

**EVALUATION AND IMPACT OF
AGROFORESTRY SYSTEMS ON SOCIO-
ECONOMIC CONDITION OF KANKE BLOCK
OF RANCHI DISTRICT**



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**MASTER OF SCIENCE IN FORESTRY
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**FACULTY OF FORESTRY
BIRSA AGRICULTURAL UNIVERSITY
RANCHI-834006 (JHARKHAND)**

2016

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OF RANCHI DISTRICT**

**THESIS
SUBMITTED TO THE
BIRSA AGRICULTURAL UNIVERSITY
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By
ANITA KUMARI
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**IN PARTIAL FULFILMENT OF THE REQUIRMENTS
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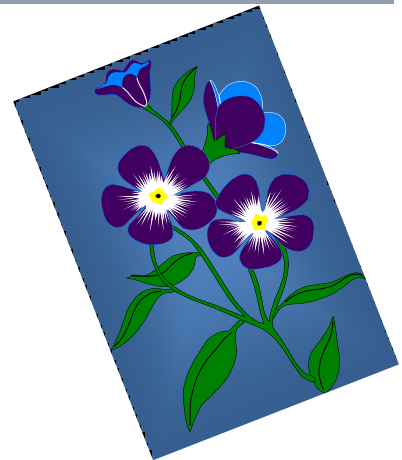
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*DEDICATED TO MY
RESPECTED PARENTS*

*"Whose blessings enabled me to
march forward and sustained me to
achieve every success
in my life"*

- Anita Kumari



BIRSA AGRICULTURAL UNIVERSITY
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**Department of Silviculture &
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(Jharkhand)

Dated

CERTIFICATE

This is to certify that thesis entitled “**Evaluation and Impact of Agroforestry on Socio- Economic Condition of Kanke Block of Ranchi District**” submitted in partial fulfillment of the requirement for the **Degree of Master of Science in Forestry (Silviculture & Agroforestry)** of Post Graduate Studies, Birsa Agricultural University, Kanke, Ranchi (Jharkhand). It is the record of bonafide research work carried out by **Miss. Anita Kumari** under the supervision and guidance. No part of the thesis has been submitted for any other Degree or Diploma.

It is further certified that such help or information received during the course of investigation and preparation of the thesis has been duly acknowledged.

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.....
Anita Kumari

Place:

Date:

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ABSTRACT

The present experiment was conducted on the “Evaluation and impact of agroforestry systems on socio – economic condition of Kanke Block of Ranchi District” with the objectives 1. To study the growth performance and yield of tree species in existing agroforestry practices. 2. To determine the soil fertility status at the agroforestry sites. 3. To assess the socio economic impacts of existing agroforestry practices on farmers. The study was carried out four villages of Kanke Block these villages are Manha (Panchayat – Malsring), Marwa (Panchayat – Upperkonki), Patratu (Panchayat – Urguttu) and Pithoria village (Panchayat – Pithoria).

The data were recorded for various parameter like Population profile, Caste profile, Family structure, Literacy status, Livestock and Poultry status, House hold status, Land holding status, land use pattern, dependency on forest (Fuelwood and Fodder consumption pattern, annual income from agroforestry). The soil properties such as pH, Organic carbon percent, Available N, P, K were estimated in the laboratory. Data on height, diameter and volume of slow, medium and fast growing trees of selected villages of Kanke Block were recorded. Economics from tree and crop and yield of agricultural and horticultural crop under agroforestry system were calculated.

Population of male was found maximum in selected villages (35.45%) and minimum in child (31.69%). In general the trends of different caste profile were in the order of OBC (50%) followed by S.T (40%), SC (10%) and general (0%). In household status, Nuclear family was 56.25% and Joint family was 43.75%. Literacy status was found in order as Primary to high school (31.32%) > Primary level (29%) > Matriculation to intermediate (21.11%) > Illiterate (17.63%). Land holding status of household were as follows medium (60.0%) > small (30.0%) > large (6.25%) > landless (3.75%). Agriculture (60.65%) and agrisilviculture (13.93%) were the important land use pattern followed by household in Kanke Block. Agriculture and Animal husbandry had been adopted by most of the working people in Kanke Block with their percentage 73.75 and 8.75.

Fuel wood at domestic level had been consumed maximum by large farmers (41.9 q yr⁻¹), followed by medium farmers (32.6 q yr⁻¹) and least by small farmers (20.5 q yr⁻¹). Consumption of fodder at domestic level was done maximum by large farmers (17.6 q yr⁻¹), followed by medium farmers (16.8 q yr⁻¹) and least by small farmers (16.1 q yr⁻¹).

Considerable improvement had taken place in soil, which was evident from the increased levels of Organic carbon, available N, P, K and pH value in agrisilvicultural system systems. The level of pH, Organic Carbon, available nitrogen, phosphorous and potassium were found better under agroforestry system than sole crop, sole tree and barren land.

Height, diameter and volume of Fast growing tree was found maximum in *Leucaena leucocephala* and minimum in *Moringa oleifera*. In medium growing trees, height, diameter and volume of trees was found maximum in *Mangifera indica* minimum in *Pongamia pinnata*. In slow growing trees height, diameter and volume of tree was found maximum in *Ficus bengalensis* and minimum in *Tamarindus indica*.

In agrisilviculture system the yield of *Oryza sativa* and *Zea mays* were 23.75 q ha⁻¹ and 20.1 q ha⁻¹. Whereas yield of *Zingiber officinale*, *Capsium annum* and *Colocasia schott* were 3.72, 8.96, 3.8 q ha⁻¹ respectively in agrihorticulture system.

The yield of *Triticum aestivum*, *Brassica nigra*, *Pisum sativum* and *Solanum tuberosum* were 19.76, 5.56, 9.28, 15.45 q ha⁻¹ respectively under agrisilviculture system. The yield of *Lycopersicon esculentum* was 13.52 and 12.4 q ha⁻¹ respectively in agrisilviculture and agrihorticulture system. The yield of *Allium cepa* and *Solanum melongena* was 9.88 and 4.85 q ha⁻¹ respectively in agrihorticulture system.

The maximum income in a year was found with the tree species *Tectona grandis* (Rs. 28,130.00) followed by *Gmelina arborea* (Rs. 24,370.00) and the minimum income was found in *Azadirchta indica* (Rs. 13,635.00).

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Agroforestry is indeed a stake for natural resources and socio-economic sustainability. In this era of global warming, fast degradation of land productivity and other environmental hazards are in common. Agroforestry is found to be the most desirable strategy for maintaining social, economic and ecological sustainability in India. The pressure on the agricultural lands has increased manifold due to the increasing population, expansion of urban area and the industrialization process. With this not only the agricultural production has been affected but the environment has also been disturbed. Under all these circumstances, agro-forestry helped in sustainable agriculture and also promote for better environment. At present farmers had a good perception of, and a favourable attitude towards agroforestry. More than one-third of the farmers (39%) belonged to the high-adoption category when all the agroforestry practices were considered, followed by a smaller percentage of farmers, *i.e.* 36% and 25% respectively who belonged to low- and medium-adoption level categories (Gangadharappa *et al.*, 2003). The majority of farmers adopted an agri-silvi-horticultural system. The impact of the adoption of agroforestry on the social, economic and ecological conditions of the farmers is significant. Economic parameters, family income, livestock possession and employment status were found to contribute more to the total impact of agroforestry on farmers. From among the ecological parameters, dependency on forests, groundwater recharge and biomass production were found to contribute more to the total impact of agroforestry on farmers (Gangadharappa *et al.*, 2003). It is also observed that the range of crop diversity increased with the increase in area owned by the farmers. The approximate annual returns of agroforestry from one acre (0.405 ha) ranged from Rs.23,916 (US\$598) to Rs.31,466 (US\$786) as compared to original returns of Rs.2250 (US\$56) to Rs.3000 (US\$60) (Gangadharappa *et al.*, 2003). Thus, agroforestry can achieve social, economic and ecological sustainability.

Agroforestry is a sustainable management system for land that increases overall production, combines agricultural crops, tree crops and forest plants and / or animals

simultaneously or sequentially and applies management practices that are compatible with the cultural patterns of local population (Bene *et al.*, 1997).

Agroforestry system is also suitable for small holding to increase soil productivity and land sustainability. Thus agroforestry is a collective name for land use system and technology where woody perennials (tree, shrubs, palms, bamboo etc.) are deliberately used on same land management unit along with agricultural crops (Singh and Osman, 1987).

Agroforestry, like multifunctional agriculture, has the objective of promoting economically, socially, and environmentally sustainable rural development (Leakey, 2012). It provides opportunities to increase the value of total production through marketing of multiple products from a given unit of land (Feldhake *et al.*, 2008). Agroforestry practices offer many advantages such as crop and livestock protection, soil and stream conservation and protection, diversification of agricultural revenues through the production of timber and non-timber forest products, promotion of biodiversity, landscape enhancement and carbon sequestration (Cole, 2010).

Recent years have witnessed a significant improvement in the adoption and promotion of agroforestry technologies among smallholder farmers world-wide and in particular, developing countries socio-economic factors that determine the actual occurrence of agroforestry are household security, access to capital and incentives, labour, gender, land tenure, farm size and knowledge for management. Sustainable development through agroforestry can be achieved through genuine and continuous involvement of farmers in agroforestry activities. Recognizing and addressing fundamental factors that determine involvement of people in developmental activities predisposes an agroforestry project to genuine local participation.

According to the Forest Survey of India, Report (2013) the forest cover in the country is 696,898 sq. Km², constituting 21.23% of its total geographical area. Out of this, dense forest constitutes 2.54% and open forest 8.99%. The forest cover in the hilly districts is only 38.34% compared with the desired 66% area. The National Agriculture Policy (2000) emphasized the role of agroforestry for efficient nutrient cycling, nitrogen fixation, organic matter addition and for improving drainage and underlining the need for

diversification by promoting integrated and holistic development of rainfed areas on watershed basis through involvement of community to augment biomass production through agroforestry and farm forestry.

The Task Force on Greening India for Livelihood Security and Sustainable Development of Planning Commission (2001) has also recommended that for sustainable agriculture, agroforestry may be introduced over an area of 14 million ha out of 46 million ha irrigated areas that are degrading due to soil erosion, water-logging and salinization. For integrated and holistic development of rainfed areas, agroforestry is to be practiced over an area of 14 million ha out of 96 million ha. This will, besides ensuring ecological and economic development provides livelihood support to about 350 million people. The practice of agroforestry can help in achieving these targets. Therefore in the quest of optimizing productivity, the multi tier system came into existence. Gap of demand and supply of forest produce in India is widening and forests are unable to fulfill the demand. Agroforestry can play an important role in filling this gap and conservation of natural resource.

Agroforestry is the set of land-use practices involving the deliberate combination of trees, agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence (Lundgren and Raintree, 1982).

Trees are grown scattered in agricultural fields for many uses such as shade, fodder, fuel wood, fruit, vegetables and medicinal uses. Some of the practices are very extensive and highly developed in India. There are strong convictions for the acceptance of these trees on agricultural fields since time immemorial. Farmers retain trees of *Acacia nilotica*, *A. catechu*, *Butea monosperma*, *Dalbergia sissoo*, *Mangifera indica*, *Zizyphus mauritiana* and *Gmelina arborea* are preferred in Jharkhand with crops. Other most common trees found on farmer's fields are *Azadirachta indica*, *Moringa oleifera*, *Tamarindus indica*, *Anacardium occidentale*, *Cocos nucifera* and fruit trees like, mango, guava, aonla and pomegranate. At many places succulents like Agave and many cacti are grown as common live fence. Many of the boundary plantation also help as shelter-belts and wind-breaks, particularly in fruit orchards.

Therefore, efforts have been made by the farmers, corporates and researchers for introducing tree based farming systems, where every sixth Indian lives, contributes to 20.37 percent of the country's agricultural production (GOI, 2005). If Indian agriculture has to prosper, the situation in Jharkhand has to improve in all sectors including crop diversification. Agroforestry can play a major role in bringing the desired level of diversification along with sustainability. The farm industry linkages have also helped the systems to be more sustainable than the traditional cropping systems (Kareemulla *et al.*, 2005; Saxena, 2000). Agroforestry land use practice has become a way of livelihood to farmers in many countries.

Further, it is necessary to identify the existing agroforestry systems of the farmers, to promote the systems, estimate the cost-benefit analysis and also assessing the impact of agroforestry with the following objectives.

- To study the growth performance and yield of tree species in existing agroforestry practices.
- To determine the soil fertility status at the agroforestry sites.
- To assess the socio economic impacts of existing agroforestry practices on the farmers.

REVIEW OF LITERATURE

The traditional agroforestry systems were practiced for long time throughout the world. With the establishment of ICRAF (International Council of Research in Agroforestry), the ancient practice of agroforestry was institutionalized. The ICRAF with the help of global inventory contributes immensely in collecting, evaluating and disseminating information on new approaches of agroforestry systems. The systems were categorized on the basis of four main criteria: viz., structure, function, socio-economic aspect and ecological spread. But the primary categorization was on the basis of structure (Nair, 1993). Structurally there are three main systems: agri-silviculture (Crops + trees), Silvo-pastoral (Pasture = animals + Trees) and agro-silvo-pastoral (Crops + pasture + animals + trees) (Boehnert, 1998).

According to the potential of agroforestry there are many different systems and the type of systems found in a particular area is determined to some extent by agro-ecological and socio-economic factors. Today there is consensus of opinion that agroforestry is practiced for a variety of objectives. The practices like hedgerow intercropping, multipurpose home garden, inter-cropping with plantation crops, *etc.* have one concept in common that is the purposeful growing of trees with crops and/or animals in interacting combinations for multiple products or benefits from the same management unit, and this is the essence of agroforestry (Nair, 1993).

The present chapter deals with relevant literature related to the study. A comprehensive review of literature forms the basis of scientific research. Literature on socio economic upliftment of villages through agroforestry seems to be scanty. However, literatures related to various aspects of the present study have been reviewed in this chapter under the following sub heads.

- 2.1 Effect of the tree growth under intercrops**
- 2.2 Effect of yield under intercrops**
- 2.3 Soil fertility status under agroforestry system**

2.4 Socio-economic impacts of existing agroforestry system

2.1 Effect of the tree growth under intercrops

Agroforestry is a modern tool to develop sustainable land use and to increase food production by growing woody species (trees, shrubs, palms, bamboos, etc) with agricultural crops and /or animals in some form of spatial arrangement or temporal sequence (Rizvi *et al.*, 1999).

Banerjee *et al.*(2009) studied to evaluate the growth and productivity of *Azadirachta indica*, *Eucalyptus tereticornis*, *Acacia plectocarpa* and *Shorea robusta* planted under Agri – silviculture system with 4 different intercrops of groundnut (*Arachis hypogaea*), rice (*Oryza sativa*), cowpea (*Vigna unguiculata*), and black gram (*Vigna mungo*), a field experiment was conducted on lateritic soil of West Bengal. Intercrops were grown during rainy season (kharif) only in rainfed condition. The result revealed that tree height, diameter at breast height (dbh) and volume of wood of trees were increased gradually with the age of the trees but the rate of increment of height and dbh was shown in a phasic manner due to change of climate throughout the year. Growth rates of *Azadirachta sp.* and *Shorea sp.* were a bit slower than *Eucalyptus sp.* and *Acacia sp.* Productivity of intercrops grown under *Azadirachta* tree cover was slightly higher as compared to other three trees. Among different intercrops, blackgram gave maximum return irrespective of different agri- silviculture system.

Gill *et al.* (1992) have studied growth of *Leucaena leucocephala* and mango based intercropped agroforestry system at Jhansi. Both *Leucaena* and mango growth (height and diameter) was found better in inter-crops than fallow plots.

Sharma (1987) reported growth performance of *Dalbergia sissoo* tree intercropped with wheat and paddy at FRI, Dehradun under semi-arid condition and noticed on hectare basis a mean height of 10.36 m, dbh 53.45 cm, total timber 1.25 cubic meter, small timber 7.08 cubic meter and fuel wood 77.45 quintal.

Patel and Singh (1994) have studied growth dynamics of ten trees species of agroforestry system in Gujarat and noticed maximum height growth in *Albizia lebbeck* (9.10m) followed by *Melia azedarach* (8.8m) and *Eucalyptus hybrid* (6.73m) at five year

age, whereas the maximum girth growth was found in *Melia azedarach* (66.0 cm) followed by *Albizzia lebeck* (39.67 cm) and *Eucalyptus hybrid* (37.00 cm) at five year age.

Mohsin *et al.* (1996) evaluated growth and biomass production of poplar (*Populus deltoides*) stands in different age groups, intercropped with *Mentha* and *Cymbopogon* species at Tarai region of Kumaon, India. Poplar stand intercropped with mint and *Cymbopogon* species attained better height and DBH than tree under monoculture plantation at both early and advanced stages of tree growth.

Datta and Dhiman (2001) studied growth and timber production of 12 tree species in association with different crops in sub-humid tropics of Tripura, India. After 12 years planting, *Acacia auriculiformis* attained maximum height (18.1m) and basal girth (92.8 cm) followed by *Eucalyptus hybrid* and *Gmelina arborea*. The lowest height and diameter growth were observed in *Morus alba*.

Toky and Khosla (1984) have studied comparative growth performance of agroforestry trees in subtropical region of Western Himalayas and observed height, diameter and bole volume of six years old trees of 41 indigenous and 5 exotic species and noticed best growth in *Grevillia robusta*, *Eucalyptus globulus*, *Populus spp*, *Albizzia lebeck* and *Melia azedarach*. However, maximum diameter was found in *Ailanthus excelsa*. *Albizzia lebeck* was found as most promising species.

Dwivedi *et al.* (1990) studied growth performance and biomass production of *Eucalyptus tereticornis* trees grown in agricultural field bunds. The above ground biomass of *E. tereticornis* at 6 years age grown on two sides of the field boundary in single row was found in the order of 16.63 and 27.22 (t ha⁻¹), respectively. The measurement in case of field bund plantation revealed that the growing stock of 1.5 mha⁻¹ yr⁻¹ to 3.5 m ha⁻¹ yr⁻¹ can be obtained which is much more than the average production (0.7 m³ha⁻¹yr⁻¹) of forest department.

Sharma and Jain (1997) prepared standard volume tables for *Gmelina arborea* Roxb. Using linear regression techniques and concluded that d_{2x} act as more reliable predictor as difference between estimated and observed volume was not significant.

Malik(2004) have studied the allelopathic effect of tree on production of agricultural crops and reported that the leaf extracts from 1-3 years old plantation of *Eucalyptus globulus* exerted less allelopathic toxicity on potato, bean and maize crops, hence intercrops can be grown under Eucalyptus during this period.

Paramathma *et al.* (2000) have studied allelopathy effect of agroforestry trees. The introduction of trees into agroecosystems has assisted on combating deforestations, but has disadvantage of getting reduced crop yield due to competition and allelopathic interaction with trees.

Datta and Dhinman (2001) studied productivity of upland rice (AR-U) and groundnut (JL-24) under twelve multipurpose trees in humid subtropical region of Tripura, India. The yields of both crops were lowest in agricultural system than sole crops. The yields of the agricultural crops of upland rice and groundnut were low under the tree in the agrisilvicultural system in compare to the agricultural crops.

2.2 Effect of yield under intercrops

Mutunal *et al.*(2000) observed thatthe groundnut pod yield was 1149 kgha⁻¹ in pure stand and 719-743 kgha⁻¹in agroforestry sytem with *Tectona grandis*. Maize grown with *Acacia auriculiformis* gave highest grain yield (1020 kgha⁻¹) compared to rice, sesame, pigeon pea, groundnut. The productivity of black gram considered of 652 and 1100 kgha⁻¹ of grain and crop residues respectively under *Acacia auriculiformis* (Bora *et al.*,1999).

Reddy and Khan (2000) reported that the groundnut yield was not affected by perennial legumes (*Calliandra callothyrsus*, *Sesbania grandiflora*, *Leucaena leucocephala* and *Gliricidia sepium*). Whereas,Suresh and Rai (1987) observed areduction in the dry fodder yield of cowpea in agroforestry systems.

Peri *et al.*,(2001) reported 11.2 t ha⁻¹fodder yield in lucerne in the open field and 7.9 t ha⁻¹ under pine trees.

Singh *et al.* (2004) concluded that wheat crop produced higher grain yield under kapok (*Ceiba pentandra*) tree at wider tree spacing of 8m×4m as compared to narrow tree spacing of 4m×4m. Out of the four tree spacing of i.e. 8m×3m, 6m×4m, 5m×5m,

and 4m×6m; Populus planted at 8m×3m and 6m×4m proved to be the best tree spacing for no or little adverse effect on the production of medicinal plant species (Partap and Vaishnu, 2005)

Ravi (2005) also observed the reduction in growth and yield of the intercrops under *Ailanthus excelsa* based agroforestry system when compared to pure cropping. Performance of eleven agricultural crops under three different spacing's (5m×2.5m, 10m×2.5m, 15m×2.5m) were tested by Nandal and Hooda (2005) and found that the yield of all crops decreased with increasing age of poplar. The yield of all crops increased with increasing poplar spacing, however a spacing of 10m×2.5m seems to be the ideal for getting optimum growth and yield of agricultural crops.

Fuwaoe and Akindel (1997) estimated biomass yield of *Gliricidia sepium*, *Gmelina arborea* and *Leucaena leucocephala* in Nigeria. Among three species, the higher above ground biomass was observed on *Gmelina arborea* followed by *Leucaena leucocephala* and *Gliricidia sepium*.

Malik *et al.* (2005) studied the growth yield of intercrops potato, maize and bean and observed that *Eucalyptus globulus* with potato intercrop gave higher yield followed by other intercrops and silvicultural manipulating.

Singh *et al.* (1999) reported that the tall stature crops like sorghum, pigeon pea and ginger significantly reduced the subabul leaf yield by 21% compared to small stature crops like black and groundnut.

Dhyani and Tripathi (1999) studied tree growth survival and crop yield under Mandrain (*Citrus reticulata*), Alder (*Alnus nephalensis*), Cherry (*Prunus cerasoides*) and *Albizia spp.* The crop sequence was (a) soyabean-linseed (b) groundnut-mustard and (c) sole tree. A positive effect of intercropping on height and diameter growth, crown width and timber volume was observed in alder, *Albizia* and cherry. *Alder* and *Albizia* attained maximum growth and woody biomass. The better growth and timber volume were observed in the tree and crop situation, which was mainly described due to application of fertilizers and weeding.

Khattaket *et al.* (1980) revealed that the yield of wheat in association with *Dalbergia sissoo* was significantly higher than *Eucalyptus camaldulensis*, *Populus deltooides* and *Bombax ceiba*.

Dwivedi and Sharma (1989) reported 20% higher yields of grain and wood in agroforestry areas of Haryana and Western UP than from pure crops.

Mehta *et al.* (1996) have found significantly higher grain yield of gram, mustard, and Indian bean crops and control in open fields than those grown in association with trees.

Dhayani and Tripathi (1999) observed lower crop yields in soyabean-linseed and groundnut-mustard cropping sequence under different agrisilvicultural systems in northeast India. Crop yields increased with an increase in distance from tree base in Alder, Mandarin and Cherry. However, in *Albizia* crop yield was not reduced in the proximity of trees.

The results of the experiment conducted with *Acacia nilotica* and four agricultural crops *viz.*, cowpea, sesame and horsegram and sorghum as intercrops revealed that the growth and yield attributes of the intercrops *viz.*, plant, height, basal girth, number of leaves, dry matter production, stalk and grain yield were greatly reduced under trees than when grown alone. Among the four intercrops, cowpea proved to be the most compatible crop with *Acacia nilotica* (Palani, 1996). It was found that the gradual increase in the shade of rubber tree to a progressive decrease in height, number of branches and pods, seeds per plant and grain yield in pigeon pea (Brahman *et al.*, 1997).

2.3 Soil fertility status under agroforestry system

Kang (1993) described that the agroforestry has shown its potentials as a land management alternative for maintaining the soil fertility and productivity in the tropics. It is known that the soil organic matter and other biotic factors are important in maintaining the productivity especially in the fragile humid tropical uplands. Home gardens can serve as models for the design of improved agroforestry practices (Kumar and Nair, 2004).

Sharma and Sharma(2012), conducted a long term study with four land use system; agroforestry(LU-1),agri-horti-silvi-pastoral(LU-2), agriculture with alder (*Alnusnepalensis*)(LU-3), and shifting cultivation (slash& burn) (LU-4) to see their effect on the soil properties, soil erosion and crop productivity. The sediment yield varied from 0.27 to 0.75 Mg ha⁻¹in LU-1, 0.11to 0.37 Mg ha⁻¹ in LU-2 and 2.76 to 4.52 Mgha⁻¹ in LU-3 as against 26.69 to 45.80 Mg ha⁻¹in LU-4. In ten years of study, there was substantial build-up of available P and K over the initial status in LU-1, LU-2 and LU-3 compared to LU-4 in which the available P status remained almost constant. Available Potash in LU-4 increased in the beginning after burning of forest vegetation but subsequently decreased to initial value after four years. Agroforestry systems ameliorated the soils by enhancing soil pH and decreasing the exchangeable aluminium content in the soil and thus, helping in higher availability of native as well as applied nutrients and enhancing the crop productivity. The agroforestry systems ensured the livelihood security and farm income.

Pandey *et al.* (2002) studied the impact of neem plantation on soil properties was of 4 and 8 year-old neem plantation at two different sites. An increase in organic carbon, available N, P, K was 0.11%, 38.90 kg ha⁻¹, 5.14kg ha⁻¹and 62.55kg ha⁻¹respectively under 4 year old neem plantation over control (without tree) after 3 years and increase was 0.18% 35.75 kgha⁻¹, 3.96 kgha⁻¹and 67.55 kg ha⁻¹for organic carbon, available N,P and K, respectively under 8 years old plantation. The increment in organic carbon and available P,N and K was lower in 15-30 cm soil depth compared to 0-15 cm. The pH was slightly lower in both the plantation in compare to control.

Verinumbe (1987) reported higher dry matter yield of maize and sorghum under the influence of forest soil in Sahel (Africa) than in ordinary fields soils. Higher crops yields were obtained in the soil under Neem followed by *Prosopis* and *Eucalyptus* than ordinary soils.

Vishwanath *et al.* (1998) studied effect of *Acacia nilotica* tree on associated rice, crop growth, and yield and physio-chemical properties of soil. They indicated that the crop parameter except grain yield was not affected by trees. Grain yield reduced by 28.3% under the tree canopy and it gradually increased away from the tree canopy.

Litter is a major source of organic matter in soil under different plantation. It is not only replenishes the organic carbon and nutrient pool on plantation floor but also improves the physical health of the soil. Litter forms are an important pathway for recycling of nutrients to the soil from trees. The decomposition of litter adds organic and inorganic elements in the soil through the process of nutrient cycling (Mudrick *et al.*, 1994).

Raizada *et al.*(2003) reviewed litter production and C- flux through litter felled in ten important species raised under plantation in different agroecological zones of India. The litter production ranged from 1.3 to 11.27 Mg ha⁻¹yr⁻¹, while C-flux varied between 0.58 to 2.22 Mg ha⁻¹yr⁻¹. Among different species litterfall and C-flux was highest in *Shorea robusta* followed by *Pinus roxburghii*, *Eucalyptus spp*, *Tectona grandis* and *Acacia auriculiformis*.

Shanmughavel and Francis (2002) investigated litter production and nutrient return behaviour of bamboo in an agroforestry system. Bamboo intercropped with Pigeon pea produced higher quality of litter than pure bamboo stand alone. Litter fall followed bimodal pattern with principal peak in the winter and another in the late summer, of the total annual production. Leaf production accounted for 58% and twig litter 42%. The annual litter production was 13.5 Mg ha⁻¹ in intercropped bamboo. The highest concentration of N,P, Ca and Mg were found in leaf litter while K was highest in twig litter. On an annual basis 89, 6,78,42 and 49 kg ha⁻¹ (agroforestry system) of N, P, K, Ca and Mg, respectively were returned through litter fall. Maximum amount of nutrients were returned through leaf litter and lowest from twig litter.

Basavaraja and Rao (2000) have studied integration of tree in agroforestry system to find out positive or negative interaction between trees and crops. Micro-climatic amelioration and maintenance of improvement in soil productivity are the major positive interaction, while competition for light, water and nutrient and allelopathy are the major negative interaction in agroforestry systems. The balance negative and positive interaction in a given agroforestry system. In such situations agroforestry system have to managed through planting optimum density of trees proper spatial arrangement and pruning and thinning of tree crown and roots to reduce the negative effect of trees.

There was fertility build-up below trees which contributes to better growth of under vegetation compared to sites away from the tree canopy (Zinke, 1962; Tiedemann and Klemmedson, 1973; Christies, 1975). However, the magnitude of soil fertility amelioration varied among species. Soil fertility studies under 14 years old tree old communities of *Prosopis cineraria*, *Prosopis juliflora* and bare site showed slight reduction in EC and pH, but improved in organic matter, total N and total P₂O₅, under *P. cineraria* (Singh and Lal, 1969).

Gupta and Sexena (2004), studied the effect of *Gmelina arborea* with intercrop on soil properties in Nigeria and observed that like yam and maize with *Gmelina arborea* had little effect on soil properties although measurable, but not significant increase in soil N and P and marginal increase in soil acidity were noticeable. An increase in nitrogen with intercrops was reported under *Gmelina arborea* (Ojenjyi and Agbede, 1980); *Leucaena leucocephala* with maize and cowpea (Kang, 1993).

A definite increase in organic carbon, phosphorus and potash was discernible after the harvest of intercultivated crops (FAO, 1981). While increased organic carbon content and available phosphorus were also observed by Chandrasekhariah (1987), and failed to obtain any change in pH or available Potash. Experiments carried out at Dharwad revealed organic content to be more at a depth of 0.15m after five years of planting under *Dalbergia sissoo*, *Derris indica* and *Acacia nilotica*. While available phosphorus was more under *Azadrachta indica*, available potassium registered an increase under *Derris indica* and *Acacia nilotica* (Chandrasekhariah, 1987). Further an increase in soil available phosphorus was evident under *Dalbergia sissoo* (Chandrasekhariah, 1987).

Thiyageshwari *et al.* (1998) reported that the available phosphorus was significantly higher under fodder grass intercropped with *Gmelina arborea* based silvipastoral system. Thiyageshwari *et al.* (1998) further reported that the available nitrogen ranged from 252 to 449 kg ha⁻¹ under teak based silvipastoral system. The lowest value of 252 kg ha⁻¹ was recorded in the open field and 25 per cent increase in the available nitrogen was recorded under hybrid Napier grass intercropped with teak.

Madheswaran (2002) observed that available nitrogen, phosphorus and potassium were more under intercropping than in open. Kathirvel (2003) reported that soil fertility viz; available nitrogen, phosphorus and potassium were improved under teak based agroforestry system.

Ravi (2005) observed the soil available nitrogen, phosphorus and potassium were more under fodder cowpea intercropped with *Ailanthus*. The highest (18.9 kg ha⁻¹) available Phosphorus was recorded at 2m×2m spacing and it decreased gradually as spacing increased between *Jatropha curcas*. Low density of tree (*Cassia siamea*, bamboo, neem) contributed for higher in C:N and C:P ratios in agroforestry systems (Prabhu and Sreemannarayana, 2007).

Rai (2003) reported that the improvement in soil nutrients in agrisilvicultural system was more pronounced as compared to sole cropping except available potassium. Mohanraj (2004) reported improvement of available nitrogen, phosphorus and potassium under *Simaruba* based Agroforestry system.

2.4 Socio-economic impacts of existing agroforestry system

Based on a study conducted in Shimoga district of Karnataka, Rafi (1991) has reported that considerable percentage of participant farmers (47%) had a high level of knowledge of farm forestry, while most equal number of non-participant farmers (43%) had low and medium levels of knowledge. Eighty five per cent of the participant farmers had a favourable attitude farm forestry and a majority of non- participant farmers had unfavourable attitude towards farm forestry.

Arnold (1995) reported that the farmers plant tree in pursuit of their livelihood goals of income generation, risk management, household food, security and optimum use of available land, labour and capital.

In agroforestry systems, it has been observed that the dry biomass yield from the lopping of 10 year-old tree species on contour bunds are high. A study at CRIDA (Central Research Institute for Dryland Agriculture) revealed that *Gravillia robusta* recorded highest biomass yield per tree (30 kg) followed by *Casuarina equisetifolia* (20 kg) and *Faidherbia albida* (15kg). Further, the tree species planted on contour bunds

served as effective windbreaks. However, trees affected the rabi crop yield in adjacent rows to the extent of 23-30 percent (Anonymous,2000).

Kindt and Leng Keek (1999), stated that farmers plant a variety of tree species on their farms. A full woody inventory carried out in 200 farms in four villages in western Kenya recorded a total of 190 trees species. Even though the average farm size was less than two hectares, about 16 tree species per farm were observed.

Mahapatra and Mitchell (2001) studied the factors influencing planting of trees and found that the likelihood of adopting agroforestry is dependent on the progressive attitude of farmers, membership of village organizations, their wealth status and, more importantly, their perceived risk concerning agricultural production. This approach enables tree planters and non-planters to be characterized and hence give better targeting of planting and social forestry programs.

Kumar *et al.* (2014), studied the field/farm boundary system of agroforestry has been widely practised in traditional agroforestry regions and observed during socio-economic diagnosis of traditional agroforestry practices followed by farmers in Aligarh district of Uttar Pradesh. Tree species like *Azadirachta indica*, *Acacia nilotica*, *Dalbergia sissoo* and *Eucalyptus* spp. were dominant in traditional agroforestry. Fuel wood (50.6%) was major driving force for agroforestry adoption followed by additional income (24.4%) and shade (17.5%) in traditional agroforestry region. The net return from tree produce ha⁻¹ yr⁻¹ in traditional system was Rs. 989, 541 and 440 for marginal, small and medium farmers, respectively. Although traditional agroforestry seems less promising as compared to commercial agroforestry, it is much relevant to the farmers' livelihood.

Negiet *al.*(2009), studied the subsistence economy of rural people has traditionally been based on forest and agriculture on the northwest India of Garhwal Himalaya. The traditional system of farming involves combine production of food, fodder, tree crops and livestock. The land use system shows that irrigated land is a very small fraction of the agricultural land. Addressing the twin problems of water resource management and soil conservation are key to the economic prosperity of the region. Maximum numbers of villages are distributed in between 1000-1500 m altitude due to the gentle slope, moderate climate, and the availability of streams and rivers. Soil

loss due to complex hill topography has increased the problem of agricultural production. Farmers do not have means to adopt soil conservation measures. Mixed cropping on small terraced field and homestead farming are the key components of subsistence farming system in the area.

Oraonet *al.* (2005), observed that people are adopting different land use practices (such as agriculture, agroforestry, home garden and fallow land) on their agricultural land, but they are not aware about the economic importance of different system in the Kumharia village of Ranchi district. In this present investigation efforts has been made to highlight the relative importance of different land use systems. Amongst agroforestry systems *viz.*, agrisilvicultural, silvipastoral and home garden systems, wood volume production by subabul (*Leucaena leucocephala*) under agrisilviculture was found maximum ($422.50 \text{ m}^3 \text{ ha}^{-1}$), whereas in silvipastoral system Gamhar (*Gmelina arborea*) produced highest wood volume ($377.50 \text{ m}^3 \text{ ha}^{-1}$). The yield performance of agricultural, vegetable and grasses have indicated additional benefits from same land.

Grewal *et al.* (1992), observed that the agri-silvi-horticulture system integrating *leucaena*, lemon, papaya and turmeric on class I irrigated land provided sustainable mean net returns of Rs. 17066 per year against from double cropped agricultural system. *Eucalyptus tereticornis* (smith) in top and Bhabbar grass (*Eulaliopsis binata*) in the under storey on a sandy loam class III land gave four years (1985-1988) mean air dry grass yield of 4.2 t ha^{-1} (used for paper pulp) from October and $1.19 \text{ t ha}^{-1} \text{ yr}^{-1}$ (used for fodder) from June cut. Bhabbar grass raised under *Acacia* species on a 25 to 30% sloping gravelly class IV land provided yield varying from 2.18 to $4.31 \text{ t ha}^{-1} \text{ yr}^{-1}$ from October cut and 0.50 to $1.1 \text{ t ha}^{-1} \text{ yr}^{-1}$ from June cut with 6 years mean of $3.9 \text{ t ha}^{-1} \text{ yr}^{-1}$ which at 1988 prices provided net returns of Rs. 2402 ha^{-1} .

Wannawong *et al.* (1991) have studied benefit cost analysis of selected agroforestry system on Northern Thailand. The potential productivity and financial return from selected agroforestry systems and traditional monocrops located in the Phuwiang. The agroforestry system studied the combination of *Eucalyptus*, *Leucaena* and *Acacia* intercropped with *Cassava* or Mungbeans. Parameter considered were tree

growth, charcoal production and crop yield. They have considered agroforestry system more preferable financially than traditional monocrops.

Rao *et al.* (2000) have studied growth and biomass production of some important multipurpose tree species on rainfed sandy loam soil on the agroforestry system in Andhra Pradesh. Evaluation of tree species of 9 years after planting showed that *D. sissoo*, *L. leucocephala*, *A. auriculiformis* and *E. camaldulensis* were fast growing and suitable for this southern Telengana Zone (AP). Data on biomass production (small wood and logs) showed that *D. sissoo* yielded maximum biomass (214.6 t ha⁻¹) followed by *L. leucocephala* (187.8 t ha⁻¹) and *Acacia auriculiformis* (162.4 t ha⁻¹). Maximum mean annual biomass production was also found for *D. sissoo* (23.8 t ha⁻¹) followed by *L. leucocephala* (20.9 t ha⁻¹) and *A. auriculiformis* (12.0 t ha⁻¹) and *E. camaldulensis* (9.9 t ha⁻¹). Cost benefit analysis showed that highest return was obtained from *D. sissoo* (4.4) followed by *L. leucocephala* (4.0), *A. auriculiformis* (3.1) and *E. camaldulensis* (2.9).

Marawar *et al.* (1995) carried out an economic analysis of *Eucalyptus* plantation on 23.39 ha of marginal land at central Research Farm, Akola (Maharashtra) and revealed that input output ratio was 1.04. Return was less due to sale of *Eucalyptus* as pulpwood rather than timber.

Rasul and Thapa (2007) reported that it is essential to evaluate agricultural land use systems from both societal and private perspectives in the pursuit of promoting particularly environmentally sustainable systems. Horticulture, timber plantation, and agroforestry, considered to be suitable land-use systems particularly for mountaineous areas, held the middle ground between these two systems. Annual cash crops provided the highest financial return at the cost of a very high rate of soil erosion.

Mathur *et al.* (1983) studied the economics of poplar plantation grown by forest department on Government land and by cultivators in their own farms. The annual returns were discounted at 12%, 15%, 20% and 25. The net present value (NPV) per hectare in case of poplar plantation with and without agriculture in the forest land and on farmers land with agriculture at 8, 10 and 12 year rotation was calculated. The NAV and benefit/cost (B/C) ratio was found maximum *i.e.* 11046 and 3.22 respectively at 12% interest rate with 8 year rotation in case of Poplar plantation combined with agriculture

on farmland as compared to Rs. 7235 and 2.15 and Rs. 3208 and 1.51 in case of Poplar plantation with agriculture on forest land and Poplar plantation without agriculture in forests land respectively. It was concluded that cultivation of agriculture crop with Poplar at 8 years rotation ensures high economic returns.

Mutanal *et al.* (2000) reported that growing of tree + fruit plants+ Field crops generated 46% more income compared to growing of field crops + fruit plants only. Jain and Singh (2000) observed that poplar based agroforestry was economically viable and more profitable than many of the crop rotations in northern region of India. This land use system was also capable of providing employment opportunities on farms. Sensitivity analysis indicated that this system was not highly risky.

Chaturvedi and Pandey (2001) reported the economics of intercropping maize-wheat-turmeric or pigeon pea-turmeric during first 10years of a poplar (*Populus deltoides*) plantation. The cumulative benefit-cost ratio at the end of the 10th year (after tree planting) was 5.01 with maize-wheat-turmeric and was 6.68 under pigeon pea-turmeric indicating that the later cropping system was more profitable. However, both cropping system improve income and generate a steady cash flow for many years.

Vergara (1985) observes that agroforestry is a land use system combining agriculture and tree crop of varying longevity arranged either temporarily or spatially (inter cropping) to maximize and sustain aggregated yield

MATERIALS AND METHODS

This chapter deals with technical program of work, details on research methodologies, including study site, methods adopted for data analysis for this investigation entitled “Evaluation and impact of agroforestry systems on socio-economic condition in Kanke Block of Ranchi District”.

3.1 Experimental site

The experiment was conducted at Kanke block which is situated North part of Ranchi district. It is located 2Km from Birsa Agricultural University. The altitude of the study site is about 632 m above mean sea level. Geographically the site is located at 23⁰ 45' N latitude and 85⁰ 30' E longitude. The topographically the site is almost hilly comprised of basic igneous rocks and granite in small pockets, which are the main geological sequence on which parent material and soil have developed.

3.2 Climate

The climate is classified as humid subtropical. Maximum temperature observed is 37⁰ C and a minimum of 7⁰C. The mean relative humidity is about 82.62% in the area. The monsoon breaks out in the middle of June and last till mid October. The annual rainfall in the area varies from 900 – 1500 mm. The mean wind velocity and evaporation is 3.3 km hr⁻¹ and 105 mm. The details of monthly meteorological data obtained from Agrometeorological department of Birsa Agricultural university.

Plate No.1: LOCATION OF SITE

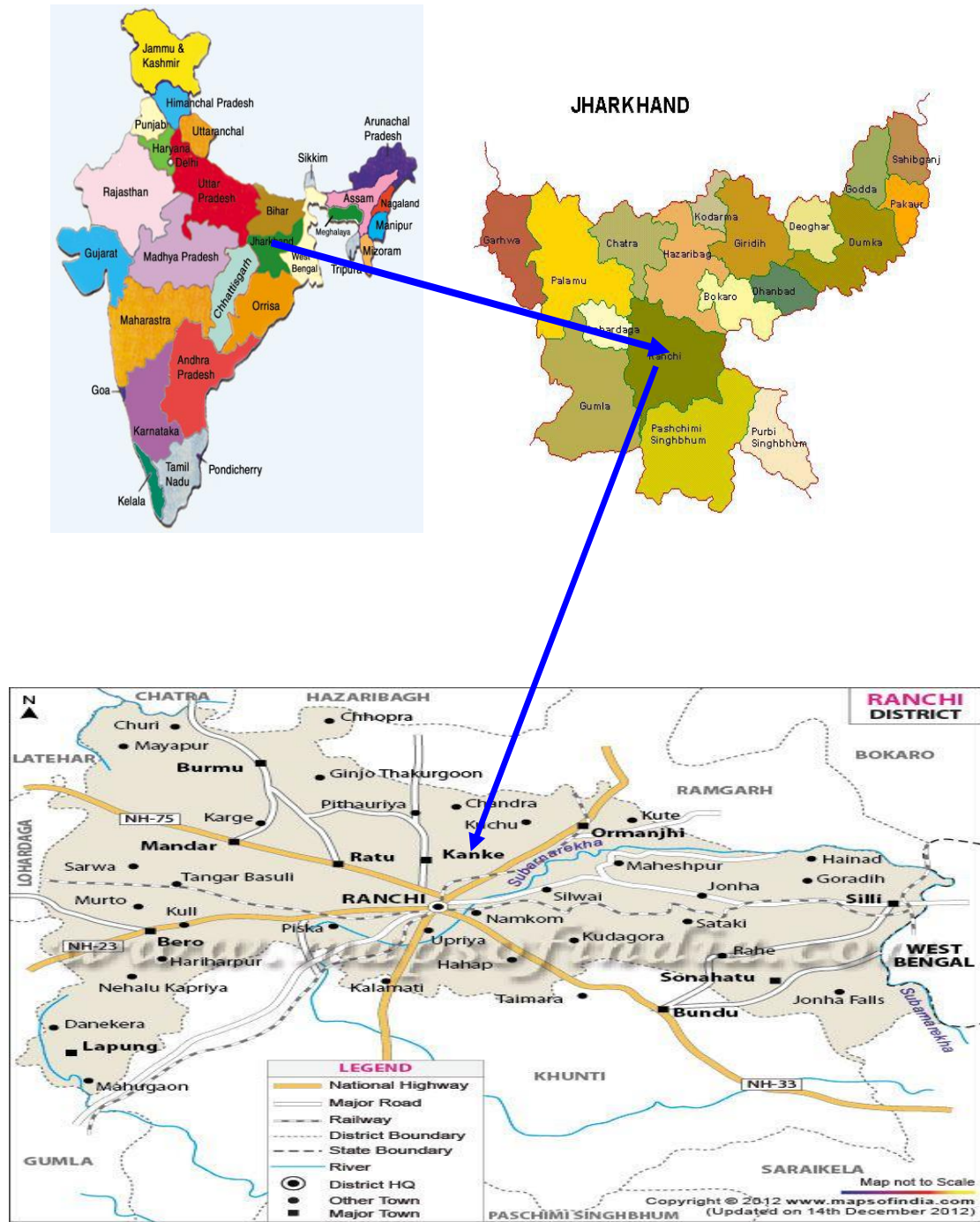


Table-3.1: Monthly meteorological data of study site, 2015

Months	Temperature (°C)		Average relative humidity (%)		Rainfall (mm)		
	Average maximum	Average minimum	7.00 A.M	2.00 P.M	Total	No. of rainy days	Cum.rain
January, 15	21.1	7.6	82.5	71.1	22.2	1	22.2
February, 15	26.8	12.7	83.2	66.9	8.1	1	30.3
March, 15	29.9	17.0	82.6	63.1	4.1	1	34.4
April, 15	33.0	21.2	82.5	68.5	69.7	5	104.1
May, 15	37.6	24.5	82.4	54.5	63.9	3	168.0
June, 15	33.3	22.3	80.0	61.7	146.0	10	314.0
July, 15	29.6	20.3	83.2	62.5	170.7	12	484.7
August, 15	30.2	21.2	83.0	62.6	290.6	9	775.3
September, 15	32.2	21.6	82.7	63.8	31.0	3	806.3
October, 15	29.0	18.9	82.7	65.7	115.1	5	921.4
November, 15	27.0	13.7	83.5	67.6	0.0	0	921.4
December, 15	23.1	9.7	83.2	54.5	3.2	1	924.6

3.3 METHODOLOGY

The investigation is based on a sample of 20 household practicing agroforestry selected randomly from total population of 80 households, using questionnaire specially designed for determination of socio –economic condition of different Panchayats of Kanke Block of Ranchi district.

Observations

3.3.1 Selection of panchayats

3.3.1.1 Procedure of selection

Number of Blocks to be taken in the district:	1
Number of Panchayats taken in a Block:	4
Number of villages taken:	4 (One in each panchayats)

Number of Households in each Village:	20
Total Number of Households to be surveyed:	20×4= 80

3.3.1.2 Name of selected panchayats

Upperkonki panchayat

Urguttu panchayat

Pithoria panchayat

Malsring panchayat

3.3.2 Information of demography:

3.3.2.1 Data on Population

Collected on the basis of sampling techniques with the help of well-structured questionnaire of different panchayat of Kanke block

3.3.2.2 Caste profile status

3.3.2.3 Family structure

3.3.2.4 Literacy status

3.3.2.5 Land holding status

3.3.2.6 Land use pattern

3.3.2.7 Professional status

3.3.2.8 Livestock and Poultry status

3.3.2.9 Fuel wood consumption pattern

3.3.2.10 Fodder consumption pattern

3.3.2.11 Agriculture crop productivity

3.3.3 Observation Recorded

The different growth parameters such as height and diameter were recorded from each village. The details of measurement and calculation methods are given below-

3.3.3.1 Height of tree species

The height of individual tree from ground level to the top of crown was considered as height, which was measured with a graduated bamboo marked in meter.

The graduation was done at one meter interval, half meter interval and at an interval of 10 cm. In the case of trees having greater height than poles Haga Altimeter instrument was used (Chaturvedi & Khanna, 1982). The mean height of tree species is calculated with the help of height of total height with the total number of tree plot. The height is expressed in meter (m).

3.3.3.2 Diameter at breast height of tree species

The diameter was measured indirectly by measuring girth because many forestry scientists have preferred the use of tape over calliper in the interest of accuracy (Chaturvedi and Khanna, 1982). Therefore, all trees of each villager were enumerated for girth at breast height (1.37 m), over bark (G.BH.OB) and it was expressed in terms of centimeter (cm). The girth, thus obtained was converted into diameter by the using standard formula $d = g/\pi$ (where d = diameter, g = girth, $\pi = 3.1415$). From total diameter of all trees, the mean diameter was calculated.

3.3.3.3 Volume

The volume of tree in the site was calculated using the following formula and is expressed in cubic meter (cu.m. or m^3) (Chaturvedi & Khanna, 1982)

$$V = \pi \frac{d^2}{4} h$$

Where d = Diameter at breast height (d.b.h) in m

h = Total height (m)

$$\pi = 3.14$$

3.3.4 General soil properties

Composite soil samples from each treatment plot were taken. The samples were air dried, powdered and sieved prior to chemical analysis. The methods employed for chemical analysis are given below-

3.3.4.1 Soil pH

The pH of the soil was determined by potentiometry (pH meter). For this purpose soil: water suspension was prepared (1:2.5) and tested with potentiometry to know the value of pH (Bronsted – Lowry concept).

3.3.4.2 Available Nitrogen

The Available nitrogen present in the soil was estimated by alkaline permanganate method (Subbiah and Asija, 1956). 20.0 gm of soil was taken in a distillation flask and moistened with 20.0 ml of distilled water. Then 100.0 ml of freshly prepared 0.32% potassium permanganate solution and 2.5% sodium hydroxide were added and distillation was done by collecting the distillate in 20.0 ml of 0.1 N sulphuric acid (with methyl red as indicator) in a beaker. After the distillation was over the contents of the beaker were titrated against 0.1 N potassium hydroxide until a straw yellow colour was obtained. From the difference in the titration value the amount of available nitrogen was calculated.

3.3.4.3 Available Phosphorous

Bray No -1 method (Bray and Kurtz, 1945)

This process is mainly followed for soil which are moderately strongly acidic pH 5.5 > less in this method combination of HCL & ammonium fluoride is used to remove easily acidic soluble phosphorous form largely calcium phosphate and portion of the aluminium & iron phosphate by its complex ion formation with these metals ions in acid.

- 2.5 gm of soil & 25 ml of extracting solution were shaken in 100ml conical flask for exactly 5 min
- Then filtered using WHATMAN filter paper to avoid interference
- 5ml filtrate each pipeted into 25 ml of volumetric flask
- Added 4ml of the ascorbic acid solution and shaken well
- After that little amount of distilled water was added
- Prepared standard curve using spectrophotometer

3.3.4.4 Available Potassium

Ammonium acetate method of K determination (Hanway and Heidel 1952)

- 5gm of soil sample in 100 ml of conical flask

- Added 25 ml of the neutral 1N ammonium acetate solution and shaken for 5 minutes
- Filtered through WHATMAN NO – 1 filter paper
- Measured K concentration in the filtrate using flame photometer
- Prepared the standard curve for K
- Recorded the flame photometer for each of the Working standards of K after adjusting blank to zero

Equation followed for calculation of Available potassium in soil:

$$\text{Available K} = C \times 25 \div 5 \times 10^6 \div 10^6 \times 2.24 = C \times 11.2$$

Where C stands for the concentration of potassium in the sample obtained on x axis against the reading

3.3.4.5 Organic Carbon percent

Walkley and Black method was used for analysis of soil organic carbon. The method of analysis is as below:

- 2 gm soil sample was taken in 500 ml conical flask.
- 10 ml of standard one normal solution of Potassium Dichromate (1N $K_2Cr_2O_7$) was taken and mixed.
- 20 ml of conc. H_2SO_4 was added to the solution.
- The content was mixed by gentle swirling for one minute. It was allowed to stand for 30 minute.
- 200 ml of water was added along with 10 ml conc. H_3PO_4 and was mixed properly.
- About 20-30 drops of Diphenyl indicator was mixed insuring the solution as deep violet in colour.
- The solution was titrated against ferrous ammonium sulphate solution to a parrot green colour.
- A blank titration following all the above steps without taking soil was also carried.

3.3.5 Growth of slow growing, medium growing and fast growing trees (5 species in each village) of selected villages.

Total 80 household survey and 20 farmers from each selected villages. Height, diameter and volume of existing trees in slow, medium and fast growing trees. Five (5) tree species from each selected villages have been selected from the observation.

3.3.6 Yield of agricultural crops

The yield of agricultural crops collected through the predesigned questionnaire with the help of persons who were doing agricultural work in their own field. The data was collected and further analyzed to get meaningful conclusion.

3.3.7 Economics:

3.3.7.1 The cost associated with management of the trees at existing agroforestry sites.

Collected through the predesigned questionnaire with the help of the persons who were responsible for management of existing agroforestry sites. The data was collected and further analyzed to get meaningful conclusions.

3.4.7.2 The direct benefits from trees and agricultural crops.

Collected through the predesigned questionnaire with the help of survey of local people. The direct benefit from the trees and agricultural crops were calculated from the data collected from experimental sites.

3.3.8 STATISTICAL ANALYSIS

Adopting multi-stage random sampling taking one district, one block, and four panchayat, one village from each panchayat will be selected for the observation. In each of the four selected villages, 20 farmers will be selected for data collection related to agroforestry practice. The data recorded on various parameters were subjected to statistical analysis for interpretations. Standard error of mean ($S.E_m$), Critical difference at 5% (C.D 5%) and Coefficient of variation (C.V%) were calculated for parameter to draw inferences. For statistical calculation Excel Package of M.S Office was used in a computer.

RESULT AND DISCUSSION

The socio- economic status and role of livelihood through the agroforestry availability was accessed under the research activity by taking data of different parameters like demographic and socio-economic status (Population profile, Caste profile, Family structure, Literacy status, Livestock and Poultry status, House hold status), Land holding status, land status, land use pattern, dependency on forest (Fuelwood and Fodder consumption pattern, annual income from agroforestry). Height and diameter of important trees of farmer's interest from selected villages of Kanke Block were recorded. Data has been collected in all 4 villages and 4 panchayat of Kanke Block. From that block, total 80 respondents were randomly selected, of which 20 respondents from each villages were selected for the study.

4.1 Population status of selected villages of Kanke Block

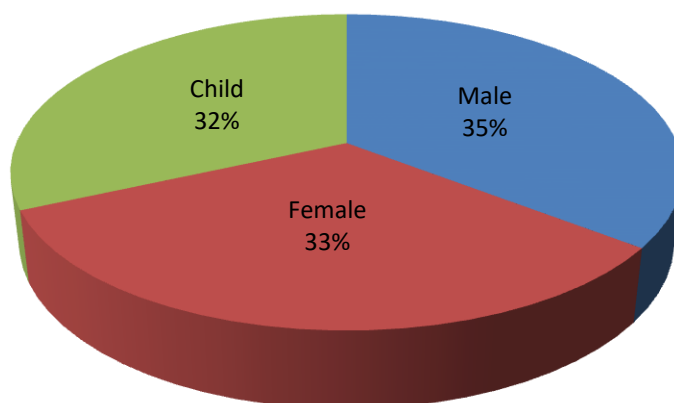
The population status of selected villages of Kanke Block are presented in Table 4.1 and Fig 4.1. The data showed that the percentage of male population was more than female and child population percentage. The trend of mean population percent was in the order of 35.45% (mean male population percentage) >32.86% (mean female population) >31.69% (mean child population percentage)

Table-4.1: Population status of selected villages of Kanke Block

Particulars	Villages				Avg . no \pm S.E	%
	Manha	Marwa	Patratu	Pithoria		
Male	36	37	40	38	37.75 \pm 0.85	35.45
Female	32	35	37	36	35.00 \pm 1.08	32.86
Children	30	35	38	32	33.75 \pm 1.75	31.69

From this Fig 4.1 it was clearly visible that the mean male population percentage was comparatively higher than female and child population percentage in all the four villages of Kanke Block.

Fig 4.1: Population status of selected villages of Kanke Block



4.2 Caste profile status of selected villages of Kanke Block

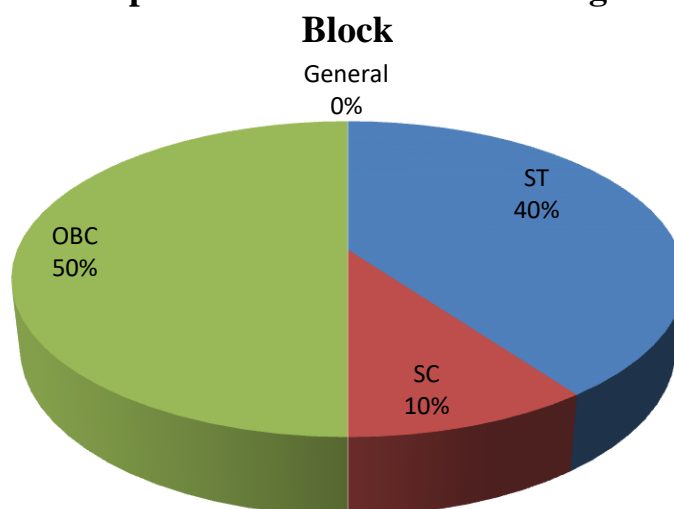
It was evident from the study that, overall Other backward caste (OBC) was most dominant in the Kanke Block than any other castes Table 4.2 and Fig 4.2. In general, trends of number of different caste profile are 10.0 (50%) followed by scheduled tribe (ST) caste population 8.0 (40 %). Remaining caste communities having lesser number and percentage as in case (scheduled caste) SC it is 2.0 (10%). There is no population of general.

Table-4.2: Caste profile status of selected villages of Kanke Block

Particulars	Villages				Avg. No \pm S.E	%
	Manha	Marwa	Patratu	Pithoria		
Scheduled tribe	12	13	3	4	8.0 \pm 2.61	40
Scheduled caste	6	0	0	2	2.0 \pm 1.41	10
Other backward caste	2	7	17	14	10 \pm 3.39	50
General	0	0	0	0	0	0

From this Figure 4.2 it revealed that OBC community was dominating in the research areas and the farmers of that community were found traditionally highly dependent upon forest resources and heavily dependent upon agriculture for their livelihood.

Fig 4.2: Caste profile status of selected villages of Kanke



4.3 Family structure of selected villages of Kanke Block

The family structure of selected villages of Kanke block is presented in Table 4.3. Average number of Household in selected villages of Kanke block was found as 145 out of which the proportion of nuclear family was 56.25 % (11.25 was families in average) and joint family was 43.75 % (8.75 families in average).

Table-4.3: Family structure of selected villages of Kanke Block.

Particulars	Villages				Avg.no \pm S.E	%
	Manha	Marwa	Patratu	Pithoria		
Nuclear family	12	13	12	8	11.25 \pm 1.10	56.25
Joint family	8	7	8	12	8.75 \pm 1.10	43.75
No.of household	150	150	80	200	145 \pm 24.66	100

As per Raid (2002), the mean household size of the survey population in Bangladesh is 4.26.

4.4 Literacy status of selected villages of Kanke Block

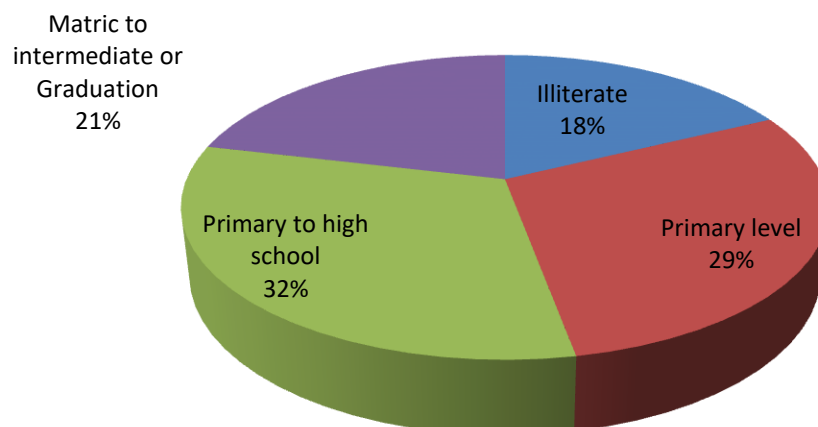
The literacy status of selected villages of Kanke Block is presented in Table 4.4 and Fig 4.3. People having primary level education and primary to high school were found more in the selected villages were recorded as 29.0 % and 31.32 % respectively. The average number of people with primary level education was found maximum (31.25 numbers) in each selected villages followed by number of people with primary to high school education (33.75 numbers) and Matric to intermediate or graduation (26.5 numbers).

Table-4.4: Literacy Status of selected villages of Kanke Block

Particulars	Villages				Avg.no ± S.E	%
	Manha	Marwa	Patratu	Pithoria		
Illiterate	17	18	22	19	19.0 ± 1.08	17.63
Primary	28	31	34	32	31.25 ± 1.25	29.0
Primary to high school	32	34	35	34	33.75 ± 0.63	31.32
Matric to intermediate or Graduation	20	24	26	21	22.75 ± 1.37	21.11

In Bangladesh Rasid (2002), observed that, 44% of all household heads are literate and it rate varies from 31% for the always poor household heads to 68% for the occasionally poor household heads. Further he mentioned that higher literacy levels are strongly correlated with use of more services. It also indicates an element of empowerment and awareness. It could possibly be associated with the better living conditions and higher status of the literate.

Fig 4.3: Literacy Status of selected villages of Kanke Block



4.5 Land holding Status of selected villages of Kanke Block

The land holding status of selected villages of Kanke Block is presented in Table 4.5 and Fig 4.4. From this table it was observed that the number of medium land holding household was found maximum with 60% of total number of household, followed by small land holding status (30.0%). Very few household, in the research area washaving large land holding with their average number and percentage 1.25 and 6.25 respectively. The least was also observed in case of landless farmer (3.75%).

Table-4.5:Land holding status of selected villages of Kanke Block

Particulars	Villages				Avg.no ± S.E	%
	Manha	Marwa	Patratu	Pithoria		
Landless	0	1	1	1	0.75 ± 0.25	3.75
Small	6	7	5	6	6.0 ± 0.40	30.0
Medium	13	10	13	12	12.0 ± 0.70	60.0
Large	1	2	1	1	1.25 ± 0.25	6.25

Rasid (2002) mentioned that usually poor households used wild foods, forest resources more than the occasionally poor group. He also mentioned that the land holding is used as one of the variables in constructing the wealth index in Bangladesh.

Fig 4.4: Land holding status of selected villages of Kanke Block

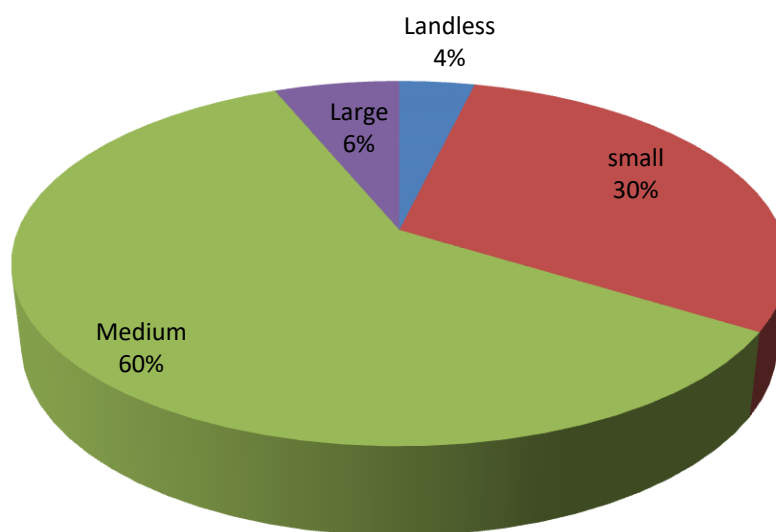


Fig 4.4 represents of the land holding status in the research area and it can be easily observed that the proportion of Medium land holding status is significantly superior to the three landholding status *i.e.* Small, Large and Landless household.

4.6: Land use pattern status of selected villages of Kanke Block

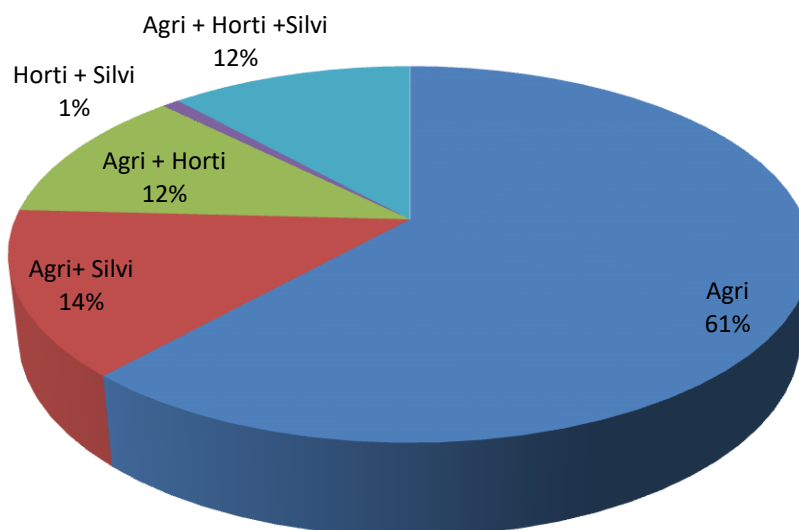
The land use pattern of selected villages of Kanke Block are presented in Table 4.6 and Fig 4.5. Agriculture was the main land use pattern followed in the selected village areas and number of households followed agriculture was 74 (60.65%). Many household also planted forest trees in their garden and farmland followed by Agrisilvicultural system maintained by 17 households (13.93%). In the selected four villages 14 households (11.48%) followed Agrihorticultural practices and cultivating vegetable, papaya, guava *etc.* Similarly, Agrihortisilvicultural practices are also followed by 14 number of households (11.48%). Further it was observed that Agriculture and Agrisilvicultural systems were the main land use pattern followed by household in the Kanke block. Integration of horticulture was also followed by some of the households for cash income was observed in the land use pattern of Agrihorticultural, Hortisilvicultural and Agrihortisilvicultural system.

Table-4.6:Land use pattern of selected villages of Kanke Block

Particulars	Villages				Avg.no ± S.E	%
	Manha	Marwa	Patratu	Pithoria		
Agriculture	18	20	16	20	18.50 ± 0.95	60.65
Agri + Silvi	5	4	4	4	4.25 ± 0.25	13.93
Agri + Horti	3	5	3	3	3.50 ± 0.5	11.48
Horti + Silvi	0	1	1	1	0.75 ± 0.25	2.45
Agri + Horti + Silvi	4	4	3	3	3.50 ± 0.29	11.48

Rasid (2002) mentioned that involvement in agriculture is still prevailing in most households as primary occupation in Bangladesh. About 63% of households depend on one form of agriculture or another ranging from producing crops on their own land as labour for agriculture.

Fig 4.5: Land use pattern of selected villages of Kanke Block



4.7 Professional Status of selected villages of Kanke Block

The professional status of selected villages of Kanke Block is presented in Table 4.7 and Fig 4.6. Agriculture and Animal husbandry had been adopted by most of the

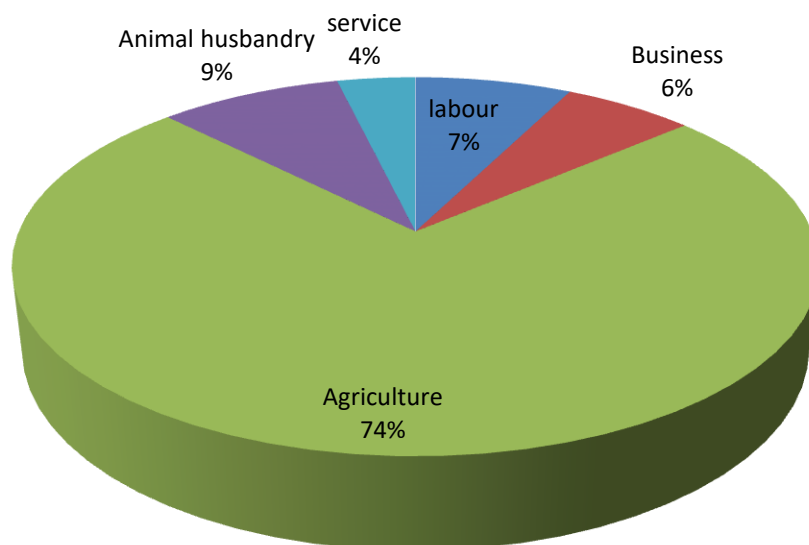
working people in villages of the Kanke block of Ranchi districts with their percentage 73.75 and 8.75 respectively. It was also observed that very less number of households were in the job.

Table-4.7: Professional status of selected villages of Kanke Block

Particulars	Villages				Avg.no ± S.E	%
	Manha	Marwa	Patratu	Pithoria		
Labour	1	2	1	1	1.25 ± 0.25	6.25
Business	2	1	2	1	1.50 ± 0.29	7.50
Agriculture	15	14	16	14	14.75 ± 0.48	73.75
Animal husbandry	2	2	1	2	1.75 ± 0.25	8.75
Service	0	1	0	2	0.75 ± 0.48	3.75

Arnold (2002) also mentioned that large numbers of landless and poor people involved in collecting, processing and trading forest products in rural and semi urban areas in general besides livestock

Fig 4.6: Professional status of selected villages of Kanke Block



4.8 Livestock and poultry status of selected villages of Kanke Block

The livestock and poultry status of selected villages of Kanke Block are presented in Table 4.8. In the research area, Goat and poultry were the two important livestock found integrated with the cultural life of tribal particularly. Highest average number of rearing poultry found in the selected four villages of Kanke Block was calculated as 25.5, which were the main source of income from animal husbandry profession of tribal. The average number of goat found in four villages was calculated as 14.5. From the sale of goat, they also extracted considerable income. Cow was also domesticated by same household and its average number in four villages was 12.5. Very few household domesticated pig and its number per village was found as 2.5 only. Rearing poultry was common and even always and usually poor households were rearing poultry bird.

Table-4.8: Livestock and poultry status of selected villages of Kanke Block

Particulars	Villages				Avg.no \pm S.E
	Manha	Marwa	Patratu	Pithoria	
Cow	10	12	15	13	12.5 \pm 1.04
Goat	12	13	18	15	14.5 \pm 1.32
Pig	5	3	0	2	2.5 \pm 1.04
Poultry	25	30	12	35	25.5 \pm 4.94

Thus, Rasid (2002) mentioned that one third of the households in Bangladesh have cattle and goats, owing two animals on average. He also mentioned that in Bangladesh, overall 37% of households have cattle and 27% own goats, in both cases two on an average, besides 42% of households in drought prone areas own cattle, but they do not have large herds. A greater percentage of always poor households have poultry 60% compared to other assets owned by the always poor households and also keeps goats.

4.9: Fuel wood consumption pattern (q household⁻¹ yr⁻¹) of selected villages of Kanke Block

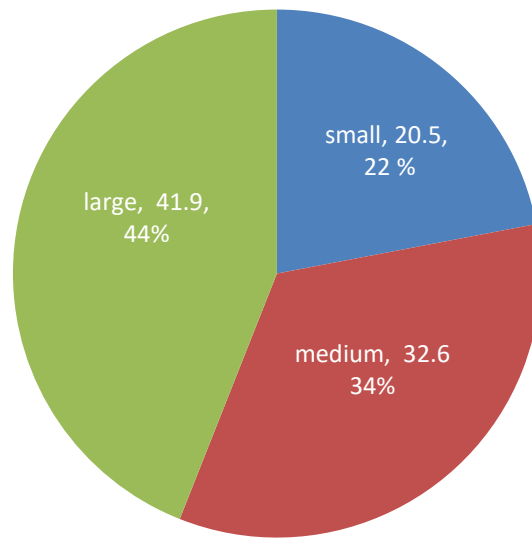
The fuel wood consumption pattern of selected villages of Kanke Block is presented in Table 4.9 and Fig 4.7. As far as consumption of fuel wood at domestic level was concerned, the maximum fuelwood was recorded to be consumed by farmers of large size household (41.9 q yr⁻¹), followed by medium farmers (32.6 q yr⁻¹) and least by small farmers (20.5 q yr⁻¹).

Table-4.9: Fuel wood consumption pattern (q household⁻¹ yr⁻¹) of selected villages of Kanke Block

Category of household	Villages				Mean ± S.E
	Manha	Marwa	Patratu	Pithoria	
Small	20	22	19	21	20.5 ± 0.64
Medium	32.7	33.5	29.8	34.5	32.6 ± 1.01
Large	42.3	43.7	40.2	41.4	41.9 ± 0.73

As per Hulscher *et al.* (1999), fuel wood emerged as the most important wood product in the northern districts of West Bengal, with more than 70% originating in state forests and Fuel wood business is found to be the main source of income for 10% of rural households in these districts, and accounted for about 45% of their cash income.

Fig 4.7: Domestic fuelwood consumption (q household⁻¹ yr⁻¹) of selected villages of Kanke Block



From the pie diagram, it was observed that percentage of fuel wood consumption at domestic level was found maximum in case of large size household's farmers (44%), followed by farmers of medium size household's (34%) and least by farmers of small size household's (22%) *i.e.* the consumption of fuel wood at domestic level was almost double in case of large farmers with respect to small farmers. Hawthorne (1996) mentioned that richer groups derive greater net income from the more important conservation species in contrast to the poor who tend to collect cultivated species.

4.10. Fodder consumption pattern (q household⁻¹ yr⁻¹) of selected villages of Kanke Block

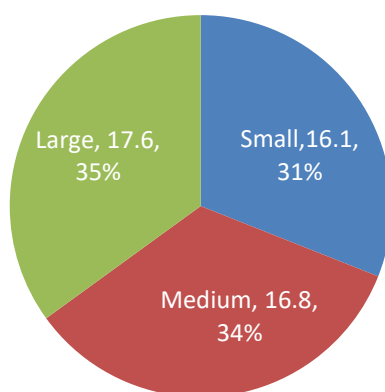
The fodder consumption pattern of selected villages of Kanke Block is presented in Table in 4.10 and Fig 4.8. As regards to consumption of fodder at domestic level, maximum consumption was done by large size household's farmers (17.6 q yr⁻¹), followed by medium farmers (16.8 q yr⁻¹) and least by small farmers (16.1 q yr⁻¹).

Table-4.10: Fodder consumption pattern (q household⁻¹ yr⁻¹) of selected villages of Kanke Block

Category of household	Villages				Mean \pm S.E
	Manha	Marwa	Patratu	Pithoria	
Small	16.2	16.5	15.3	16.4	16.1 \pm 0.27
Medium	16.8	17.3	15.9	17.5	16.8 \pm 0.35
Large	17.4	17.7	16.8	18.5	17.6 \pm 0.35

Fodder consumption at domestic level by different categories of farmers. More or less same percentage of fodder utilization is shown by large and medium farmers and it is calculated as 35% and 34% respectively. In case of small farmers, it is calculated 31%.

Fig 4.8: Domestic fodder consumption (q household⁻¹ yr⁻¹) of selected villages of Kanke Block



4.11 Soil pH of selected villages of Kanke Block

The soil pH of selected villages in different area are presented in Table 4.11. In Manha village, pH value was recorded highest in Agri + Silvi (6.1) and lowest in barren land (4.9). In case of Marwa village highest pH value was found in Agri + Silvi (6.2) and lowest for barren land (5.1). In Patratu village, pH value of soil was highest in sole crop (6.3) and lowest was recorded in Horti + Silvi system (5.2). In Pithoria village, pH value was recorded as 6.9 for Agri + Silvi areas which was highest and lowest pH was found in barren land (5.4). Soil of the agrisilvicultural system is less acidic in nature than any other.

Table-4.11: Soil pH value of selected villages of Kanke Block.

Treatment	Villages			
	Manha	Marwa	Patratu	Pithoria
Agri + Silvi	6.1	6.2	5.8	6.9
Horti + Silvi	5.3	5.7	5.2	6.4
Sole tree only	5.6	5.3	5.7	5.8
Sole crop only	5.7	5.4	6.3	6.7
Barren land	4.9	5.1	5.6	5.4

Table 4.11 shows that pH value was decreasing and in Agri+ Silvi, Sole crop only, Horti+Silvi, Sole tree crop respectively and least pH was recorded in barren land.

Hosur and Dasog (1995) who worked on effect of tree species on soil properties in red loam soil have found decrease pH planted area of teak, shisham and khair.

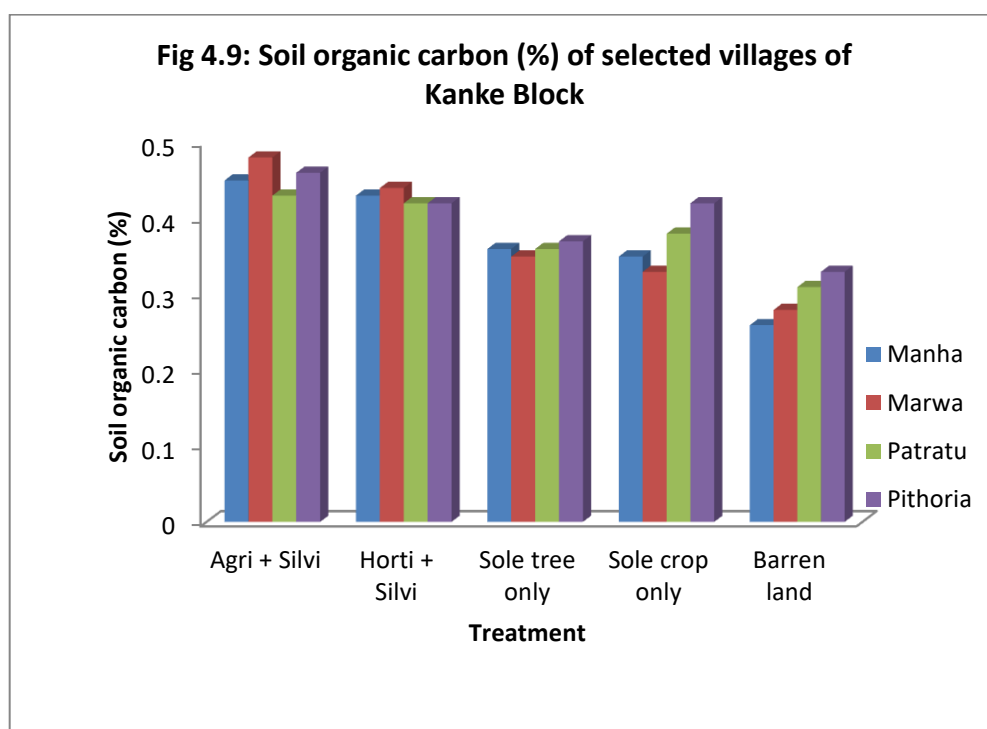
4.12 Soil Organic Carbon of selected villages of Kanke Block.

The soil organic carbon of selected villages in different area are represented in Table 4.12. and Fig 4.9. In Manha village, level of organic carbon percent was 0.45 for Agri+Silvi, 0.43 for Horti+Silvi, whereas 0.36 and 0.35 for sole tree and sole crop respectively. The least organic carbon percent was found in the barren land (0.15). In Marwa, village level of organic carbon percent were 0.48 for Agri + Silvi, 0.44 for Horti + Silvi, 0.35 for sole tree, 0.33 for sole crop and less in barren land (0.28). The organic carbon percent in soil was recorded maximum as in case of Patratu village (0.43) for Agri + Silvi, 0.42 for Horti + Silvi, 0.36 for sole tree only, 0.38 % for crop was recorded, whereas, lowest organic carbon percent 0.31 was recorded in barren land. In Pithoria village, organic carbon percent was 0.46, 0.42, 0.37 and 0.42 for Agri + Silvi, Horti + Silvi, sole tree, and sole crop respectively. Overall highest organic carbon percent was recorded with Agri + silvi system (0.45) which was at par with Horti + Silvi (0.43) and significantly superior over sole tree (0.36), sole crop system (0.37) and barren land (0.30) also.

Table-4.12: Soil Organic Carbon of selected villages of Kanke Block.

Treatment	Villages				Mean
	Manha	Marwa	Patratu	Pithoria	
Agri + Silvi	0.45	0.48	0.43	0.46	0.45
Horti + Silvi	0.43	0.44	0.42	0.42	0.43
Sole tree only	0.36	0.35	0.36	0.37	0.36
Sole crop only	0.35	0.33	0.38	0.42	0.37
Barren land	0.26	0.28	0.31	0.33	0.30
C.D at 5%					0.037
C.V					6.212

Similarly, Rai *et al.* (2001) also reported higher level of organic carbon in silvipastoral system as compared to pasture alone. Similar results were also depicted by Chauhan *et al.* (1995) when studied under agrisilvicultural system.



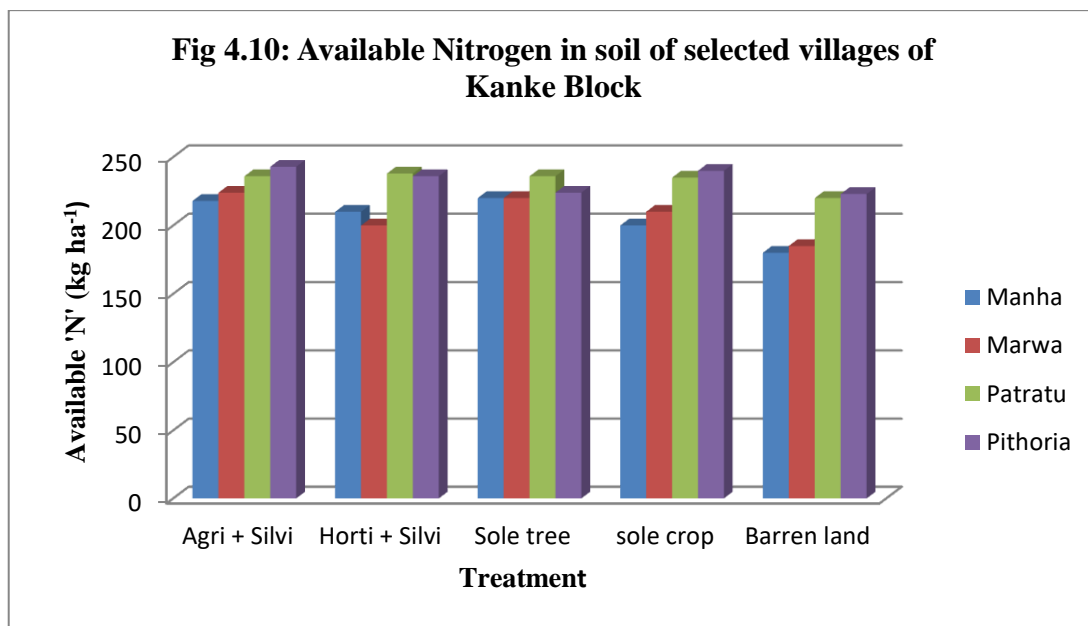
4.13 Available nitrogen in soil of selected villages of Kanke Block.

The available nitrogen in soil of selected villages in different area is presented in Table 4.13 and Fig 4.10. In Manha village, available nitrogen was recorded highest as 218 kg ha⁻¹ for Agri+Silvi, 210 kg ha⁻¹ for Horti+Silvi, 220 kg ha⁻¹ for sole tree only, and 200 kg ha⁻¹ in sole crop respectively. The least available nitrogen found in the barren land (180 kg ha⁻¹). In Marwa village, available nitrogen was recorded highest as 224 kg ha⁻¹ for Agri + Silvi, followed by 200 kg ha⁻¹ for Horti + Silvi, 220 kg ha⁻¹ for sole tree, 210 kg ha⁻¹ for sole crop and the least was recorded in barren land (185 kg ha⁻¹). The available nitrogen in soil recorded in Patratu village were in the order of 236 kg ha⁻¹ for Agri + Silvi, 238 kg ha⁻¹ for Horti + Silvi, 236 kg ha⁻¹ for sole tree only, 235 kg ha⁻¹ for sole crop, whereas lowest was recorded as 220 kg ha⁻¹ in case of barren land. In Pithoria village, available nitrogen was 243 kg ha⁻¹, 236 kg ha⁻¹, 224 kg ha⁻¹, and 240 kg ha⁻¹ for Agri + Silvi, Horti + Silvi, sole tree, and for sole crop respectively and least available nitrogen was found in barren land (223 kg ha⁻¹). Overall highest available nitrogen 230.25 kg ha⁻¹ was recorded in Agri + silvi system which was at par with Horti + Silvi (221.00 kg ha⁻¹), sole tree (225 kg ha⁻¹), & sole crop (221.25 kg ha⁻¹) and was significantly superior over barren land (202.00 kg ha⁻¹).

Table-4.13: Available nitrogen in soil of selected villages of Kanke Block.

Treatment	Villages				Mean	S.E
	Manha	Marwa	Patratu	Pithoria		
Agri + Silvi	218	224	236	243	230.25	5.6
Horti + Silvi	210	200	238	236	221.00	9.4
Sole tree only	220	220	236	224	225.00	3.7
Sole crop only	200	210	235	240	221.25	9.6
Barren land	180	185	220	223	202.00	11.3
C.D at 5%						16.67
C.V						4.86

Ravi (2005) reported higher level of soil available nitrogen, phosphorus and potassium under fodder cowpea intercropped with *Ailanthus*. Low density of tree (*Cassia siamea*, bamboo, neem) was found to be contributed for higher in C:N and C:P ratios in agroforestry systems (Prabhu and Sreemannarayana, 2007).



4.14 Available Phosphorous in soil of selected villages of Kanke Block.

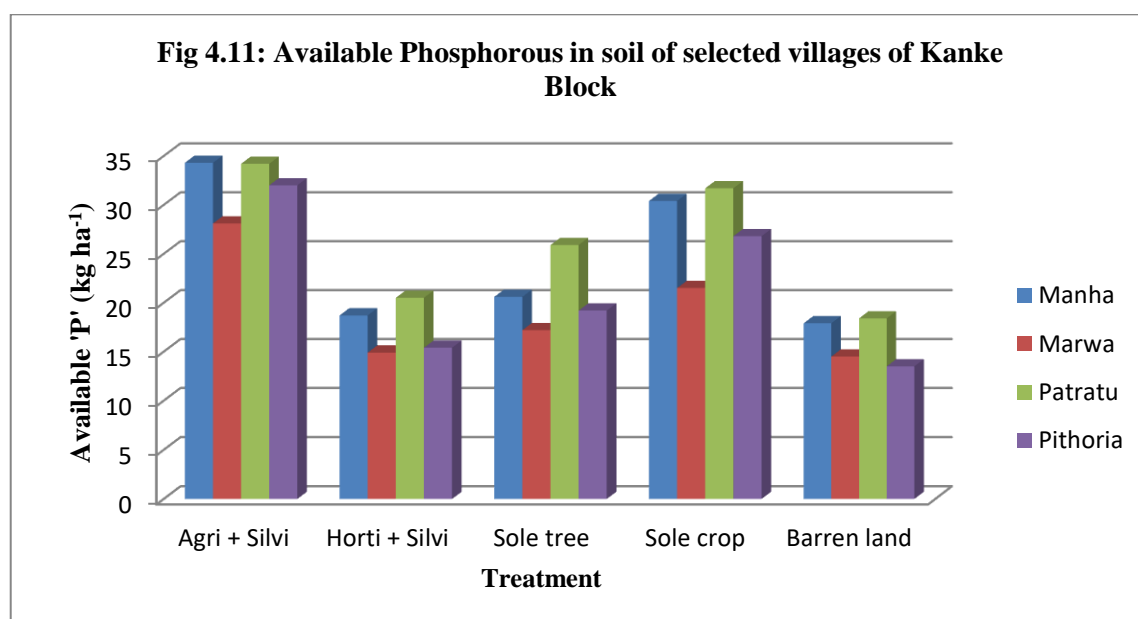
The available Phosphorous of selected villages in different area is presented in Table 4.14 and Fig 4.11. In Manha village, soil available phosphorous was recorded highest as 34.3 kg ha⁻¹ for Agri+Silvi, followed by 18.7 kg ha⁻¹ for Horti+Silvi, 20.6 kg ha⁻¹ and 30.4 kg ha⁻¹ for sole tree and sole crop respectively. The least available was found in the barren land (17.9 kg ha⁻¹). In Marwa village, soil available phosphorous was found highest as 28.1 kg ha⁻¹ for Agri + Silvi, followed by 14.9 kg ha⁻¹ for Horti + Silvi, 17.2 kg ha⁻¹ for sole tree, 21.5 kg ha⁻¹ for sole crop and less available phosphorous was found in barren land (14.5 kg ha⁻¹). The available phosphorous in soil was recorded in Patratu village, as 34.2 kg ha⁻¹ for Agri + Silvi, 20.5 kg ha⁻¹ for Horti + Silvi, 25.9 kg ha⁻¹ for sole tree only, 31.7 kg ha⁻¹ for sole crop, whereas the lowest was found as 18.4 kg ha⁻¹ for barren land. In Pithoria village, available phosphorous was recorded as 32.0 kg ha⁻¹,

15.4 kg ha⁻¹, 19.2 kg ha⁻¹ and 26.8 kg ha⁻¹ for Agri + Silvi, Horti + Silvi, sole tree, and sole crop, and least available phosphorous was found in barren land (13.5 kg ha⁻¹). Overall, highest available phosphorous 32.15 kg ha⁻¹ was recorded in Agri + silvi system which was significantly superior over Horti + Silvi (17.07 kg ha⁻¹), sole tree (20.72 kg ha⁻¹), sole crop (27.60 kg ha⁻¹) and barren land (16.37 kg ha⁻¹).

Table-4.14: Available Phosphorous in soil of selected villages of Kanke Block.

Treatment	Villages				Mean	S.E
	Manha	Marwa	Patratu	Pithoria		
Agri + Silvi	34.3	28.1	34.2	32.0	32.15	2.28
Horti + Silvi	18.7	14.9	20.5	15.4	17.07	1.34
Sole tree only	20.6	17.2	25.9	19.2	20.72	1.86
Sole crop only	30.4	21.5	31.7	26.8	27.60	1.45
Barren land	17.9	14.5	18.4	13.5	16.37	1.28
C.D at 5%						2.43
C.V						6.86

Ravi (2005) observed the highest (18.9 kg ha⁻¹) available phosphorus was recorded at 2m×2m spacing and it decreased gradually as spacing increased between *Jatropha curcas*.



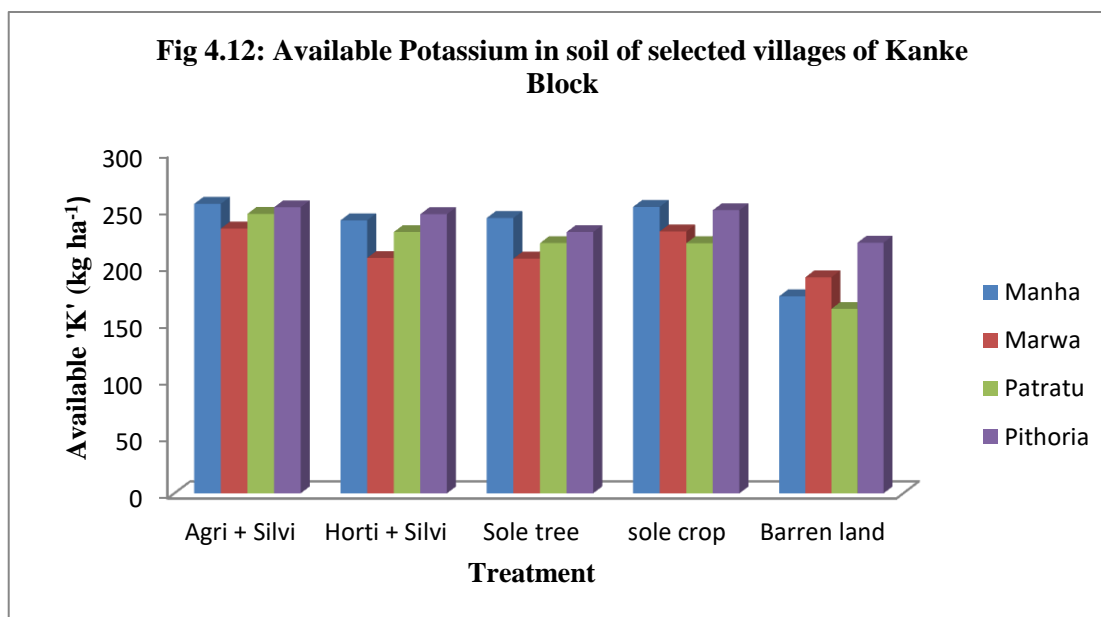
4.15 Available Potassium in soil of selected villages of Kanke Block

The data on a available potassium in soil of selected villages in different area is presented in Table 4.15 and Fig 4.12. In Manha village, available potassium in soil was 254.8 kg ha⁻¹ for Agri+Silvi, 240.3 kg ha⁻¹ for Horti+Silvi, 242.4 kg ha⁻¹ and 252.1 kg ha⁻¹ for sole tree and sole crop respectively. The least available potassium was found in the barren land (173.6 kg ha⁻¹). In Marwa village, available potassium was 233.1 kg ha⁻¹ for Agri + Silvi, 207.2 kg ha⁻¹ for Horti + Silvi, 206.7 kg ha⁻¹ for sole tree, and 230.5 kg ha⁻¹ for sole crop and least available potassium was recorded in barren land (190.3 kg ha⁻¹). The available potassium in soil was recorded in Patratu village as 246.5 kg ha⁻¹ for Agri + Silvi, 230.0 kg ha⁻¹ for Horti + Silvi, 220.3 kg ha⁻¹ for sole tree only, 220.2 kg ha⁻¹ for crop was recorded whereas lowest available potassium was found in barren land (162.5 kg ha⁻¹). In Pithoria village, available potassium was estimated as 251.8 kg ha⁻¹, 245.7 kg ha⁻¹, 230.0 kg ha⁻¹ and 249.2 kg ha⁻¹ for Agri + Silvi, Horti + Silvi, sole tree, and sole crop and least was found in barren land (220.7 kg ha⁻¹). Overall highest available potassium 246.43 kg ha⁻¹ was recorded with Agri + silvi system which was at par with Horti + Silvi (230.80 kg ha⁻¹), sole tree (224.85 kg ha⁻¹), sole crop (238.00 kg ha⁻¹)and significantly superior over barren land (186.77 kg ha⁻¹).

Table-4.15: Available Potassium in soil of selected villages of Kanke Block

Treatment	Villages				Mean	S.E
	Manha	Marwa	Patratu	Pithoria		
Agri + Silvi	254.8	233.1	246.0	251.8	246.43	8.15
Horti + Silvi	240.3	207.2	230.0	245.7	230.80	8.51
Sole tree only	242.4	206.7	220.3	230.0	224.85	7.55
Sole crop only	252.1	230.5	220.2	249.2	238.00	4.81
Barren land	173.6	190.3	162.5	220.7	186.77	12.66
C.D at 5%						20.81
C.V						5.92

Ravi (2005) observed the highest available potassium as 269 kg ha⁻¹ 2m×2m geometry of *Jatropha curcas* plantation.



Higher level of available Nitrogen, Phosphorous and Potassium were noticed in agrisilvicultural plots as compared to tree/crop/barren land plots only whereas in horticultural plots it is lesser

4.16 Growth of slow growing trees of selected villages of Kanke Block

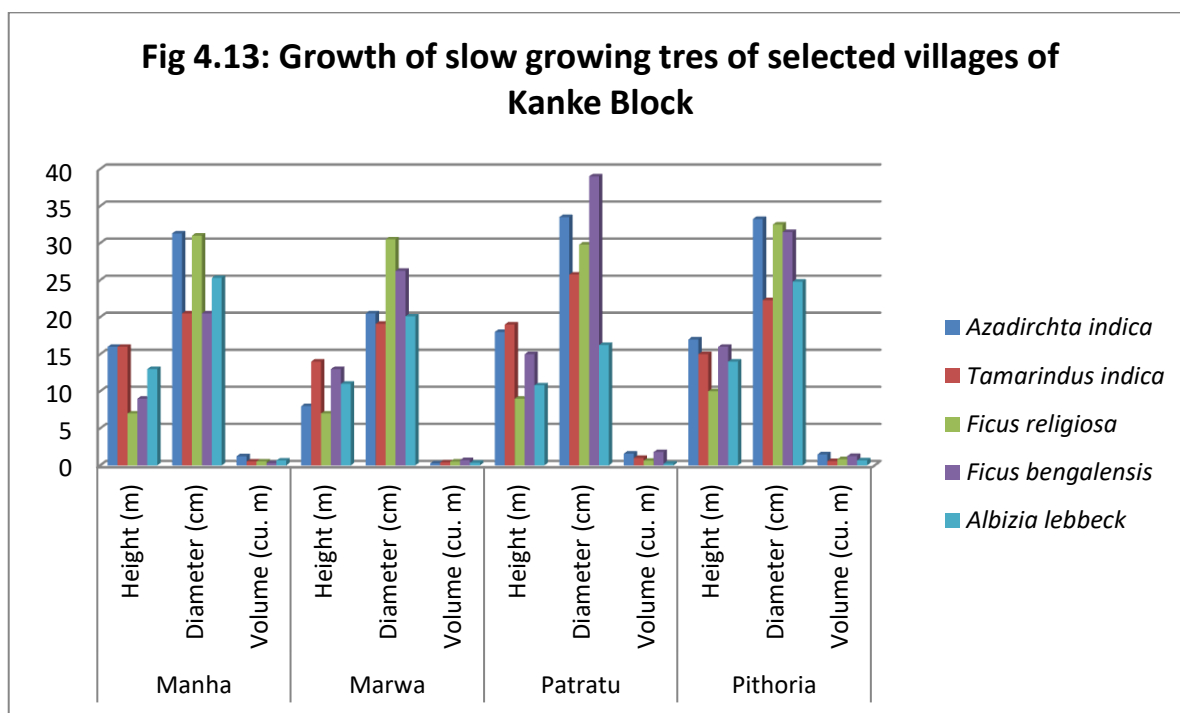
The growth of slow growing trees of selected villages of Kanke Block is presented in Table 4.16 and Fig 4.13. Perusal of the data has indicated that in Manha village height, diameter and volume of *Albizia lebbek* were highest and lowest in *Tamarindus indica*. Whereas in Marwa village, height, diameter and volume of *Albizia lebbek* were highest and lowest were in *Tamarindus indica*. In Patrattu, height, diameter and volume of *Ficus bengalensis* were highest and lowest in *Tamarindus indica* and in Pithoria village, those were recorded highest in *Albizia lebbek* and lowest were in *Tamarindus indica*.

Among all four villages and five species of slow growing trees, height, diameter and volume of the trees were found maximum in *Albizia lebbek* of Pithoria village and minimum in *Tamarindus indica* of Patrattu village.

Table 4.16: Growth of slow growing trees of selected villages of Kanke Block

Slow growing trees	Manha			Marwa			Patratu			Pithoria		
	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)
<i>Azadirachta indica</i>	10	16.25	0.207	12	18.5	0.322	8	13.25	0.110	14	19.5	0.418
<i>Tamarindus indica</i>	7	21.20	0.247	9	22.35	0.353	5	18.5	0.134	12	24.25	0.554
<i>Ficus religiosa</i>	15	28.5	0.957	16	29.0	1.057	18	30.35	1.302	14	28.0	0.862
<i>Ficus bengalensis</i>	14	26.35	0.757	16	28.5	1.021	19	30.0	1.343	15	26.5	0.8276
<i>Albizia lebbek</i>	16	34.5	1.496	19	38.35	2.195	15	33.0	1.283	21	42.5	2.980

Slow growing trees	Height (Avg ± S.E) (m)	Diameter (Avg ± S.E) (cm)	Volume (Avg ± S.E) (cu. m)
<i>Azadirachta indica</i>	11.0 ± 1.3	16.9 ± 1.4	0.26 ± 0.06
<i>Tamarindus indica</i>	8.3 ± 1.5	21.4 ± 1.2	0.32 ± 0.89
<i>Ficus religiosa</i>	15.8 ± 0.9	28.9 ± 0.5	1.04 ± 0.94
<i>Ficus bengalensis</i>	16.0 ± 1.0	27.8 ± 0.9	0.98 ± 0.13
<i>Albizia lebbek</i>	17.8 ± 1.4	37.1 ± 2.1	1.98 ± 0.38



4.17 Growth of medium growing trees of selected villages of Kanke Block

The growth of medium growing trees of selected villages of Kanke Block is presented in Table 4.17 and Fig 4.14. Perusal of the data has indicated that among all five species height, diameter and volume of *Emblica officinalis* was maximum in manha village and minimum in *Mangifera indica*. Whereas in Marwa village, maximum height, diameter and volume found in *Emblica officinalis* and minimum in *Tectona grandis*. In Patratu village, height, diameter, and volume were found highest in *Mangifera indica* and lowest in *Pongamia pinnata* and height, diameter and volume of *Mangifera indica* in Pithoria village were found maximum among all five species and minimum were recorded in *Psidium guajava*.

Among all the four villages and five species of medium growing trees, height, diameter and volume were found maximum in *Mangifera indica* of Pithoria village and minimum in *Pongamia pinnata* of Patratu village.

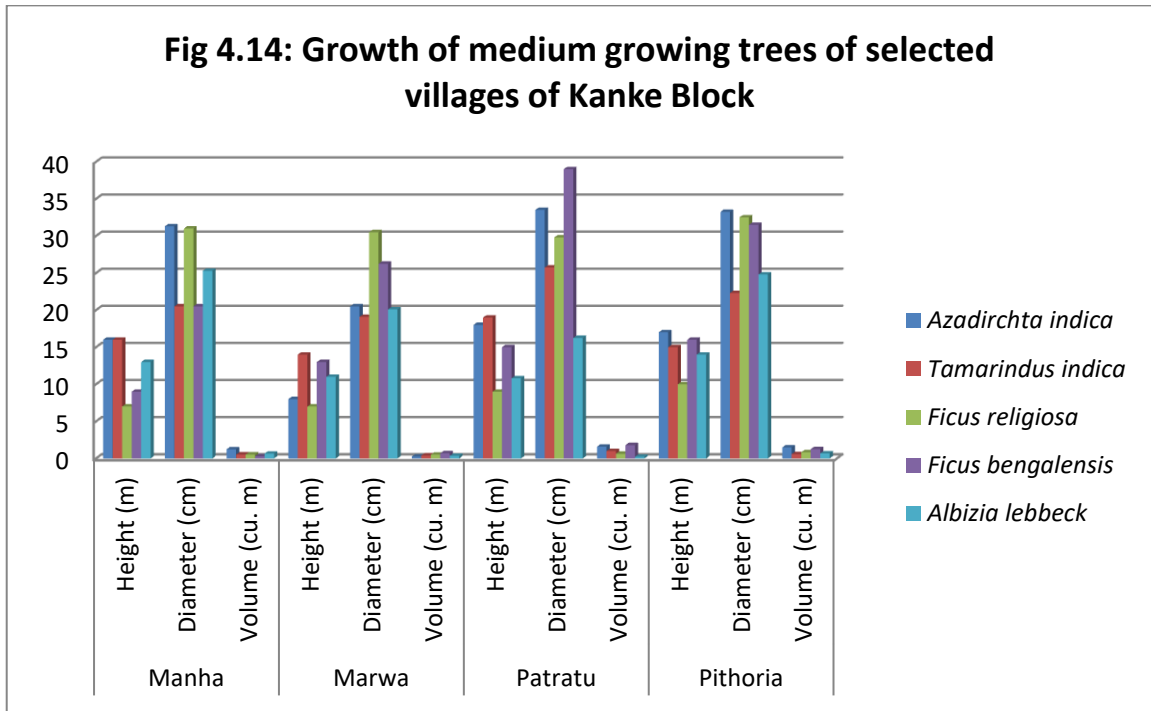
Toky and Khosla (1984) had studied comparative growth performance of agroforestry trees in subtropical region of Western Himalayas and had observed height, diameter and bole volume of six years old trees of 41 indigenous and 5 exotic species

and had noticed best growth in *Grevellia robusta*, *Eucalyptus globulus*, *Populus sps*, *Albizia lebbeck* and *Melia azedarach*. However, maximum diameter was found in *Ailanthus excelsa*. *Albizia lebbeck* was found as most promising species.

Table-4.17: Growth of medium growing trees of selected villages of Kanke Block

Medium growing trees	Manha			Marwa			Patratu			Pithoria		
	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)
<i>Mangifera indica</i>	8	14.25	0.127	9	21	0.311	12	18.5	0.322	15	27.7	0.904
<i>Tectona grandis</i>	9	16.9	0.209	5.8	15.75	0.113	9	12.4	0.108	13	23.2	0.549
<i>Pongamia pinnata</i>	12	21.2	0.423	7	20.75	0.236	5	14.25	0.079	9	18.25	0.235
<i>Psidium guajava</i>	9	12.5	0.110	10	14.2	0.158	6.2	10.5	0.053	8	12.85	0.103
<i>Emblica officinalis</i>	13	25.3	0.653	11	20.1	0.349	10.8	16.25	0.224	14	24.8	0.676

Medium growing tree	Height (Avg ± S.E) (m)	Diameter (Avg ± S.E) (cm)	Volume (Avg ± S.E) (cu. m)
<i>Mangifera indica</i>	11.0 ± 1.6	20.4 ± 2.8	0.41 ± 0.17
<i>Tectona grandis</i>	9.2 ± 1.5	17.1 ± 2.3	0.24 ± 0.11
<i>Pongamia pinnata</i>	8.3 ± 1.5	18.6 ± 1.6	0.24 ± 0.07
<i>Psidium guajava</i>	8.3 ± 0.8	12.5 ± 0.7	0.11 ± 0.02
<i>Emblica officinalis</i>	12.2 ± 0.8	20.3 ± 3.3	0.47 ± 0.11



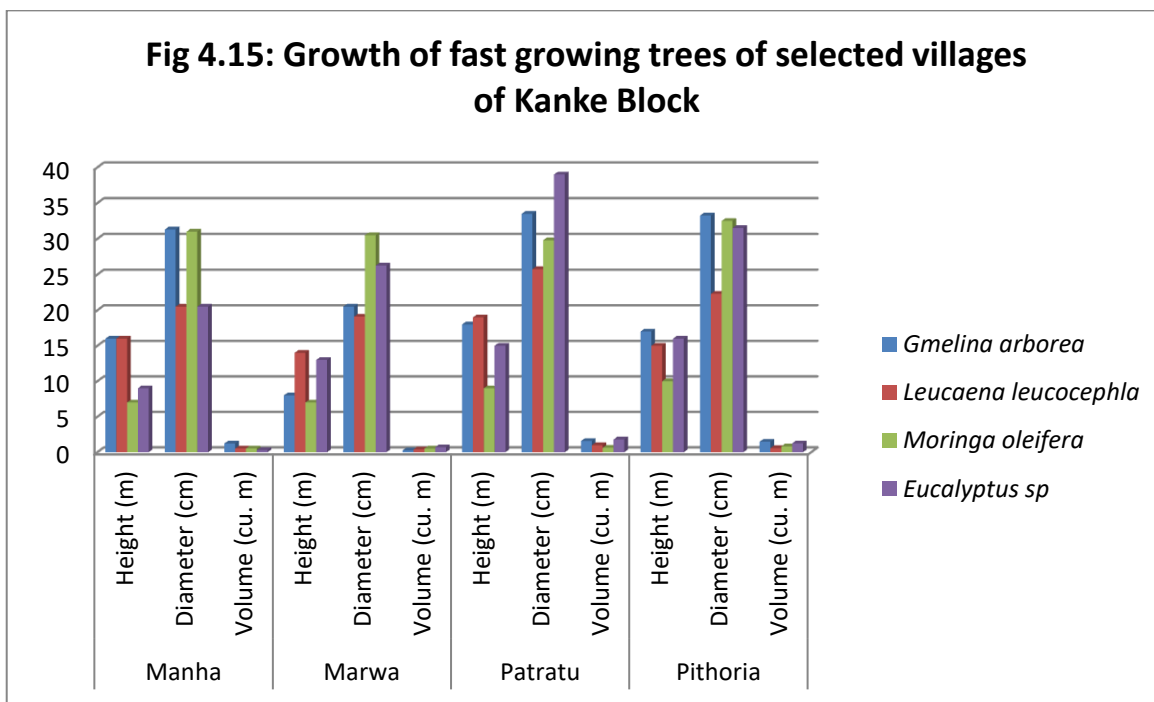
4.18: Growth of fast growing trees of selected villages of Kanke Block

The Growth of fast growing trees of four villages of Kanke Block is presented in Table 4.18 and Fig 4.15. Perusal of the data has indicated that, height, diameter and volume of trees were found maximum in *Gmelina arborea* and *Leucaena leucocephala* of Manha village and minimum in *Moringa oleifera*. In Marwa and Patratu village maximum height, diameter and volume of trees were found in *Leucaena leucocephala* and minimum in *Moringa oleifera*. Whereas in Pithoria village, height, diameter, and volume were found highest in *Gmelina arborea* and lowest in *Moringa oleifera*.

Among all the four villages and five species of fast growing trees, height, diameter and volume of the trees were found maximum in *Leucaena leucocephala* of Patratu village and minimum in *Moringa oleifera* of Manha and Marwa villages.

Table 4.18: Growth of fast growing trees of selected villages of Kanke Block

Fast growing trees	Manha			Marwa			Patrattu			Pithoria		
	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)	Height (m)	Diameter (cm)	Volume (cu.m)
<i>Gmelina arborea</i>	16	31.3	1.231	8	20.5	0.264	18	33.5	1.587	17	33.25	1.476
<i>Leucaena leucocephala</i>	16	20.5	0.528	14	19.1	0.401	19	25.75	0.989	15	22.3	0.586
<i>Moringa oleifera</i>	7	31.0	0.528	7	30.5	0.511	9	29.8	0.627	10	32.5	0.829
<i>Eucalyptus sp</i>	9	20.5	0.297	13	26.25	0.703	15	39	1.792	16	31.5	1.247
Fast growing trees	Height (Avg ± S.E) (m)			Diameter (Avg ± S.E) (cm)			Volume (Avg ± S.E) (cu. m)					
<i>Gmelina arborea</i>	14.7 ± 0.29			29.7 ± 3.09			0.30 ± 0.09					
<i>Leucaena leucocephala</i>	16.0 ± 1.08			20.1 ± 2.21			1.13 ± 0.30					
<i>Moringa oleifera</i>	8.3 ± 0.76			30.9 ± 0.57			0.62 ± 0.12					
<i>Eucalyptus sp</i>	11.3 ± 1.54			29.1 ± 3.91			1.00 ± 0.32					



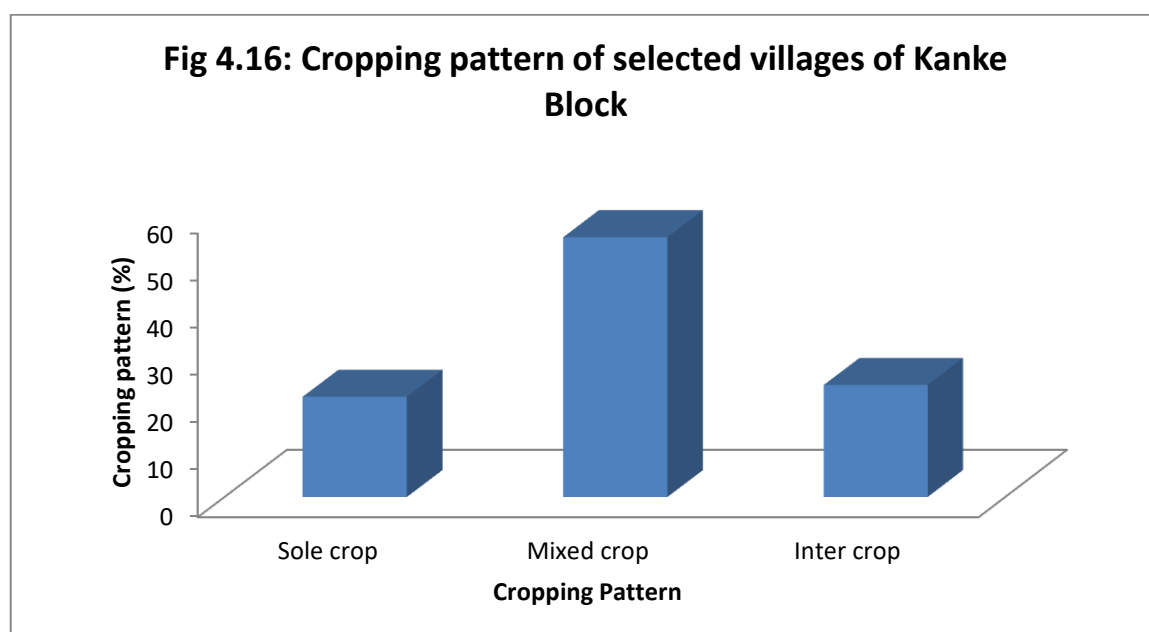
4.19 Cropping Pattern of selected villages of Kanke Block

The cropping pattern of selected villages of Kanke block is presented in Table 4.19 and in Fig 4.16. Perusal of data of the cropping pattern has indicated that in all the selected villages of Kanke block, the maximum mixed crop was found in the maximum area followed by inter crop and minimum area of sole crop. Among the villages, the maximum respondents of Pithoria village had mixed crop area followed by village Manha and minimum in Patratu and Marwa, whereas in case of inter crop, maximum areas were recorded in Marwa and Patratu villages followed by Pithoria and Patratu villages. Maximum number of respondents from Marwa and Patratu villages were having sole crop as the third most cropping pattern followed by number of respondents from Manha village and the least number of respondents from Pithoria villages were following sole crop as one of the cropping patterns. Among all the cropping patterns, mixed crop was found very common as 55%, followed by inter crop (23.75%), and minimum in sole crop (21.25 %).

Table-4.19: Cropping pattern of selected villages of Kanke Block

Cropping pattern	Villages				Avg.no ± S.E	%
	Manha	Marwa	Patratu	Pithoria		
Sole crop	4	5	5	3	4.3 ± 0.47	21.25
Mixed crop	12	9	10	13	11.0 ± 0.91	55.0
Inter crop	4	6	5	4	4.3 ± 0.62	23.75

Banerjee *et al.*(2009) studied to evaluate the growth and productivity of *Azadirachta indica*, *Eucalyptus tereticornis*, *Acacia plectocarpa* and *Shorea robusta* planted under Agri–silviculture system with 4 different intercrops of groundnut (*Arachis hypogaea*), rice (*Oryza sativa*), cowpea (*Vigna unguiculata*), and black gram (*Vigna mungo*), a field experiment was conducted on lateritic soil of West Bengal. Intercrops were grown during rainy season (kharif) only in rainfed condition. They reported that, tree height, diameter at breast height (dbh) and volume of wood of trees were increasing gradually with the age of the trees but the rate of increment of height and dbh was showing in a phasic manner due to change of climate throughout the year .Growth rates of *Azadirachta sp.* and *Shorea sp.* were also reported as a bit slower than *Eucalyptus sp.* and *Acacia sp.* Productivity of intercrops grown under *Azadirachta* tree cover was slightly higher as compared to other three trees. In their study among different intercrops, blackgram gave maximum return irrespective of different agri- silviculture system.

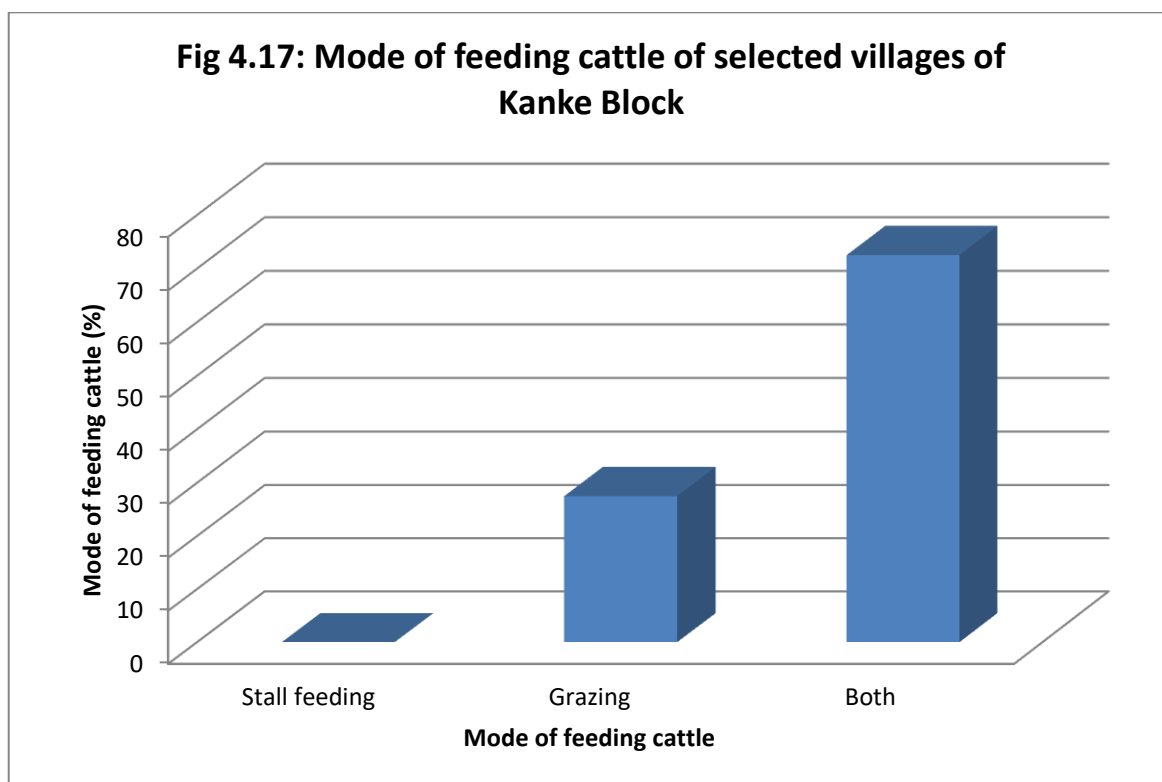


4.20 Mode of Feeding Cattle of selected villages of Kanke Block

The mode of feeding cattle in selected villages of Kanke block is presented in Table 4.20 and in Fig 4.17. Perusal of data has indicated that in all the selected villages of Kanke block, mode of cattle feeding was both stall feeding and grazing found maximum in Manha village and minimum in Marwa village. Mode of cattle feeding through grazing was only found maximum in Marwa village and minimum in Manha village. Maximum percentage of stall feeding and grazing was found in the selected villages of Kanke block which is 72.5% and 27.5% respectively.

Table-4.20: Mode of feeding cattle of selected villages of Kanke Block

Mode of feeding cattle	Villages				Avg.no ± S.E	%
	Manha	Marwa	Patratu	Pithoria		
Stall feeding	0	0	0	0	0	0
Grazing only	4	7	5	6	5.5 ± 0.64	27.5
Both	16	13	15	14	14.5 ± 0.64	72.5



4.21. Economics from tree and crop of Kanke Block

The economics from tree and crop of Kanke block is presented in table 4.22. Perusal of data has indicated that the maximum income from tree and crop in a year was found with the tree species *Tectona grandis* Rs. 28,130.00 followed by *Gmelina arborea* Rs. 24,370.00 and the minimum was found in *Bamboo* Rs. 13,635.00. The maximum B:C ratio was found in *Tectona grandis*(4.71) followed by *Gmelina arborea*(3.71) and the minimum was found in *Bombax ceiba* (2.90).

Mutanal *et al.* (2000) reported that growing of tree + fruit plants+ Field crops generated 46% more income compared to growing of field crops + fruit plants only. Jain and Singh (2000) also observed that poplar based agroforestry was economically viable and more profitable than many of the crop rotations in northern region of India. This land use system was also capable of providing employment opportunities on farms. Sensitivity analysis indicated that this system was not highly risky.

Table-4.21: Economics from tree and crop of Kanke Block

Species	Cost on tree ha ⁻¹ (Rs.)	Cost on crop ha ⁻¹ (Rs.)	Total cost	Income from tree ha ⁻¹ (Rs.)	Income from crop ha ⁻¹ (Rs.)	Income from fruit ha ⁻¹ (Rs.)	Total income	Net returns	Income yr ⁻¹ ha ⁻¹ (Rs)	B:C ratio
<i>Gmelina arborea</i>	7800	81800	89600	187100	146200	-	333300	243700	24370	3.71
<i>Tectona grandis</i>	15000	76500	91500	232000	140800	-	372800	281300	28130	4.71
<i>Dalbergia sissoo</i>	8300	74300	82600	120600	166000	-	286600	204000	20400	3.46
<i>Mangifera indica</i>	45000	73250	118250	47000	174000	12600	347000	228750	22875	2.93
<i>Pongamia pinata</i>	4450	69600	74050	43000	164000	10600	217600	143550	14355	2.93
<i>Cassia seamea</i>	8500	73500	82000	63780	137500	45000	246280	164280	16428	3.00
<i>Bombax ceiba</i>	7100	69600	76700	86300	136700	-	223000	146300	14630	2.90
<i>Bamboo</i>	7250	64000	71250	75600	132000	-	207600	136350	13635	2.91

4.22. Yield of agricultural crop and horticultural crops under agroforestry system in Kanke Block.

The yield of agricultural crop under agroforestry system in Kanke block is presented in Table 4.22. The major agricultural crops *Oryza sativa*, *Zea mays*, *Zingiber officinale*, *Capsium annum* and *Colocasia schott* were mainly found to grow in Kharif season under agroforestry system whereas *Triticum aestivum*, *Brassica nigra*, *Pisum sativum*, *Lycopersicon esculentum*, *Allium cepa* and *Solanum melongena* in rabi season under agroforestry system in Kanke block. The *Oryza sativa* and *Zea mays* were found to grow only in agrisilviculture system in Kharif season. The yield of *Oryza sativa* and *Zea mays* were 23.75 (q ha⁻¹) and 20.1 (q ha⁻¹) respectively in agrisilviculture system. The yield of *Zingiber officinale*, *Capsium annum* and *Colocasia schott* were 3.72, 8.96 and 3.8 (q ha⁻¹) respectively in agrihorticulture system.

In rabi season, *Triticum aestivum*, *Brassica nigra*, *Pisum sativum* and *Solanum tuberosum* were grown under agrisilviculture system whereas *Lycopersicon esculentum* was grown both under agrisilviculture and agrihorticulture system. *Allium cepa*, and *Solanum melongena* were grown under agrihorticulture system.

The yield of *Triticum aestivum*, *Brassica nigra*, *Pisum sativum* and *Solanum tuberosum* were 19.76, 5.56, 9.28 and 15.45 (q ha⁻¹) respectively under agrisilviculture system. The yield of *Lycopersicon esculentum* was 13.52, 12.4 (q ha⁻¹) respectively in agrisilviculture and agrihorticulture system. The yield of *Allium cepa* and *Solanum melongena* was 9.88 and 4.85 (q ha⁻¹) respectively in agrihorticulture system.

Malik *et al.* (2005) studied the growth and yield of intercrops potato, maize and bean and observed that *Eucalyptus globulus* with potato intercrop gave higher yield followed by other intercrops and silvicultural manipulation.

Table-4.22: Yield of agricultural crop and horticultural crops under agroforestry system in Kanke Block

Name of crops	Local name	Agrisilviculture (q ha ⁻¹)	Agrihorticulture (q ha ⁻¹)
Kharif crop			
<i>Oryza sativa</i>	Paddy	23.75±0.77	
<i>Zea mays</i>	Maize	20.1 ±0.49	
<i>Zingiber officinale</i>	Ginger		3.72 ± 0.21
<i>Capsicum annum</i>	Chilly		8.96 ± 0.22
<i>Colocasia schott</i>	Kacchu		3.8 ±0.10
Rabi crop			
<i>Triticum aestivum</i>	Wheat	19.76 ± 0.21	
<i>Brassica nigra</i>	Mustard	5.56 ± 0.13	
<i>Solanum tuberosum</i>	Potato	15.45 ± 0.30	
<i>Pisum sativum</i>	Pea	9.28 ± 0.32	
<i>Lycopersicon esculentum</i>	Tomato	13.52 ± 0.15	12.4 ± 0.11
<i>Allium cepa</i>	Onion		9.88 ± 0.25
<i>Solanum melongena</i>	Brinjal		4.85 ± 0.14

Mutunal *et al.* (2000) observed that the groundnut pod yield was 1149 kg ha⁻¹ in pure stand and 719-743 kg ha⁻¹ in agroforestry system with *Tectona grandis*. Maize grown with *Acacia auriculiformis* gave highest grain yield (1020 kg ha⁻¹) compared to rice, sesame, pigeon pea, groundnut. The productivity of black gram considered of 652 and 1100 kg ha⁻¹ of grain and crop residues respectively under *Acacia auriculiformis* (Bora *et al.* 1999).



Plate No.2: A view of Pithoria village



Plate No.3: A view of Marwa Village



Plate No. 4: A view of Manha village



Plate No .5: A view of Patratu village

SUMMARY AND CONCLUSION

5.1 Summary:

The present experiment entitled “Evaluation and impact of agroforestry systems on socio-economic condition of Kanke block of Ranchi district” was conducted in Jharkhand state with the following objectives:

- To study the growth performance and yield of tree species in existing agroforestry practices
- To determine the soil fertility status at the agroforestry sites.
- To assess the socio economic impacts of existing agroforestry practices on the farmers.

On the basis of results obtained, the finding in the present investigation are summarized as below

- Total estimated population of 80 respondents of selected of villages of Kanke Block. Mean male population per village was calculated 37.75 (35.45%), while the mean female population per village as 35.00 (32.86%). Maximum total population was found in Patratu village (115) and minimum in total population found in Manha village (98). Mean child population per village was calculated as 33.75 (31.69%). It was clearly visible that the mean male population percentage is superior to female and child population percentage in selected villages of Kanke block.
- The mean number of tribals in each village of Kanke Block is significantly superior to other castes. In general the trends of mean number of different caste profile are OBC (10.0, 50%) followed by S.T (8.0, 40%), SC 2.0 (10%).
- Average number of household in each village of Kanke Block was calculated as 20.00, out of which the proportion of Nuclear family was 56.25% (11.25 in average) and 43.75% of Joint family (8.75 in average).
- Illiterate to Primary level education status people consisted nearly 49% of the total population. Descending literacy status was found in order as Primary to high

school (31.32%) > primary level (29%) > Matriculation to intermediate (21.11%) > Illiterate (17.63%).

- Average number of household having medium land holding status in four village was calculated as 12.0 (60.0%) followed by household having small land holding status 6.0 (30.0%). Different land holding status household in descending order are as follows medium (60.0%) > small (30.0%) > large (6.25%) > landless (3.75%).
- Agriculture (60.65%) and agrisilviculture (13.93%) are the important land use pattern followed by household in Kanke Block. Other land use pattern is agrihorticulture (11.47%), agrihortisilviculture (11.47%) and hortisilviculture (0.83%).
- Agriculture and Animal husbandry has been adopted by most of the working people in Kanke Block with their percentage 73.75 % and 8.75%. Business and labour followed by 7.50% and 6.25%. Service is followed by fewer number of working people and its average number is 0.75 (3.75%).
- Goat and poultry are the two important livestock found integrated with the cultural life of tribals of Kanke block. Highest average number of rearing poultry found in the selected four villages Kanke block is calculated as 25.5. The average number of goat found in four villages is calculated as 14.5. Cow is also domesticated by same household and its average in four villages is 12.5.
- Consumption of fuel wood at domestic level has been used maximum by large farmers (41.9 q yr⁻¹), followed by medium farmers (32.6 q yr⁻¹) and least by small farmers (20.5 q yr⁻¹). Consumption of fodder at domestic level was done maximum by large farmers (17.6 q yr⁻¹), followed by medium farmers (16.8 q yr⁻¹) and least by small farmers (16.1 q yr⁻¹).
- Considerable improvement has taken place in soil which evident from the increased levels of Organic carbon, available N, P, K and pH value in agrisilvicultural system systems as compared to sole crop, sole tree and barren land. The level of pH, Organic Carbon, available nitrogen, phosphorous and potassium were found better under agroforestry system.

- Growth of slow growing trees of selected villages of Kanke block was found maximum in *Ficus bengalensis* and minimum in *Tamarindus indica*. Growth of medium growing trees was found maximum in *Mangifera indica* minimum in *Pongamia pinnata*. In Fast growing trees height, diameter and volume of tree was found maximum in *Gmelina arborea* and minimum in *Moringa oleifera*.
- Cropping Pattern was found maximum in mixed crop followed by inter crop and minimum was sole crop found in that areas. Mode of feeding of cattle found maximum in both (stall feeding & grazing) followed by grazing and minimum in stall feeding.
- The maximum income in year was found with the tree species *Tectona grandis* (Rs. 28,130.00) followed by *Gmelina arborea* (Rs. 24,370.00) and the minimum income was found in *Madhuca indica* (Rs.13,635.00)
- The maximum B:C ratio found in *Tectona grandis* i.e. 4.71 followed by *Gmelina arborea* 3.71 and minimum B:C ratio in *Bombax ceiba* 2.90.
- In kharif season *Oryza sativa* and *Zea mays* grown only in agrisilviculture system. *Zingiber officinale*, *Capsium annum* and *Colocasia schott* grown only in agrihorticulture system.
- In rabi season *Triticum aestivum*, *Brassica nigra*, *Pisum sativum* and *Solanum tuberosum* were grown under agrisilviculture system whereas *Lycopersicon esculentum* was grown both under agrisilviculture and agrihorticulture system. *Allium cepa*, and *Solanum melongena* were grown under agrihorticulture system.
- In agrisilviculture system the yield of *Oryza sativa* and *Zea mays* were 23.75 (qha⁻¹) and 20.1 (qha⁻¹). The yield of *Zingiber officinale*, *Capsium annum* and *Colocasia schott* were 3.72, 8.96, and 3.8 (qha⁻¹) respectively in agrihorticulture system.
- The yield of *Triticum aestivum*, *Brassica nigra*, *Pisum sativum* and *Solanum tuberosum* were 19.76, 5.56, 9.28, 15.45 (qha⁻¹) respectively under agrisilviculture system. The yield of *Lycopersicon esculentum* was 13.52, 12.4 (qha⁻¹) respectively in agrisilviculture and agrihorticulture system. The yield of *Allium*

cepa and *Solanum melongena* was 9.88 and 4.85 (qha⁻¹) respectively in agrihorticulture system.

CONCLUSION:

On the basis of the results obtained and discussions, the following conclusions can be arrived at:

1. Traditional agroforestry systems and practices associated with them plays an important role in securing the sustainable livelihood security of the rural people of Kanke block.
2. Agrisiliviculture system is the most preferred system by the farmers of Kanke block.
3. Most of the people doing agriculture and animal husbandry in block.
4. Maximum number of people having medium land holding size.
5. A considerable improvement has taken place in the level of soil nutrient because value of pH, Organic Carbon and available N, P, K were found more in agrisilivicultural system than sole cropping systems.
6. More awareness and training programme on scientific methods of agroforestry are required so as to increase income and employment generation at farm level.

IMPLEMENTATION

It was observed that adoption of Agrisiliviculture system is the most preferred system by the farmers of Kanke block. Agroforestry besides producing diverse type of products per unit of land also provides direct and indirect benefit. It was essential that awareness and objective oriented information regarding the ecological and economic benefits of the trees should be disseminated widely to farmers through extension workers, media and press.

BIBLIOGRAPHY

- Anonymous, (2000). Annual report of Central Research Institute for Dry land Agriculture (CRIDA), Hyderabad, 82-85.
- Arnold, J.E.M. (1995). Retrospect and prospect. In: Arnold, J.E.M. and Dewees, D.A. (Eds). Tree Management in Farmers Strategies; Responses to Agricultural Intesification 271-287. Oxford University Press, New York.
- Arnold, JEM. (2002). Identifying links between forests and poverty. In ECTF/IIED Forestry and Poverty Reduction Workshop, Edinburgh 13 June 2002.
- Banerjee, H., Dhara, P.K., Pal, S and Maiti, S. (2009). Agri-horti-silviculture system of Cropping in Red laterite tract of West Bengal. In : Proceedings of national Workshop On “Organic Horticulture – Its Production, Marketing & Export For Sustainability” pp.185 -189. Chattopadhyay, P.K and Mitra, S.K. (Eds). Society for Advancement of Horticulture, Bidan Chandra Krishi Viswavidyalya, West Bengal.
- Basavaraja, T.B. and Gururaja Rao, M.R. (2000). Tree- crop interaction in agroforestry system, Indian Forester, 126 (11): 1155-1161.
- Bene, S.G., Beal, N.W. and cote, A. (1997). Tree, Food and people. IDRC., Ottawa, Canada.
- Boehnert, J. (1988). The potential of Agroforestry. Agroforestry in agricultural education with a focus on the practical implementation. Ed: Dr. Doris Knuth Chapter II PP 44-81.
- Bora, I.P., Singh, J., Borthakur, R. and Bora, E. (1999). Allelopathic effect of leaf Extract of *Acacia auriculiformis* on seed germination of some agricultural Crop. *Ann. For.*, 7 (1): 143-146.
- Brahmam, M., Pillai, S.S.K. and Patil, U.K. (1997). Influence of rubber Hevea (Brasiliensis) tree shade on growth performance and seed yield of Pigeonpea (*Cajanus cajan*) intercrop. *Indian Journal of forestry*, 20(2): 181-182.

- Bray, R. H. and Kurtz, L.T. (1945). Determination of total, organic and available forms of phosphorous in soils. *Soil Sci.*, 59: 39 – 45.
- Chandrasekhriah, A.M. (1987). Some investigation on agroforestry in black soils of Transitional belt. PhD. Thesis, Univ. Agrl. Sciences, Banglore, India.
- Chaturvedi, A.N. and Khanna, L.S. (1982). Forest Mensuration. International Book Distributors. Dehradun. pp. 39,90,183.
- Chaturvedi, O.P. and Pandey, I.B. (2001). Yield and economics *Populus deltoides* G-3 Marsh based intercropping system in eastern. *India Forest trees and livelihood*, 11(3): 207-216.
- Chauhan, V.K., Sood, S.K., Bhargava, J.N. and Mishra, V.K. (1995). Effect of different trees on the yield of rainfed wheat crop. *Ann. For.*, 3: 147 – 151.
- Christie, E.K. (1975). A note on the significance of *Eucalyptus populnea* grass Production in infertile semi- arid rangelands. *Tropical Grasslands*, 9:243-246.
- Cole, R.J. (2010). Social and environmental impacts of payments for environmental services for agroforestry on small-scale farms in southern Costa Rica. *International Journal of Sustainable Development & World Ecology* **17**, 208–216.
- Datta, M. and Dhiman, K.R. (2001). Effect of some multipurpose trees on soil properties and crop productivity in Tripura areas. *J. Ind. Soc. Soil. Sci.*, 49:511-515.
- Dhyani, S.K. and Chauhan, D.S. (1989). Evaluation of crops in relation to shade in densities of Khasi pine (*Pinus khasya*). Progress Report Agroforestry Division, ICAR Research Complex for N.E.H Region, Shillong.
- Dhayani, S.K. and Tripathi, R.S. (1999). Tree growth and crop yield under Agrisilvicultural practices in north india. *Agroforestry system*, 44:1-2.
- Dwivedi, A.P. and Sharma, K.K. (1989). Agroforestry its potential. In: seminar on Social forestry and Agroforestry, FRI, Dehradun.
- Dwivedi, A.P., Sharma, K.K. and Kauswal, B.D. (1990). Productivity under Agroforestry. Proc. Sem. Forest Productivity, FRI.
- FAO. (1981). Forest resources of tropical Asia. F.A.O. Rome.

- Feldhake, C.M., Belesky, D.P. & Mathias, E.L. (2008). Forage Production Under and Adjacent to Robinia pseudoacacia in Central Appalachia, West Virginia. *Advances in Agroforestry* 4, 55–66.
- FSI (Forest Survey of India) (2013). State of forest Report, Ministry of Environment and Forests, Dehra Dun, India.
- Fuwae, J. A and Akindel, S.O. (1997). Biomass yield and energy value of some fast Growing multipurpose trees in Nigeria. *Biom and Bioem*, 12(2): 101-106.
- Gangadharappa, N.R., Shivamurthy, M. & Ganesamoorthi, S. 2003. Agroforestry a viable alternative for social, economic and ecological sustainability
- George, S.J. and Kumar, B.M. (1998). Litter dynamics and soil fertility improvement in Silvopastoral systems of the humid tropics of southern India. *International Tree crops. Journal*, 9: 267-282
- Gill, A.S., Roy, R.D. and Bajpai, C.K. (1992). Growth of *Leucaena leucocephala* in mango based intercropped agroforestry system. *Lecaena Reports*, 13: 22-23.
- Grewal, S.S., Mittal, S.P. Surjit Dyal and Agnihotri, Y. (1992). Agroforestry systems for soil and water conservation and sustainable production from foothill areas of north India. *Agroforestry systems*, 17(3): 183-191.
- GOI (2005). Flow of institutional credit to agriculture. Credit division. Ministry of Agriculture and Cooperation, Govt. of India.
- Gupta, J.P, and Sexena, S.K. (2004). Studies on the monitoring of the dynamics of moisture in the soil and the performance of ground flora under deserted communities of trees. *Indian journal of Ecology*, 5: 30-36.
- Hawthorne, W.D. (1996). Holes and sums of parts in Ghanaian forest: regeneration, scale and sustainable use, vol. 104B. Proceedings of the Royal Society of Edinburgh 104B. pp. 75-176
- Hosur G.C. & Dasog G.S., (1995). Effect of tree species on soil properties .Journal of the Indian Society of soil science. Volume.43 (2) : 256-259.

- Hulscher, W., Auke Koopmans, Conrado Heruela, Tara Bhattarai, Joost Siteur and Bert van der Plas. (1999). Regional Wood Energy Development Programme in Asia (GCP/RAS/154/NET). *Forest in India*, Vol. 14 No.2, page 3.
- Jain, S.K. Singh, P. (2000). Economic analysis of industrial agroforestry. Poplar in Uttar Pradesh. *Agroforestry*, 49: 259-273.
- Kang, B.T. (1993). Soil tillage in Africa: needs and challenges. *FAO Soils Bulletin* 69.
- Kathirval, P. (2003). Studies on compatibility of forage crops under established teak.
- Kareemulla K.R.H. Rizvi, Kuldeep Kumar, R.P. Dwivedi and Ramesh Singh (2005). Poplar Agroforestry Systems in Western Uttar Pradesh: A Socio – economic analysis. *Forests, Trees and Livelihoods*.15 (4): 375-382.
- Khattak, G.M., Sheikh, M.I. and Khalia, A. (1980). Growing trees with agricultural crops. *Pak. Journal of Forestry*, 31:95-97.
- Kindt, R and Leng keek, A.G. (1999). Tree diversity on farm-use it or loose it. Paper Presented at the National Workshop on Agricultural Biodiversity Conservation, January 27-29, 1999. Kenya College of Communication and Technology.
- King, B.T. (1993). Soil tillage in Africa: needs and challenges. *FAO soils Bulletin* 69.
- King, K.F.S and Chandlar, M.T. (1978). *The wasteland*. ICRAF, Nairobi, 85 pp.
- Kumar, B.M. and Nair, P.K.R. (2004). The enigma of tropical homegardens. *Agroforestry Systems*.61: 135-152.
- Kumar, R.P., Dwivedi, K. Kareemulla, R.H.Rizvi, Ramesh Singh (2014). Socio – economic Diagnosis of traditional agroforestry practices followed in Aligarh district of Uttar Pradesh.
- Kumar, S. (2011). FSI (Forest survey of India), (2011), State of Forest Report, Ministry of Environment and Forests, Dehradun, India, p. 15.
- Leakey, R.B. 2012. Multifunctional Agriculture and Opportunities for Agroforestry: Implications of IAASTD. *Advances in Agroforestry* 9, 203–214.
- Lundgren, B.O. and Raintree (1982). Cited in Editorial: What is Agroforestry? *Agroforestry Systems* 1: 7-12

- Madheswaran, M. (2002). Screening of shade tolerant medicinal plants under teak (*Tectona Grandis* Linn) based agroforestry systems. M.sc Thesis, Tamil nadu Agricultural University, Coimbatore, India.
- Mahapatra, A.K and Mitchell, C.P. (2001). Classifying tree planters and non planters in a Subsistence farming system using a discriminate analytical approach. *Agroforestry Systems*. 52:41-52.
- Malik, M.S. (2004). Effects of aqueous leaf of *Eucalyptus globules* on germination and Seedling growth of potato, maize and bean. *Allelopathy Journal*, 14(2): 213-220.
- Malik, M.S., Surendran, C. and Kailashan, K. (2005). Predicting growth of *Eucalyptus globules* under Agroforestry plantation. *India J. Agroforestry*, 7(1): 57-61.
- Marawar, S.S, Mukewar, A.M. and Zope, J.S. (1995). Economic of Eucalyptus growing On marginal land. *Advances in forestry Research in India*, 12:111-115.
- Mathur, R.S., Sharma, K.K. and Ansari, M.Y. (1983). Economics of poplar plantation Under Agroforestry. *India Forester*, 110: 171-201.
- Mehta, K.B., Kukadia, M.V., Vashi and Jadeja, D. (1996). Effect of forest tree species on the yield potential of intercrops. *Indian Forester*, 122 (7): 651-65.
- Mohammed Rafi, B. (1991). Knowledge, attitude and adoption of farm forestry among the participant and non-participant farmers in Shimoga district. M.Sc. Thesis, University of Agricultural Sciences, Bangalore, 97-103.
- Mohan Raj, T. (2004). Studies on compatibility of agricultural crops with *Simaroubaglauca* DC. M.Sc. Thesis, Tamil Nadu Agricultural University, Coimbatore, India.
- Mohanpatra. S.C. (2002). Productivity of four common kharif field crops in the Allies of four trees species. *Ind. J. of forestry*, Vol.25(4): 453-455.
- Mohsin, F., R.P. Singh and K.Singh. (1996). Growth and biomass production by *Poplar deltoides* under agroforestry in Tarai of Keimaun region of U.P. *Indian Forester*, 122(7):631-636.

- Mudrick, D.A., M. Hoosein. Jr. Hicks and E.C. Yownsend. (1994). Decomposition of litter fall in Appola Chain forest, effect of leaf species, aspect,slope position and time. *For.Ecol.Manage.*, 68:231-250.
- Mutanal, S.M., Patil, S.J., Nadagondar, B.S., Madiwalar, S.L. and Devaranavadgi, S.B. (2000). Suitability of tree species in an agroforestry system in hill Zone of Karnataka.*Indian Forester*, 126(11):1187-1190.
- Nair, P.K.R. (1989). Agroforestry defined .Agroforestry Systems in the tropics, Kluwer Academic Publication, pp-13-18.
- Nair, P.K.R. (1993). An Introduction to Agroforestry. Kluwer Academic Publisher. Nairobi. In co-operation with ICRAF.
- Nandal, D.P.S. and M.S. Hooda. (2005). Production potential of some agricultural Crops under different spacings of Poplar. *Indian journal of Agroforestry*. 7(1):16-20.
- National Agriculture Policy (2000). Role of agroforestry for efficient nutrient cycling, nitrogen fixation, organic matter addition and for improving drainage and biomass production through agroforestry and farm forestry. Ministry of Agriculture, Govt. of India.
- Negi, A.K. Bhatt, B.P and Todaria, N.P (2009). Local population impacts on the forest of Gharwal Himalaya, India. *The Environmentalist* 19: 297-307.
- Ojeniyi, S.O. and Agbede (1980). Effect of inter planting *Gmelina arborea* with food crops on soil condition. *Turrialba*,30:268-271.
- Oraon P. R, Yadav M.S and Siddiqui M.H (2005) Comperative performance of Agroforestry in Kumharia Village of Ranchi District. *Indian journal of Agroforestry*, 7(2): 19-24.
- Palani, M. (1996). Studies on intercropping agricultural crops with Multi utility tree under rainfed condition.Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore, India.
- Pandey. A.K. Solanki. K.R. and Gupta. V.K. (2002). Impact of Neem *Azadiracta indica* A.juss) plantation under agroforestry system on On soil properties in semi-arid Region of Indian. *J.Agroforestry*, vol.4 no.2:109-112.

- Paramathma, M., Amal, J.A. and Rajkumar, M. (2000). Allelopathy in ecological agriculture and forestry proceeding of the III international congress on allelopathy in ecological, agriculture and forestry, Dehradun, India.
- Partap S. Thakur and Vaishnu Dutt. (2005). Diversification of Farming System by Combining Commercial Tree species with Medicinal Plants to boost Economy of Farmers Under Rainfed Condition. In proceedings of the 4th International Crop Science Congress , Brisbane, Australia, 26 Sept-1Oct. 2004.
- Patel. N. L. and S.P. Singh. (1994). Biomass production and its distribution in some Agroforestry tree species raised in South Saurashtra Region of Gujrat. *Journal of Tropical Forestry*, 10 (4): 255-262.
- Peri, P.L, Varella, A.C., Lucas, R.J. and Moot, D.J. (2001). Cock foot and Lucerne Productivity in a Pinusradiata silvipastural system: a grazed comparison. In New zealand Grassland association Sixty- third Conference, Waikato, New zealand, 30th October to 1st November. Proceedings of the New Zealand Grassland Association, 63: 139-147.
- Planning Commission (2001), Greening India for Livelihood security and Sustainable Development. GOI.
- Prabhu Prasadini and Sreemannarayana, B. (2007). Impact of agroforestry systems on nutritional status and biological activity of Rainfed red loamy soils *Indian Forester*, 133 (11):15190-1525.
- Rai, A.K. (2003). Soil improvement through *Anogeissus pendula* baesd agroforestry System. *Indian Journal of Agroforestry*, 5 : 60-64.
- Raizada, A., Parandiyal, A.K. and Ghosh, B.N. (2003). Estimation of carbon flux through litter fall in forest plantation of India. *Indian Forester*, 126 (7): 881- 894.
- Rao, M.R., Palada, M.C. and Becker, B. N. (2000). Medicinal and aromatic plants in agroforestry systems. *Agroforestry Systems*, 61: 107-122.
- Rasid, D.A. (2002). The findings of the Northwest Rural Livelihoods Monitoring Project, care Bangladesh. pp. 59-67.

- Rasul, G. and Thapa, G.B (2001). Financial and economic suitability of agroforestry an alternative to shifting cultivation: The case of the Chittagong Hill Tracts, Bangladesh, *Agriculture, Ecosystems & Environment*, 86 (7): 23-37.
- Ravi, R. (2005). Investigation on shade tolerant fodder crops for Ailanthus based Agroforestry system. M.Sc. Thesis, Tamil Nadu Agricultural University, Coimbatore, India.
- Rawat, C.R. and Hazara, C.R. (1991). Productivity of forages and soil physio-chemical aspects subabul based dry land agroforestry in Bundelkhand region. *Range Management and Agroforestry*, 12: 195 -200.
- Reddy, Y.T.N. and Khan, M.N. (2000). Weed control in sapota orchards through use of soil covers. *Indian Journal of Weed Science*, 32 (1-2):103-104.
- Rice, E.L. (1984). *Allelopathy*, Academic Press, New York. pp: 422.
- Rizvi, S.J.H., Tahir, M.J.H., Rizvi, V.J.H., Kohl, R.K. and Ansar, A.K. (1999). Allelopathic interactions in agroforestry systems . *Critical Reviews in Plant Sciences*, 18 (11): 773-796.
- Saxena, N.C. (2000). Farm and agroforestry in India - Policy and legal issues. Planning Commission. Government of India. 50p.
- Shanmughavel, P. and Francis, K. (2002). Litter production and nutrient return in Agroforestry system. *J. Non-Timb. For. Prod.*, 9 (314): 176-178.
- Sharma, K.K. (1987). Effect of trees on agricultural crops. Institutional seminar FRI, Dehradun.
- Sharma, R.P. and R.C.Jain (1997). Standard volume tables for *Gmelina arborea* Roxb (based on data from Tripura). *Indian Forester*, 103 (8): 536-537.
- Sharma, C.U and Sharma, V. (2012). Sustainability of agroforestry systems on acid soils for livelihood security. *Indian Journal of agroforestry*, 14(2): 27-36.
- Singh, H.P., Batish, D.R. and Kohli, R.K. (1999). Allelopathic effect of *Leucaena leucocephala* on *Zea mays*. *Journal of Tropical Forest*, 116(4): 801-808.

- Singh, K.S. and Lal, P. (1969). Effect of Khejri (*Prosopis cineraria* Linn.) and babul (*Acacia nilotica*) trees in the soil fertility and profile characteristics. *Annual Arid Zone*, 8:33-36.
- Singh, R, Singh, R.K. and Singh, L. (2004). Effect of different plant covers on soil Characters. *Indian Forester*, 116(11): 795-802.
- Singh, R.P. and Osman, M. Mohomad. (1987). Agroforestry system for small holdings. International Workshop on Agroforestry for Rural Needs, Vigyan Bhawan, New Delhi, February, 22-26.
- Suresh, K.K. and Vinaya Rai, R.S. (1987). Studies on the allelopathic effects of some agroforestry tree crops. *International Tree Crops Journal*, 4: 109 – 115.
- Thiyageswari, S., Dasthagir, M.G. and Mohamed Yassin, M. (1998b). Soil Fertility improvement in teak based silvipastoral system. In National Seminar on Integration of Livestock and Agroforestry systems in Wasteland Development. Tamil Nadu Veterinary Research Institute, Chennai. Pp. 52-53.
- Tiedemann, A.R. and Klemmedson, J.O. (1973). Effects of mesquite on physical and Chemical properties of the soil. *Journal Range Management*, 25: 27-29.
- Toky, O.P. and Khosla, P.K. (1993). Comparative growth of agroforestry tree (Indigenous Vs. exotics) in subtropical western Himalaya. *Journal of Tree Science*, 3(1-2):93-98.
- Vergara, N.T. (1985). Agroforestry System. A primer. *Unasyuva*, 37:22-28.
- Verinumbe, I. (1987). Crop production on soil under some forest plantation in the sahel. *Agroforestry System*, 5(2):185-188.
- Verma, K.S. Zegeye, M.W. and Kaushal, R. (2002). Growth and yield performance of Wheat in Agri-horticultural System of Agroforestry in Mid-hills of Himachal Himalayas. *Indian Journal Agroforestry*, 4(1):1-7.
- Vishwananth, S., Kaushik, P.K., Pandey, D.K. (1998). Effect of *Acacia nilotica* (L.) Rainfed rice crop at Chhattisgarh on India. *Ann. Fox.*, 6(1): 103-109.

- Wannawong, S., Belt, G.H. and Mcketta, C.W. (1991). Benefit cost analysis of selected Agroforestry system in north eastern Thailand. *Agroforestry System*, 16 (1): 83-94.
- Zinke, P.J. (1962). The pattern of influence of individual forest trees on soil properties, *Ecology*, 43: 130 -133.