return
6.	<b>Poultry</b>	No.	Production	Cost	Gross Return	Net Return
7.	<b>Fisheries</b>	No. of ponds/Fish	Production	Cost	Gross Return	Net Return
8.	<b>Sericulture</b>	Size of unit	Cocoon/Silk production	Cost	Gross Return	Net Return

3. Cultivation of crops (2020-21) – per kanal

Crop	Area (kanal)	Seed		Manure	Urea (kg)	D.A.P (kg)	M.O.P (kg)	Irrigation		Labour		Herbicide/pesticide	Machinery	Others	
		Variety	Qty					Rs.	Qty	Rs.	Qty			Rs.	Qty
<b>Kharif</b>															
Maize															
Rice															
Fodder															
Black/Green gram															
Vegetables															
<b>Rabi</b>															
Wheat															
Fodder															
Rapeseed/ Mustard															
Chickpea															
Lentil															
Vegetables															
<b>Fruits</b>															
<b>Forestry</b>															

Crop	Yield of main product						Yield of By-product						
	Total Qty	Qty Sold	Price	Home consumption	Farm consumption (seed)	Given as wages	Given as gift	Total Qty	Qty Sold	Price	Farm consumption	Given as wages	Given as gift
<b>Kharif</b>													
Maize													
Rice													
Fodder													
Black/Green gram													
Vegetables													
<b>Rabi</b>													
Wheat													
Fodder													
Rapeseed/Mustard													
Chickpea													
Lentil													
Vegetables													
<b>Fruits</b>													
<b>Forestry</b>													

**Cultivation of Acacia**

1.	<b>No. of trees</b>		Age			
2.	<b>Area</b>					
3.	<b>Type of plantation</b>	Area	No. of trees			
	<b>Border</b>					
	<b>Block</b>					
	<b>Pure</b>					
	<b>Boundary</b>					
4.	<b>Establishment cost</b>	Rs./tree	Rs./ha	Returns		
	<b>Nursery</b>					
	<b>Land preparation/Digging of pits</b>					
	<b>Irrigation</b>					
	<b>Fertilizer</b>					
	<b>Plant protection chemicals</b>					
	<b>Labour</b>					
5.	<b>Operational cost (Rs.)</b>	1-10 years	10-20 years	20-30 years	30-40 years	>40 years
	<b>Irrigation</b>					
	<b>Fertilizer</b>					
	<b>Plant protection chemicals</b>					
	<b>Labour</b>					
	<b>Gross returns</b>					
	<b>Loss in crop revenue</b>					

**Cultivation of Fruits**

Type of Fruit: \_\_\_\_\_

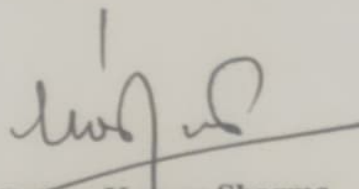
Area: \_\_\_\_\_

Age: \_\_\_\_\_

1.	Establishment cost	Rs./tree	Rs./ha	Returns		
	Nursery					
	Land preparation/Digging of pits					
	Irrigation					
	Fertilizer					
	Plant protection chemicals					
	Labour					
5.	Operational cost (Rs.)	1-5 years	5-10 years	10-15 years	15-20 years	>20 years
	Irrigation					
	Fertilizer					
	Plant protection chemicals					
	Labour					
	Gross returns					
	Loss in crop revenue					

## CERTIFICATE- IV

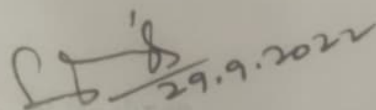
Certified that all necessary corrections as suggested by the External examiner and advisory committee have been duly incorporated in the thesis entitled "Economic Appraisal of cultivating Khair (*Acacia catechu*) on farm lands in Jammu region of Jammu and Kashmir", submitted by Miss Ramanpreet Kour, Registration No. J-20-M-713.



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Date: 29-09-2022



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