REVIEW OF

LITERATURE
II. REVIEW OF LITERATURE

Review of literature helps to investigation to keep abreast of the previous work done in that area and provides a basis to the theoretical frame work in addition to providing an insight into the methods and procedures followed.

Hence, the available literature relevant to the objectives of the study was reviewed since the literature directly related to agroforestry land use systems and silvi-pasture is rather limited related studies on other crops or technologies were also reviewed the literature reviewed is presented under the following heads.

Land is the most valuable natural resource on which will being of mankind is dependent. However, the growing biotic interference throughout the globe has resulted in considerable degradation of our natural resource (land, water, vegetation, ground water aquifers etc.).

In India nearly 175 m ha out of total geographical area of 328 m ha is subjected to serious soil and water erosion problems and other degrees and forms of degradation.

Agroforestry is the cultivation of trees in association with crops in our anxiety to increase food production, we have increased the area under cultivation by directing most of our shrub jungles and other wasted land. Even forests have been indiscriminately felled, with the result that the effective area under forest tree has been reduced to mere 13 per cent of our total land area, as against the desirable 33 per cent.
In villages fire wood sometimes contributes 80 per cent of the energy consumed. As fuel wood becomes scarce, dried cow dung is burnt to keep the pot boiling. An estimated 100 million metric tones of dried cow dung cakes representing 500 million tones of freshly collected dung is burnt away every year which is a shear waste of valuable organic fertilizer. The sustainability of agro-ecosystems especially in fragile environments of dryland areas. In fact agro-ecosystems are different from natural ecosystem in the sense that the farmer are modified by human pressure to produce food and agriculture products whereas the latter in free of human pressure and such is always sustainable. Sustainability is the ability of an agro-eco system to maintain productivity when subject to major distributing forces (Singh and Poonia, 2005).

By the turn of this century we have to increase our food production by 75 million tones and fuel production by 140 million tones. Also fodder and pasture form an important component of our current strategy on agroforestry in which multipurpose trees and other woody perennials that yield fruits, fibre and fuel wood are combined on the same land management unit with crops, in some from of space or time sequence (Ramshe, 1991). Here an attempt has been made to review the literature pertaining to causes and effects of soil degradation.

2.1 Effect of land use systems

Crops like Phaseolus aureus Linn (Moong beans) and P. munga Linn (Blackgram) developed dense canopies and protected the soil from splash erosion. These crops developed more than 85
per cent canopy reduced soil losses to less than 2 tonnes per ha per event (Bhatia and Srivastava, 1984).

Sharma and Panwar (1977) reported that urd and groundnut + arhar offered better cover thereby reducing soil loss, whereas growing crops like maize, jowar + arhar and bajra + arhar had a poor canopy, high erosion index and hence failed to reduce soil loss efficiently. Similar results were reported by Anon. (1978).

Eltz et al. (1973) reported that erosion losses in the plots under grassland and cultivated pasture were insignificant in comparison with bare soil which amounted to 5.3 tons/ha/year. The gradual cover provided by wheat and soybean resulted in a decrease in erosion loss when compared with bare soil.

Runoff and soil loss was maximum in cultivated fallow plot and minimum in Cenchrus ciliaris grass plot on 2 per cent slope. Among the cropping systems uniform crop of bajra permitted maximum runoff (28%) and soil loss (6.34 t/ha/year) whereas intercropping of bajra with cowpea or moong reduced the soil loss to 4 tons/ha/year (Bhushan et al., 1984).

Studies conducted by Shrinivas Sharma et al. (1988) on alfisols (red soils) revealed that soil loss varied from 0.37 to 4.78 tonnes/ha/year depending upon land use pattern. Among the cultivated crops, annual soil loss was found to be 1.38, 2.21 and 2.89 tons/ha for sole crop of pearl millet, sorghum and castor respectively and the same was 0.37 and 4.71 tonnes/ha for grass (Cenchrus ciliaris) and cultivated fallow, respectively.
The study of watershed revealed that the natural erosion (from the least distributed forest land) has been largely accelerated by deforestation and agricultural activities. In the month of harvest rainfall the suspended and dissolved load accelerate 2.6 to 7.25 times higher in the most disturbed agricultural land than that of forest land (Rawat and Rawat, 1990).

Mishra et al. (1995) observed lowest runoff and soil loss and highest infiltration rate from the plots of Vetivera zizanoides and Dichanthium annulatum. This was proably due to deep penetration of roots and formation of dense at the surface soil thus providing obstruction to flow of water.

2.1.1 Effect of soil conservation measures

While studying the effect of different conservation measures on runoff and soil losses from arable land of red soils having 2.5 to 3.0 per cent slope. Krishnappa et al. (1994) reported that adoption of improved conservation measures comprising bunding and interland tillage and cultural practices on contour found to reduce both runoff and soil loss considerably. They observed that the reduction in runoff soil loss under contour bund was very low (3.80%) and (1.30 t/ha/yr) followed by khus grass on contour (7.90% and 2.48 t/ha/yr) and graded bund (10.60% and 3.70 t/ha/yr) compared to 26.30 per cent and 11.01 t/ha/yr under compartmental bunding along with slope cultivation.

According to Channappa and Ranga (1988) runoff and soil losses were significantly reduced by the surface crop cover management practices. Rates of runoff and soil loss increased
significantly as the density and crop canopy decreased and they observed direct relationship between erosion and runoff. Finally they concluded that high rainfall intensities and duration increased the runoff and soil loss more than crop and land management treatments.

While studying the effect of various cropping systems and land treatments in reducing runoff and soil loss. Kale et al. (1992) reported that contour bunding + strip cropping (CB + SC) system was found most efficient in reducing runoff by 37.7 per cent and soil loss by 57.7 per cent over broadbed furrow + intercropping system (BBF + IC). However, CB + SC system reduced runoff and soil loss by 51.5 per cent and 71.1 per cent over CB + IC system respectively.

In one of the studies having six runoff plots under different vegetation viz., cleared eucalyptus, uncleared acacia cleared geranium, uncleared apple and cleared vegetables with conservation measures such as stone wall terraces and bench terraces in the western ghats at Kodaikanal revealed that cleared eucalyptus with no conservation measures recorded highest runoff and sediment yield, while the lowest was observed in apple plantation with bench terraces and grass as soil cover (Kannan and Mathan, 1993).

The studies conducted by Channappa and Ramaiah (1988) at Dryland Agricultural Project, Bangalore Centre on red soils on slopes of 1 to 3 per cent indicated that losses of water through runoff was 24 to 36 per cent of annual rainfall the runoff was of very high order when the soil was compared and crusted the
system of ridges the runoff losses to large extent as compared to flat sowing.

2.2 **Soil and nutrient losses**

2.2.1 **Effect of different land slope and rainfall intensity in land use system**

The plant nutrients are depleted from the soil through crop removal, runoff and soil erosion, in a study Duley and Miller (1923) obtained 111 kg nitrogen, 42405 kg calcium and 113 kg total sulphur from bare cultivated Shelby loam soil in 3.658 per cent slope.

Bonde *et al.* (1982) studied cropping pattern and its effect on nutrient loss on 2 per cent slope. Losses were maximum in grasses and cotton crop cover with traditional method of sowing. Ridging across the slope in both bidi tobacco and cotton considerably reduced the nitrogen loss by 50.9 and 45.8 per cent, respectively.

Bhatt *et al.* (1991) observed that Dhulot silty clay loam soil on eight per cent slope continued to suffer heavy losses of nutrients till middle of August during South West monsoon. Large quantities of plant nutrients were lost during the first fortnight of July due to more rainfall. The cultivated fallow plot continued to loses nutrients throughout the rainy season.

Kale *et al.* (1992) revealed that the nutrient loss under 1.00, 1.25 and 1.50 per cent slope at different cropping systems at Solapur on shallow typic ustochrepts soils showed that intercropping reduced nitrogen, phosphorus and potassium losses
to the extent of 48.90, 45.00 and 92.30 per cent, respectively over sole cropping at 1.50 per cent slope.

While studying the influence of soil conservations measures and vegetation covers on nutrient loss, Kannan and Mathan (1993) reported that loss of total nitrogen through sediment was higher that of total phosphorus and potassium. This might be due to more of total nitrogen in the soil itself. Further cleared eucalyptus plantation without any conservation measures recorded highest nutrient losses (total and available N, P and K). While the lowest observed in apple plantation with bench terraces and grass as a cover.

2.3 **Effect of different agroforestry land use systems**

2.3.1 **Use of different land use system**

Malkhania (1983), Mathur *et al.* (1984) and Parveez Ahmed (1989) revealed that the results suggesting adverse effects of tree species on associated field crops. Further, it was more severe near the tree line and decreased with distance, monetary returns per year was maximum with eucalyptus + groundnut combination (Rs. 17,218) followed by Sissoo + groundnut (Rs. 16,598), rose wood + groundnut (Rs.14,446) and lastly the sole crop of groundnut (Rs.13,522).

Ramshe (1991) observed that the sunflower was more sensitive crop followed by pearlmillet and redgram. Four years mean data indicated that the recovery in grain production of crops and alley width in association with neem, sussoo, subabul and eucalyptus was to the tune of 71.66, 33.00 and 55.00 per cent
respectively while recover in the grain production of arable crops irrespective of tree species and alley width was to the extent of 56 to 59 per cent respectively.

Dey Roy and Gill (1991) observed that in general, MPTs (multiple tree species) registered much better growth under agroforestry system as compared to control. Maximum plant height under agroforestry system during March 90 was observed with eucalyptus (602.90 cm) as compared to its control plant height of 427.3 cm in case of collar diameter, highest values of 9.89 cm and 6.91 cm were registered with eucalyptus under agroforestry system and control conditions respectively.

Gupta (1991) observed that revealed that trees in general did not interfere with the grass production rather there was an increase in the production of grasses grown in association with *Zizyphus rotundifolia* (Ber). The yield of bajra and guar grown in between the two rows of ber were at par with control (without tree).

Ram Newas and Gill (1994) reported that the production potential of different crops in interspaces of per plants indicated that moong produced highest grain yield as compared to other crops, spacing and varieties of fruit plant did not express any effect on the crop yield after four years of plantation.

Bheemaiah *et al.* (1995) observed that the cropping of castor and sunflower after 2 and 3 years style *Zanthus* species resulted in higher seed yields of castor and sunflower over continuous cropping and cropping after 2 years fallow at the level of N in both the years. The seed yields of castor and sunflower at 50 per cent
less recommended dose of N after 2 and 3 years style were almost similar to he yields recorded at recommended dose of N in continuous cropping. It is evident that the yields of castor and sunflower are decreasing year after year in association with sissoo (*Dalbergia sissoo*) which may be due to competition from the 4 years old trees. To get good yields of associated crops at the age of fourth years.

Lakhdive *et al.* (1996) observed that all among the tree, agro-horticultural system (custard apple, aoula and ber) ber + legume crops system (greengram + blackgram / soybean) found most remunerative.

Nadagouder (1998) observed that the major benefits of agroforestry are some returns even in drought year i.e., stability in agriculture, reliable fodder, source in lean season and wide range of subsistence and cash products. If agroforestry in conceived in right spirit and containing efforts are made, the productivity of land can be stabilized in addition to getting non-yield benefits and helps in upgrading the polluted environment.

2.4. **Effect of canopy cover microbial activities**

2.4.1 **Effect of canopy cover in different land use system**

Chandran (1988) and Itnal (1987) observed that the organic carbon content under different tree species was increased by 50 and 200 per cent compared non-tree control. The increase may be attributed to the accumulation of leaf litter on soil surface which upon decomposition adds humus content to soil.
According to Channappa and Ranga (1988) runoff soil loss were significantly reduced by the surface crop cover and management practices. Rates of runoff and soil losses increased significantly as the density and crop canopy decreased and they observed direct relationship between erosion and runoff. Finally they concluded that high rainfall intensities and duration increased the runoff and consequently no soil loss recorded under coffee system on account of staggered contour trenches provided plants poor grass cover and splash erosion from large water drops from high canopy shade trees.

Nadagouda and Desai (1998) observed that the deleterious effect of all the tree species on pod yield of groundnut increased progressively with the age of the species. It may be attributed to the increase in tree canopy and extension of root system to larger volume of soil thus the resultant competition between tree species and the associated crop increased with the advance in the age and tree species.

Shreerangappa et al. (1999) observed that the enzyme activities increased after rainy season compared to the rainy season because of continued soil moisture availability resulted in enhanced root activity and nutrient releases in all the three zones. Irrespective of the land use systems the relationship suggests that the soil organic matter plays a vital role in maintaining higher biological activity in soil.

Vinoda et al. (2003) the results revealed that the development of natural vegetation in the natural land use system had reduced the runoff from 22 mm to 12.2 mm and soil loss form
79.8 kg ha\(^{-1}\) to 22.5 kg ha\(^{-1}\) in cardamom land use system. The runoff ranged between 4 mm to 18.6 mm with a soil loss of 55.5 kg ha\(^{-1}\) to 530 kg ha\(^{-1}\) in multicanopy system and influenced by the conservation practice.

Yada et al. (2003) the result revealed that the long run agroforestry systems have been found to be more productive and profitable than sole cropping. *Tectona grandis* (Teak), *Azadirachta indica* (neem) and *Albizia procera* (safed siris).

Chaturvedi and Das (2005) observed that the agri-horticultural system is a land management system in which agricultural crops are grown in and around the orchards and provides greater benefit than agriculture and horticulture alone. This helps in diversification of opportunities for employment in crop production, management of orchards and post-harvest of fruits and processing, thereby increasing in come and reducing migration of rural poor to urban areas.

Hand et al. (1999) observed that the bundelkhand region of the country has nearly 45 per cent of the area degraded. If these degraded levels of the region are rehabilitated and optimally utilized with viable technology than they can meet the growing demands of food, fodder, fuel, fibre and timber on suitable basis.

Ittnal (1987) observed that the organic carbon content under different tree species was increased by 50 and 200 per cent compared to non-tree control. This increase may be attributed to the accumulation of leaf litter on soil surface which upon decomposition adds humus content to soil.
Chaturvedi and Das (2005) reported that the development of orchards and intercropping under agri-horticultural systems at different ages of front trees has potential for providing sustainable agricultural to the rural people in various activities related to crop and fruit productions.

**Runoff soil loss**

The effect of rainfall, degree and length of slope in vertisols of Bellary (Karnataka) on runoff. Soil and to determine optimum length of runoff plots. Runoff and soil losses as influenced by rainfall, degree and length of slopes were assessed from plots of far length i.e., 22.13, 44.26, 66.39 and 88.52 m having uniform width of 1.8 m at three slope namely 0.5, 1.0 and 2.0 per cent.

The results, the smallest length (22.13 m) has produced maximum runoff and soil loss. As the length of the slope increases runoff percentage as well as soil loss per unit area decreased considerably. Runoff and soil loss increase with increased percentage of slope (Nalatwadmath et al., 2004).
**Erosion index**

The average annual and seasonal rainfall of eastern ghat high land zone varies from 1300 to 1900 mm and 1000 to 1600 mm respectively.

June-July are the most erosive month in the rainy season. Erosion index during the month from May to September accounts for about 83.7 per cent of annual value. Highest erosion index was recorded during the year 1995 and lowest in 1997 (Sudhishri and Patnaik, 2004).

**Natural resources management**

Managing natural resources for increasing agricultural production in eastern India, India is endowed with a vast and rich diversity of natural resources particularly soil, water, climate and agro-biodiversity. To realize the optimum potential of agriculture production system. In India with a geographical area of 329 m ha presently supports 17 per cent of the world’s land area and 4 per cent of worlds fresh water resource (Sarkar, 2005).

**Agroforestry**

Prosopis cineraria - *Acacia nilotica* based extensive agroforestry system which is capable of providing multitudes of products on sustainable basis. The leaf / pod fodder obtained from trees / shrubs on crop field was to the tune of 272.4 t and from CPR and it was only 12.0 t . Therefore the system is quite self reliant (Tewari, Shann, Harsh and Khan, 2005).
**Horti-silvi pasture system**

Vashistha and Prasad (1997) observed that, drought hardy fruit crops can survive and provide income to the farmers even under severe drought and creating favourable micro-climatic conditions, to manage the arid lands in judicious way.

**Agroforestry land use system**

Goyal (2005) reported that, it creates an alternate food source in ecologically and maintain the ecological balance by mitigating green house effects and sequestering atmospheric carbon dioxide and checks soil erosion, conserve soil moisture and increase the soil fertility and provides an alternate option for reclamation of degraded lands.

**Biological measures**

Tomar (2005) reported that a rainy season crop which trends to develop a thick canopy. Intercepts rainfall and dissipates energy of falling rain drop, generally called a cover crop is helpful in reducing soil erosion, soybean, maize and sorghum crops are quite effective in this regard as they develop canopy at fast rate (Verma, 1981).

Perucci *et al.* (1997) observed that, crop residues on the soil surface or incorporation provides a favourable environment for soil and surface residue dwelling organisms because of reduced water loss, amelioration of temperature, extremes, fluctuations, substrate for decomposers (Hartley *et al.*, 1994).
2.5 Runoff and soil loss

2.5.1 Effect of rainfall

The increase in runoff as with increase in rainfall amount (62.50 to 127.00 mm). Runoff increased slightly with rainfall intensity but most of the variation in runoff and soil loss was due to rainfall amount (Rogers et al., 1964).

Srivastava (1974) stated that severe erosion hazards are due to slope, erratic and high intensity rainfall and improper land use. However, Jones et al. (1985) reported that large and intense storms have the potential to cause severe erosion on crop land.

Balvir Verma et al. (1986) observed that soil loss was most significantly related to erosive index $E_{30}$.

$$Y = -41.00 + 11.36\ E_{30}; \quad \gamma = 0.83$$

Where, $Y$ = daily soil loss in t ha$^{-1}$

$E_{30}$ = Erosive index of the rainfall at maximum intensity during 30 minute duration

It was evident that soil loss from runoff plots at one per cent slope had highest correlation coefficient with $E_{30}$ value. Maximum and minimum values of soil loss measured in an individual storm was 3.1 and 0.018 tons per ha from rainfall intensity of 84.0 and 17.0 mm hour$^{-1}$ having $E_{30}$ values of 28.5 and 6.2 unit respectively.
The highest intensity (30 cm hour\(^{-1}\)) of rainfall yielded maximum runoff and severe soil loss in all the soil series under both dry and wet conditions. Generally runoff and soil loss bear direct relationship with intensity of rainfall (Santhan Basu and Sivanappan, 1989).

According to Beke et al. (1990) soil losses were highly dependent on rainfall characteristics and appeared to increase mainly in a linear manner with increase in rainfall amount and duration or rainfall intensities. However, the extent of runoff and soil loss varied from season to season depending upon the intensity and quantity of rainfall (Kale et al., 1992).

2.5.2 Effect of land slope length and its steepness

Generally runoff and soil losses increased as the slope of the land increased (Ballal and Deshpande, 1960). The increase in the slope from 2 to 4 per cent produced greater soil loss as well as relative density of runoff material. According to Smith and Wischmeir (1962) the increase in soil loss with each unit increase in per cent slope became greater as the slope become steeper.

Thomas et al. (1968) conducted soil losses and runoff studies on loamy soil land having 3 per cent slope and 25.0 m in length and found a soil loss of 12.5 tonnes per hectare. The runoff as percentage of rainfall was 24.4.

Dumbare and Gaikwad (1985) reported the effect of rainfall intensities and land slope on soil loss. The estimated soil loss was 37.11, 22.80 and 17.63 tonnes per hectare with 10.8, 7.10 and
3.40 cm hr\(^{-1}\) rainfall intensity under 12, 8 and 4 per cent land slope, respectively.

There was no considerable effect of 10 and 20 mm hr\(^{-1}\) rainfall intensities on the land slopes of 1, 2 and 3 per cent on soil loss but 30 mm hr\(^{-1}\) intensity increased the soil loss by 14.71 and 19.82 per cent when the slope of the land was increased from 1 to 2 and 1 to 3 percentages, respectively (Bangal et al., 1992). According to Kurothe (1992) steeper slope causes more soil erosion. The average soil loss has increased from 21.1 tonnes per hectare at 2 per cent slope to 85.3 tonnes per hectare at 9 per cent slope with higher amount of rainfall.

El Hassanin et al. (1993) concluded that soil loss from bare fallow soil per unit of rainfall and also runoff increased with increase in slope gradient.

2.5.3 **Effect of soil properties**

Peele (1937) reported that the physical properties of soil, as indicated by the percolation rate, suspension percentage and dispersion ratio appear to give a good index of relative erodibility of soils. The runoff data indicated that the soils having sandy loam surface was found to be more susceptible to erosion and have a higher percentage of runoff than soils having clay loam surface.

John and Kuhlman (1962) found more than three times runoff from the fine textured soils compared to medium textured soils. However, the extent of erosion by water depends not only on the time of contact of the soil with water but also on the physico-chemical properties of soil (Anupam Verma and De, 1970).
In red sandy loams of Bangalore, the annual loss of top soil ranged from 2.25 tonnes to 9.50 tonnes/ha/year with a runoff water from 26 cm to 37 cm when the average rainfall was 83 cm. On the other hand, on black soils at Hagari the annual loss of top soil ranged from 16.50 to 24.75 tonnes/ha/year with a loss of water ranging from 23 to 29 cm where the average rainfall was 66 cm (Krishnamurthy, 1971).

Singh and Verma (1975) observed that the time lapse before the runoff started was much greater in soils which had higher intake rate. Even when the rainfall intensity was higher than the intake ratio of the soil, the runoff did not start for half an hour in the loamy sand soil. This was due to the fact that the soils had a very low initial moisture content. Further he noticed that some runoff occurred even in soils where the water intake rate was higher than the rainfall intensity, this was attributed to the fact that the raindrop action dispersed the surface soil thereby reducing its intake rate.

Efficient control of soil erosion can be achieved by increasing permeability and water infiltration rates of the soil through the biological loosening effects of the root system (Kemper and Derpsch, 1981). However, Sorochnik (1975) established the positive correlation between the infiltration index with soil structure and total porosity and negative correlation with bulk density and moisture content of the soil.

According to Hindson (1981) compacted soil with a grass cover was not easily eroded. But runoff occurred evenly across the entire width of the field, causing little erosive damage. However,
Sheshaiah and Kandaswamy (1989) noticed that increased level of compaction increased the bulk density from 1.5 to 1.8 Mg m\(^{-3}\) and decreased the hydraulic conductivity and infiltration rate by six times.

Livington and Norton (1990) observed that erosion increased through reduction in organic matter and aggregate size in forest and prairic soils of mid continental USA.

Sharma and Acharya (1990) evaluated the erosion behaviour of soil under cultivation, forest, and grass land use systems in a humid temperate region of Himachal Pradesh using erodibility indices viz., dispersion ratio, erosion ratio and erosion index. A significant positive correlation was observed among the indices and they were also significantly correlated negatively with soil aggregation.

2.5.4 **Effect of land use systems**

Grasses play a vital role in the control of soil erosion and increasing in situ moisture conservation. Earlier research (1934-45) carried out at Solapur indicated that soil erosion in black soils was as high as 9 tons/ha/year from unprotected lands, while under natural grass cover the same was only 1.3 tons/ha/year (Kanitkar et al., 1960).

On Kota clay soil having 0.5 and 1.0 per cent slopes under different vegetative cover viz., natural, cultivated fallow, cowpea, greengram, guar and maize with average rainfall of 800 mm per year Bhola et al. (1975) observed the significant reduction in runoff and soil loss under natural cover. Among the crops grown maize
gae the highest runoff and soil loss which were marginally next to those from cultivated fallow.

Crops like *Phaseolus aureus* Linn. (Moong beans) and *P.murga* Linn. (Blackgram) developed dense canopies and protected the soil from splash erosion. These crops developed more than 85 per cent canopy, reduced soil loss to less than 2 tonnes per ha per event (Bhatia and Srivastava, 1976).

Sharma and Panwar (1977) reported that urd and groundnut + arhar offered better cover thereby reducing soil loss, whereas growing crops like maize, jowar + arhar and bajra + arhar had a poor canopy, high erosion index and hence failed to reduce soil loss efficiently. Similar results were reported by Anon. (1978).

Eltz *et al.* (1973) reported that erosion losses in the plots under grassland and cultivated pasture were insignificant in comparison with bare soil, which amounted to 53 tons/ha/year. The gradual cover provided by wheat and soybean resulted in a decrease in erosion loss when compared with bare soil.

Runoff and soil loss was maximum in cultivated fallow plot and minimum in *Cenchrus ciliaris* grass plot on 2 per cent slope. Among the cropping systems, uniform crop of bajra permitted maximum runoff (28%) and soil loss (6.34 t/ha/year), whereas intercropping of bajra with cowpea or moong reduced the soil loss to 4 tons/ha/year (Bhushan *et al.*, 1984).

According to Abio (1987) grass cover was most effective in controlling soil erosion when 85 per cent of the plots were covered with the grass. While studying the influence of different crop
canopies on soil loss Laurence et al. (1988) observed the maximum soil loss under beans and minimum from coffee plantation. The soil losses recorded from different crops were 143.4 tonnes/ha/year from beans, 64.8 tonnes from corn, 58.6 from sorghum, 41.5 from potato, 20.7 from banana and 4.4 tonnes/ha/year from coffee.

Studies conducted by Shrinivas Sharma et al. (1988) on Alfisols (red soils) revealed that soil loss varied from 0.37 to 4.78 tonnes/ha/year depending upon land use pattern. Among the cultivated crops, annual soil loss was found to be 1.38, 2.21 and 2.89 tonnes/ha for sole crop of pearl millet, sorghum and castor respectively and the same was 0.37 and 4.71 tonnes/ha for grass (Cenchrus ciliaris) and cultivated fallow, respectively.

Balvir Verma et al. (1990) observed the highest runoff (37%) and soil loss (3.96 t/ha) from cultivated fallow and lowest runoff and soil loss (7% and 0.21 t/ha, respectively) from Dichanthium annulatum grass plot.

The study of watersheds revealed that the natural erosion (from the least disturbed forest land) has been largely accelerated by deforestation and agricultural activities. In the month of heaviest rainfall the suspended and dissolved load accelerate 2.6 to 7.25 times higher in the most disturbed agricultural land than that of forest land (Rawat and Rawat, 1990).

Mishra et al. (1995) observed lowest runoff and soil loss and highest infiltration rate from the plots of Vetivera zizanoides and Dichanthium annulatum. This was probably due to deep
penetration of roots and formation of dense base at the surface soil thus providing obstruction to flow of water.

2.5.5 **Effect of conservation measures**

In a study on runoff (Anon., 1978) it was reported that the fallow plots having 1.5 per cent slope allowed runoff to the extent of 78 per cent with 23 to 36 mm of rainfall prior to tillage operations and sowing of crops. Ploughed land allowed runoff not more than 50 per cent till the two to three good showers were received.

While studying the effect of different conservation measures on runoff and soil loss from arable land of red soils having 2.5 to 3.0 per cent slope, Krishnappa *et al.* (1994) reported that adoption of improved conservation measures comprising bunding and interland tillage and cultural practices on contour found to reduce both runoff and soil loss considerably. They observed that the reduction in runoff and soil loss under contour bund was very low (3.80% and 1.30 t/ha/yr) followed by khus grass on contour (7.90% and 2.48 t/ha/yr) and graded bund (10.60% and 3.70 t/ha/yr) compared to 26.30 per cent and 11.01 t/ha/year under compartmental bunds along with slope cultivation.

Large and intense storms have the potential to cause severe erosion on crop land. However, with conservation tillage on the contour and graded terraces, erosion was less than the soil tolerance during the study (Jones *et al.*, 1985).

According to Channappa and Ranga (1988) runoff and soil losses were significantly reduced by the surface crop cover and
management practices. Rates of runoff and soil loss increased significantly as the density and crop canopy decreased and they observed direct relationship between erosion and runoff. Finally they concluded that high rainfall intensities and duration increased the runoff and soil loss more than crop and land management treatments.

High intensity rainfall caused more runoff and soil loss under cotton crop with conventional tillage, followed by reduced tillage with no crop cover and reduced tillage with winter crop (Yoo and Touchton, 1989).

Patil and Bangal (1991) noticed that the soil losses were reduced for each storm (73.1, 65.4 and 30 mm/hr) due to sowing of crops across the slope. As a result of this the decrease in soil erosion was 32.6 and 34.2 per cent in 1.0 and 1.5 per cent slopes, respectively.

While studying the effect of various cropping systems and land treatments in reducing runoff and soil loss Kale et al. (1992) reported that contour bunding + strip cropping (CB + SC) system was found most efficient in reducing runoff by 37.7 per cent and soil loss by 57.7 per cent over broadbed furrow + intercropping system (BBF + IC). However, CB + SC system reduced runoff and soil loss by 51.5 and 71.1 per cent over CB + IC system, respectively.

In one of the studies having six runoff plot under different vegetation viz., cleared eucalyptus, uncleared acacia, cleared geranium, uncleared apple and cleared vegetables with
conservation measures such as stone wall terraces and bench terraces in the western ghats as Kodaikanal revealed that cleared eucalyptus with no conservation measures recorded highest runoff and sediment yield, while the lowest was observed in apple plantation with bench terraces and grass as soil cover (Kannan and Mathan, 1993).

Effect of three conservation farming practices viz., (i) sowing along slope, (ii) sowing across slope, (iii) ridges and furrows formed at sowing was studied on runoff and soil loss in maize crop under rainfed condition. Formation of ridges and furrows at sowing reduced mean runoff by 86 per cent (32.1 to 4.60%) and soil loss by 95 per cent (from 8.5 to 0.3 t ha⁻¹ per event) as compared to conventional practices of sowing along the slope (Mittal et al., 1986).

The studies conducted by Channappa and Ramaiah (1988) at Dryland Agricultural Project, Bangalore center on red soils on slopes of 1 to 3 per cent indicated that loss of water through runoff was 24 to 36 per cent of annual rainfall. The runoff was of very high order when the soil was compacted and crusted. The system of ridges and furrows across the slope reduces the runoff losses to a large extent as compared to flat sowing.

2.6 Nutrient losses

2.6.1 Effect of land slope, rainfall intensity and land use systems

The plant nutrients are depleted from the soil through crop removal, runoff and soil erosion. In a study Duley and Miller
(1923) obtained 111 kg nitrogen, 424.5 kg calcium and 113 kg total sulphur from bare cultivated Shelby loam soil in 3.68 per cent slope.

Middleton et al. (1934) found that the eroded material was richer than the original soil in respect of colloidal clay and plant nutrients. Similar results were reported by Tamhane et al. (1959) on 3.5 per cent slope.

Organic matter being the lightest constituents of the soil, is easily picked up by runoff and removed through the process of erosion. Nutrients contained in organic matter are thus the first to be carried away in runoff (Slater, 1942).

Knoblauch et al. (1942) working on collington silt loam with 3.5 per cent slope recorded the losses of 1287 kg organic matter, 75 kg nitrogen, 477 kg total potassium and 113 kg total calcium from fallow soil. Loss of nitrogen by erosion is probably more serious than loss of any other nutrient (Wooley, 1943). The very fact that most of the nitrogen being lost is combined with soil organic matter, which is susceptible to erosion.

The eroded material contained twice as much organic matter as remaining in the surface soil. Bedell et al. (1946) found that the soil loss to the tune of 453.6 tonnes per hectare through erosion contained 622 kg of organic matter, 22.4 kg of phosphorus and 0.9 to 7.4 kg of available potassium. Further the amount and kind of material in solution also depend on the nature and intensity of rainfall (Bryant and Slater, 1948). Timmons and Holt (1977) studied the nutrient losses in surface runoff from a native prairie
soil for five years. Average annual total nitrogen and phosphorus losses were 0.8 and 1.0 kg per ha, respectively. Average weighted concentrations for all parameters were high in high intensity rainfall.

Goel and Khanna (1969) in Uttar Pradesh observed that losses of nutrients on plots with 8.5 per cent slope left fallow during monsoon were two to three times higher than the plots under crop. Nutrient losses per hectare have been 245.8, 13.2, 118.7, 82.1, 30.6, 127.8 kg of organic matter, nitrogen, calcium oxide, magnesium oxide, phosphorus and potassium, respectively. Similar results also reported by Bhatt (1977) on Dhulkot silty clay loam soil on 8 per cent slope in Doon valley.

Bonde et al. (1982) studied cropping pattern and its effects on nutrient loss on 2 per cent slope. Losses were maximum in grasses and cotton crop cover with traditional method of sowing. Ridging across the slope in both bidi tobacco and cotton considerably reduced the nitrogen loss by 50.9 and 45.8 per cent, respectively.

The studies of Gopinath et al. (1988) revealed that the loss of nitrogen, phosphorus and potassium were 416, 116 and 680 kg ha⁻¹, respectively at 2.5 per cent slope with sandy clay loam texture on cultivated fallow.

Bhatt et al. (1991) observed that Dhulkot silty clay loam soil on eight per cent slope continued to suffer heavy losses of nutrients till middle of August during South-West monsoon. Large quantities of plant nutrients were lost during the first fortnight of
July due to more rainfall. The cultivated fallow plot continued to lose nutrients throughout the rainy season.

The field experiments conducted by Kale et al. (1992) on nutrient loss under 1.0, 1.25, 1.5 per cent slope at different cropping systems at Solapur on shallow typic ustochrepts soils showed that intercropping reduced nitrogen, phosphorus and potassium losses to the extent of 48.9, 45.0 and 92.3 per cent, respectively over sole cropping at 1.5 per cent slope.

Mathan and Kannan (1993) while studying the nutrient losses under contrasting land use system as influenced by the distribution of rainfall. They found that the loss of dissolved nitrogen was more than total and available nitrogen through sediments. Total phosphorus and potassium lost through sediment was more than the dissolved and available phosphorus and potassium losses from runoff water. The amount of nutrients thus, lost mainly depends on the amount of rainfall, sediment yield, amount of runoff, initial nutrient content in soil and particle size distribution of the sediment.

While studying the influence of soil conservation measures and vegetation cover on nutrient loss, Kannan and Mathan (1993) reported that loss of total nitrogen through sediment was higher than that of total phosphorus and potassium. This might be due to more of total nitrogen in the soil itself. Further, cleared eucalyptus plantation without any conservation measures recorded highest nutrient loss (Total and available N, P and K), while the lowest observed in apple plantation with bench terraces and grass as a cover.
Relatively higher losses of nutrient (total soluble salts 18.7, nitrogen 1.07 and potassium 1.29 kg/ha) occurred under continuously grazed plot compared to cut and carry system (13.2, 0.63 and 0.80 kg/ha) of grass lands (Yadava et al., 1997). Further, they mentioned that 2 to 3 times higher losses of nutrient took place under bare land as compared to different grazing systems.

Literature pertaining to the influence of different land use systems on physical, chemical and biological properties of soil is reviewed under following parameters.

2.7 **Physical properties of soil**

Distribution of soil separates and bulk density, water stable aggregates, infiltration rate, field capacity, wilting point etc., are some of the physical properties which decide soil quality and crop growth.

2.7.1 **Distribution of soil separates**

Ratan Singh and Kanwar (1981) observed variation in texture under citrus plantation when compared to virgin forest. However, Ekanade (1985) observed that texture of the soil changed over years due to cocoa cultivation. The percentage and content increased and clay content decreased. This was observed when cocoa garden soil was compared with adjacent forest soils. Similar type of results was also obtained by Koyamu and Nambiar (1978) when cocoa was mixed with coconut and arecanut plantation.

While studying the soils of mango orchard in the hills of Konkan, Pereira *et al.* (1986) observed that the soils at higher slope
were predominantly sandy clay loam in texture, whereas the soils at lower levels were predominantly clay loam to loam, this was attributed to accumulation of finer soil particles at the foot hills.

The soil separates of mango plantation showed that the sand content ranged from 16 to 76 per cent, silt from 14 to 46 per cent and clay from 10 to 38 per cent in surface soil (Biswas et al., 1987) whereas in subsurface soil and content ranged from 8 to 72 per cent, silt ranged from 14 to 48 per cent and clay from 10 to 52 per cent. The higher clay content in the subsoil was due to illuviation of clay over a period of time from surface to subsurface of a profile.

Mongia et al. (1991) observed that the soils under virgin forest were silty loam in texture, whereas soils under plantation were silty clay to clay loam in texture. Variation in texture was attributed to loss of silt particles due to erosion.

While studying properties of lateritic soils under forest tree species, Chavan et al. (1995) reported that soils were sandy loam to clay in texture. The clay content increased downward with soil depth. This may be due to high rainfall resulting in the vertical downward movement in the soil profile through the voids created by the plant roots and decomposed organic matter.

2.7.2 Bulk density

Bulk density or unit volume weight of the oven dry soil decides a soil to be good or bad for plant growth. For a given textural class higher the bulk density higher will be the compaction of the soil leading to poor soil structure that offers resistance to entry of water resulting in more runoff and soil loss.
Sen and Deb (1946) have reported that bulk density increases with depth. Bulk density was maximum in tilled land than no tilled land and when land was brought under intensive tillage operation the bulk density also increased (Agbola and Akinola, 1981). Intensive tillage might have caused compaction and increased bulk density.

Ekanade (1985) observed an increase in bulk density due to cocoa cultivation when compared to virgin forest. Martin et al. (1991) also observed similar results under sugarcane cultivation. The increase in bulk density was due to cultivation and reduction in soil organic matter content over the years.

Obi and Nnabude (1988) observed that continuous cropping with centrosema reduced the bulk density by 0.23 Mg m⁻³ compared to bare soil. Similar results were quoted by Viswanath et al. (1978) under continuous maize cropping. This was probably due to increased organic carbon, humus and root exudation by the profuse root system which could have helped in the formation of better soil aggregates thereby reducing the bulk density.

Conspicuous changes in the soil bulk density of paduk, teak, rubber and red oil palm plantation were observed when compared to forest cover (Mongia and Bandyopadhyay, 1992). The bulk density of surface soil increased to 1.30, 1.49, 1.35 and 1.28 Mg m⁻³ in paduk, teak, rubber and red oil palm plantation respectively as compared to initial value of 1.50 Mg m⁻³ in pre-plantation virgin forest soils. The increase in bulk density was attributed to decrease in organic matter content of soil. This was also confirmed by Ganeshmurthy et al. (1991).
While studying the properties of vertisols under forest vegetation, Contractor and Badanur (1996) reported that there was improvement in bulk density in forest vegetation compared to control with field crops. Similar results were also reported by Hosur and Dasog (1995) in red loam soils of Dharwad under tree plantation.

Badanur and Tolanur (1992) reported that bulk density of soil was reduced significantly with grasses or legumes or grasses + legumes as compared to field crops.

2.7.3 Stable aggregates in soil

Stable aggregates in any soil besides promoting better air circulation and root penetration of crop plants, offers maximum resistance to soil erosion without which or otherwise the silt and clay particle would be the first victims of the erosion. The influence of soil organic matter and aggregates are closely related as observed by Martin (1942).

Pathak et al. (1964) noticed more aggregation and bigger size aggregates in forest cover than the normal cultivated soils. In case of sal (Shorea robusta) plantation highest amount of total water stable aggregates were found in surface soil while there was decreasing trend with depth of the profile.

Yadav and Singh (1976) evaluated the effect of teak, khair, sal, chir plantations on water stable aggregates. The results revealed that the largest sized aggregates were more dominant in the surface layer, while the proportion of smaller sized aggregates were greater in lower depth. The large sized water stable
aggregates showed a highly significant positive correlation with the organic matter content in the surface soil. While the small sized aggregates showed positive correlation with clay content in the sub-soil.

Cultivated soils have less water stable aggregates (Skidmore et al., 1975). Sharma and Agarwal (1984) who worked on the soils of native grassland, forest land and tea garden soils reported that tea garden soils had good percentages of water stable aggregates than native grassland and forest soils.

Martin et al. (1991) notice that the intensive cultivation of sugarcane reduced the structure and percentage of stable aggregates when compared to soil under forest. This was attributed to decrease in soil organic carbon upon cultivation.

Soils of natural and cultivated pasture soils had highest percentages of >2.0 mm sized aggregates (37.6) while, fallow and maize cropped soils had the smallest percentage (7.4) (Paladini and Mielnicaok, 1991).

Water stable aggregates of >0.25 mm increased with grasses, legumes and grasses + legumes compared to field crops in black soil (Badanur and Tolanur, 1992). Parvathappa and Srinivasamurthy (1994) recorded higher mean weight diameter under pasture and forest soils indicating better aggregation. It may be due to vegetative cover, high organic matter build up and firm binding of soil particles by deep penetrating roots. Further, they observed a significant correlation between mean weight diameter and organic matter contents in soil.
2.7.4 **Infiltration rate**

The process of entry of water into the soil is infiltration. It is an important process for replenishment of ground water. Infiltration rate is affected by a number of factors. Of which soil moisture, soil texture and vegetative cover are considered to be the most important (significant) ones. Evaluation of infiltration rate under different covers, therefore, provides a comparative account of the influence of type of cover on soil moisture availability directly and non-off indirectly.

Williams and Donnen (1960) have reported that the infiltration rate of cropped land was dependent on rooting pattern of crops. The deeper the rooting system as in cotton, the greater will be the infiltration rate than when compared with burley and maize root system.

Lopez *et al.* (1968) have indicated that the average infiltration rate of sandy soils was higher than clayey soils of Puerto-Rico. Agarwal *et al.* (1974) reported that coarser soils have higher infiltration rate.

Wilkinson and Aina (1976) observed that normal rate of infiltration in forest soils of Nigeria was 20 to 25 cm per ha. But when cultivated, crusting becomes a major problem and arrests infiltration. Mathur *et al.* (1982) recorded higher rates of infiltration (both initial and final) in forest land than those in agricultural lands in temperate climate of Himachal Pradesh.
Soni et al. (1985) compared infiltration rate under different vegetative covers like teak, eucalyptus, bamboo, pinus, sal plantations and grass lands in Dehra Dun. Highest rates of infiltration found in eucalyptus (31.5 cm/hr), and the lowest (0.3 cm/hr) in pinus plantation. They pointed out that the infiltration capacities under different vegetation covers were positively correlated with soil porosity and negatively with bulk density.

Abdel Majid et al. (1987) noticed that in continuously grazed lands or lands with heavy stockages recorded lower infiltration rate. Grasses, legumes and grasses + legumes recorded higher infiltration rate than field crops (Badanur and Tolanur, 1992).

A study taken up by Sharma and Acharya (1990) to evaluate the effects of prevailing land use systems on infiltration rate in humid temperature region of Himachal Pradesh revealed that the infiltration rate of forest and grass soils was on par, whereas the infiltration rate in cultivated land was observed to be low. Although soils in cultivated land were coarser in texture, infiltrability was less due to presence of structurally stable and staking and sorting of particles.

Mathan and Mahendran (1994) observed the correlation between clay and infiltration rate \( r = -0.761 \) and between silt and infiltration rate \( r = -0.530 \) were highly significant. Naturally, the correlation between infiltration rate and sand was positive (0.761). However, the dispersion coefficient of clay was significantly but negatively correlated with infiltration rate. Further, they worked out multiple regression equation and it indicated that 51 per cent of variation in infiltration rate was accounted by clay, 59 per cent
by clay + silt, 18 per cent by aggregate stability. Thus clay, silt, exchangeable sodium percentage, aggregate stability and dispersion coefficient of clay jointly contributed to 87 per cent variation in infiltration rate.

Infiltration rate exhibited wide variation among the plantation (Hosur and Dasog, 1995). Infiltration rate was highest in soils under sisoo and lowest in teak plantation. Higher infiltration rate under sisoo may be attributed to good soil structure, lower bulk density and higher organic matter content of soil. Similar results were reported by Contractor and Badanur (1996).

2.7.5 Soil moisture constants

Ali et al. (1966) reported that soil moisture curves of black, red, laterite, lateritic, mountainous, forest and desert soils was a function of clay content of soil. Soong and Yap (1977) reported that moisture content at 0.1, 0.3, 3.0 and 15 bar was less in sandy soils than clayey soils.

Water retention capacity of any given soil is dependent on adsorptive forces of clay and pore size distribution (Rangaswamy and Murthy, 1978). The adsorptive forces were more in expanding type of clay than non-expanding types. Rajani (1968) reported that adsorptive forces of soil were decreasing in the order of black soil > peaty soil > laterite soil > red soil > alluvial desert soil.

Krishnakumar et al. (1990) while studying the soil under rubber plantation reported that moisture retained at the field capacity (-0.03 Mpa) was higher by 5.45 per cent compared to
adjacent field. This was due to increase in organic matter content of soil under rubber plantation. Moisture at field capacity increased with grasses, legumes and grasses/legumes cropping system compared to field crops (Badanur and Tolanur, 1992).

Mongia and Bandyopadhyay (1992) reported that moisture content was minimum under plantation and maximum under virgin forest. This was due to variation in vegetation covers and difference in their evaporative demands.

Correlation studies between moisture retained at different tension and sands showed highly significant negative correlation, while silt and clay had highly significant positive correlation. Contrary to this, organic matter did not show any significant effect on soil water retention at any of the soil tension (Patgiri et al., 1993). Parvathappa and Srinivasamurthy (1994) reported that soil water retention at different suction (0.01, 0.03, 0.30, 1.00 and 1.50 MPa) increased at lower depths may be due to higher amount of illuviated clay. Further they observed that water held at given suction was high in pasture and forest lands than in cultivated arable land.

Soil water content at 0.033 MPa and 1.5 MPa and maximum water holding capacity increased significantly under forest plantation as compared with the field crops in vertisols (Contractor and Badanur, 1996).

2.7.6 Soil erodibility

Middleton (1930) established a quantitative relationship between erosion ratio and soil erodibility. According to his
criterion, soils having dispersion and erosion ratio values greater than 15 and 10, respectively are erosive in nature.

Dispersion ratio, erosion index, clay ratio, aggregation and organic matter content have been found to bear significant relationship with erodibility (Bhatia and Sarmah, 1976; Sahi et al., 1977).

Sharma and Agarwal (1980) reported that cultivated soils in general were found to be more erodible than soils under grasses, tea and forest. There was not appreciable difference in the erodability of soil under the grasses, tea and forest land uses. Dispersion ratio was significantly correlated with erosion ratio under all land uses. Clay ratio significantly correlated with erosion ratio in virgin and forest soils, and water stable aggregates in forest soils only. Similar results were reported by Sharma and Acharya (1990).

Bhatia and Srivastava (1984) noticed that bare soil and soils cropped with maize and maize + urd (blackgram) were found to be erodible, while those under forest plantation and grass cover were not so. Further they mentioned that erosion ratio, clay ratio, silt clay ratio showed positive and significant relationships with erodability, while water stable aggregates were negatively and significantly correlated with erodability of soil.

Datta et al. (1990) noticed that clay content was significantly and negatively correlated with erosion ratio. Hence fine textured soils were less erodible than the soils of light textured. Salvi et al. (1993) reported that erodability indices viz., clay ratio, dispersion
ratio, erosion index indicated relatively more erodability with increase in the slope.

2.8 Chemical properties of soil

The different land use systems are known to exert varied influence on chemical properties of soil owing to the different management practices. Chemical properties like soil reaction (pH), organic carbon, electrical conductivity, exchangeable cations, major and micronutrient content of soils are the important parameters that can be changed through land use systems.

2.8.1 Soil reaction (pH)

Soil reaction (pH) is the important chemical property being influenced by the type and amount of fertilizer or manure added directly and the land use systems indirectly.

Roy and Landey (1962) observed that surface sample are slightly acidic and the pH tends to increase with depth in red and lateritic soils indicating downward leaching of bases. Similar results were reported by Nandi and Dasog (1992) in calcareous soils of vertisols.

Maida and Chilima (1981) reported that pH dropped due to continuous cropping from 5.4 to 4.0. This may be ascribed to respiration of roots, root exudates and microbial activity which leave certain amount of organic acids and also application of nitrogenous fertilizers result in lowering of soil pH (Viswanath et al., 1978).
In cultivated soils, pH decreased by 0.7 units compared to soil under natural vegetation Cointepas and Makilo (1982). This was attributed to loss of organic matter and basic cations from cultivated soils.

The addition of organic matter ameliorate the acidification and increase the accumulations of calcium oxide in upper layers of mulberry cultivated soil (Inamatsa and Shibuya, 1991). Mongia and Bandyopadhyay (1992) observed that the pH dropped significantly in plantations when compared to virgin forest due to leaching of bases.

Gurbachan Singh and Singh (1995) observed marked decrease in pH when the alkali soils brought under trees and trees + grasses. The decrease in pH under forest plantation attributed to gradual decomposition of litter which produce weak or organic acids (Contractor and Badanur, 1996).

2.8.2 Electrical conductivity

Duffy et al. (1984) in their study on the effect of different farming systems on some properties of soil noticed that arable soils having high electrical conductivity compared to traditional farming system. Further they observed that the soil which received organic manures have low electrical conductivity compared to arable and mixed farming systems. While studying the soils of mango orchard Pereira et al. (1986) observed that values of electrical conductivity were 0.03 ds m\(^{-1}\) in the soils of lower slope and 0.028 ds m\(^{-1}\) in the soils of higher slopes in hill soils of Konkan.
Gundlur (1991) observed that electrical conductivity was found to increase with depth in some soils of vertisols. In salt affected soils growing of fruit crop like phalsa found to reduce the electrical conductivity compared to guava. This ascribed to the addition of more litter under phalsa orchard and release of organic acids during the decomposition of leaves and litter (Verma et al., 1994). Similar results were observed by Gurbachan Singh and Singh (1995) under tree and tree + grasses in alkali soils.

2.8.3 Organic carbon

Organic matter content in soil, is responsible for most of the process taking place in soil. Havangi and Mann (1970) recorded an increase in organic carbon values due to farm yard manure application under dry farming conditions.

Haynes and Goh (1980) reported that organic carbon was high in the surface soil of grassed plots, intermediate in uncultivated plots and low in cultivated plots. This may be due to breakdown of organic matter in cultivated plots.

While studying the influence of different land use systems on fertility status of soil, Singh and Ganeshmurthy (1991) noticed that organic carbon was higher in soils under forest cover and was lowest in rice soils, whereas it was intermediate in soils under plantation. Severe surface erosion and absence of organic farming lead to decrease in organic carbon under plantation and rice crop. Similar results were reported by Mongia and Bandyopadhyay (1992).
Build up of organic carbon was slightly higher in phalsa compared to guava orchard. This ascribed to the addition of relatively more litter under phalsa orchard than under guava through defoliation, which ultimately added the organic matter (Verma et al., 1994).

While studying the soil characteristics of major land use systems of alfisols in Meghalaya, Madhumita Das et al. (1997) reported that the organic matter build up was highest by the dairy farming (1.63%) followed by agroforestry (1.60%), pasture (1.09%) and horticulture (0.75%) systems.

2.8.4 Total and available nitrogen, phosphrous and potassium

Loganathan and Krishnamurthy (1976) observed that the total nitrogen and phosphorus content in soil decreases with the soil depth. This was due to fall in organic matter lead to decrease in organic phosphorus with depth in black, red, lateritic and alluvial soils of Tamil Nadu. However, Mandal and Pain (1965) reported that application of organic manure and ammonium sulphate for over 15 years increased total and available nitrogen in mulberry soils.

While studying changes in characteristics of Virgin soil brought under plantation, Koyamu and Nambiar (1978) observed a reduction in total nitrogen and potassium in all the fields and an increase in the phosphorus content. Haynes and Goh (1980) noticed that total nitrogen was highest in grassed plots, intermediate in uncultivated plots and low in cultivated plots,
whereas total and sodium bicarbonate extractable phosphorus was high in uncultivated plots.

While studying the acid soils of mango orchard in Konkan, Pereira et al. (1986) observed that soils of both upper and lower slopes were deficient in available phosphorus and were well supplied with available potassium. However, Biswas et al. (1987) observed that the available phosphorus and potassium did not differ markedly between two depths in soils of mango orchards.

Attah-Krah (1990) compared the soil characteristics under alley cropping with leucanea and grass, against convention cropping systems without trees and with continuous cultivation. His observations revealed that total nitrogen content of soil under conventional cropping systems were lower than those under alley cropping and alley grazing treatments, whereas phosphorus levels were lower in the alley cropping and grazing plots.

Pal (1992) reported that cultivated field lost more nutrients than they gained. The depletion of soil nutrient reserves lead to soil degradation. In support to this Tiessen et al. (1992) observed that available nitrogen and phosphorus greatly reduced after six years of cultivation compared to bare fallow soil.

Mongia and Bandyopadhyay (1992) reported that available nitrogen, phosphorus, potassium decreased in all the soils under plantation crops compared to virgin forest soil. This was due to decrease in organic matter content which adversely affected the cycling of these plant nutrients. Similar results were reported by Chavan et al. (1995).
Patgiri and Dutta (1993) studied the tea growing soils and indicated that available phosphorus (6 to 9 ppm) correlated significantly and positively with total P. The total phosphorus varied from 810-1162 ppm. The low available phosphorus might be due to slow decomposition of organic matter because of continuous shedding effect coupled with high rainfall. On the other hand, the pasture system proved superiority to over other systems in the build up of organic carbon, available phosphorus, potassium in the soil profiles followed by horticulture, agroforestry, agriculture and fallow (Madhumita Das et al., 1997).

2.8.5 Calcium, magnesium and sulphur

Haynes and Goh (1980) from their studies on land uses viz., grass, cultivated and zero tilled lands observed that sulphur content was highest in the surface soils of grassed plots and intermediate in cultivated plots. The level of exchangeable calcium and magnesium in the surface soil under grass was markedly higher than those of non-grassed plots indicating less leaching of cations in grassed plots.

Maida and Chilima (1981) reported that continuous cropping reduced the exchangeable calcium from 1.80 to 0.195 c.mole ($P^+$) kg$^{-1}$ and exchangeable magnesium from 1.890 to 0.280 c. mole ($P^+$) kg$^{-1}$. Exchangeable calcium and magnesium decreased with cultivation compared to fallow soil (Balasubramanian et al., 1984).

Schnog et al. (1985) reported that coffee plantations were deficient in calcium and magnesium, whereas no deficiency could be detected with regard to sulphur.
The exchangeable calcium and magnesium was high in natural forest and low in plantation crop soils (Mongia and Bandyopadhyay, 1992). Similar results were reported by Contractor and Badanur (1996) in vertisols, where they find calcium as dominant cation.

Madhumita Das et al. (1997) observed the higher calcium and magnesium in pasture lands followed by horticulture, agroforestry, agriculture and lower in fallow in alfisols of Meghalaya.

2.8.6 DTPA extractable micronutrients

Ahlawat et al. (1985) from their nutritional survey of mango orchard of Haryana noticed that the zinc content of the orchard soil varied from 0.392 to 1.232 ppm and iron content from 3.36 to 28 ppm. Schnog et al. (1985) while studying the studied nutrient status of coffee plantation in tropen land observed that zinc and iron were deficient in soil and no deficiency could be detected with regard to manganese and copper.

Singh and Ganeshmurthy (1991) reported that available zinc and copper was high in forest soils and low in soils under plantation and rice crop. This was due to soil deterioration under monoculture cropping without any fertilizer application with no/low organic matter addition, break down of nutrient recycling, continuous removal of nutrients by crops and leaching of nutrients. On the other hand, iron and manganese were lowest under forest soils, lower in rice soils and intermediate in plantation
soils. Increase in iron and manganese in plantation soil was due to acidification of soils following deforestation.

DTPA extractable zinc, copper, iron and manganese were found higher in surface layers and these are negatively and significantly correlated with soil pH (Vijayakumar et al., 1996).

2.9 Biological properties of soil

2.9.1 Dehydrogenase, phosphatase and urease

Pancholy and Rice (1973) noted that the activities of urease, phosphatase and dehydrogenase were related to the type of vegetation and quality of organic material incorporated in the soil.

Kiss et al. (1975) reported that fertile, cultivated soils exhibited high dehydrogenase activity but saline and high pH soils with very low activity. Dehydrogenase and urease activity were more in permanent agriculture land compared to terrace land and slash and burn agriculture (Dkhar and Mishra, 1983). However, Duffy et al. (1984) indicated that biological activity was greater in organic farming when compared to mixed farming and was lowest in the arable farm.

The activity of both phosphatase and urease enzymes were higher in soil having pH range of 5.0 to 7.0 and decreased at pH range of 7.1 to 8.4. The greater activity of phosphatase in virgin soil is associated with low pH. The concentration of these enzymes increased drastically in soils containing organic carbon between 0.5 to 1.0 per cent and greater than one. The soils of grassland and forest land shown higher activity of phosphatase and urease.
than those of cultivated land owing to more content of organic carbon. Urease content was highest in the soils of grassland, probable that the dense network of roots characteristic of many grasslands might have produced higher content of urease in soils of grassland as compared to those of forest and uncultivated land (Gupta and Bhardwaj, 1990).

Singh et al. (1991) reported that urease activity down the depth of the soils did not follow any regular pattern but irrespective of depth it was positively correlated with organic carbon, silt and clay and negatively with pH and sand. However, Baligar et al. (1991) reported similar type of correlation for dehydrogenase activity.

Tiwari and Mishra (1995) studied the seasonal variation in dehydrogenase and urease activity under grass and forest lands and reported that the activity of these enzymes under forest and natural grasslands were higher during the rainy season (July to September) and lower during the winter season (October to February) and least during April-May. However, Manna et al. (1996) reported that dehydrogenase and urease activity increased significantly with the application of farm yard manure and reached a maximum in the month of August for dehydrogenase activity, and in September for urease activity. Similar trends were also observed in case of alkaline phosphatase upto August. However, it increased further at latter stages under soybean wheat system.

Lakhdive et al. (1996) observed that all among the three agro-horticultural system (custard apple, anoula and ber) ber +
legume crops system (greengram/blackgram/soybean) was found most remunerative.

Nadagouda and Desai (1988) observed that the deleterious effect of all the tree species on pod yield of groundnut increased progressively with the age of tree species, it may be attributed to the increase in canopy and extension of root system to larger volume of soil thus the results competition between tree species and the associated crop increased with the advance in the age of tree species.

Nadagoudar (1998) observed that the major benefits of agroforestry are some returns even in drought year i.e., stability in agriculture, reliable, source in lean season and wide range of subsistence and cash products. If agroforestry is conceived in right spirit and containing efforts are made, the productivity of land can be stabilized in addition to getting non-yield benefits and helps in upgrading the polluted environment.

Hand et al. (1999) observed that the Bundelkhand region of the country has nearly 45 per cent of the area degraded. If these degraded lands of the region are rehabilitated and optimally utilized with viable technology then they can meet the growing demands of food, fodder, fuel, fibre and timber on sustainable basis.

Shreerangappa et al. (1999) observed that the enzyme activities increased after rainy season compared to the rainy season because of continued soil moisture availability resulted in enhanced root activity and nutrient releases in all the three zones.
Irrespective of the land use systems the relationship suggests that the soil organic matter plays a vital role in maintaining high or biological activity in soil.

Joshi et al. (2004) the result reveal that soil in terraced agriculture land was more stable than that in open pine forest, tea gardens and grazing lands. The maximum water, soil and nutrient losses were recorded from areas covered with open pine and the minimum from agriculture land. The well maintained agricultural land had higher conservation values of water, soil and nutrient than the other land use systems.

Khera and Kahlon (2005) observed that, four different land uses viz., bare, cultivated, grassed and forest land use. Soils under forests were observed to be less erodible with mean soil loss of 14.1 t ha\(^{-1}\) as compared to bare soil 23.1 t ha\(^{-1}\). Mean runoff over different rainfall intensities also reduces from 7.1 mm under bare land use to 5.6 mm under forest land use conditions. Soil erodibility factor (K) calculated from adjusted soil loss to erosivity factor \(EL_{15}\) was also observed to be less under forest land use (0.23) than bare land (0.38). Erosion ratio and dispersion ratio were 99.5 and 91.3 under bare soil as compared to 71.5 and 78.7 under forest soil respectively.

Sharam et al. (2000), the results reveal that forest soils were more stable than the soils under orchards and cultivation. The maximum runoff (13.5% of the total rainfall). Soil loss (32.11 t ha\(^{-1}\)) and available NPK losses (58.47, 16.46 and 10.62 kg ha\(^{-1}\)) were recorded from the lands under cultivation followed by orchards and minimum under forest.
Kaushik et al. (2002) the results agreement with among various crops chickpea gave maximum net returns both under sole cropping and silvi-horticulture system. This might be due to higher value of its grain i.e., Rs. 1300 and Rs. 1900 per quintal during 1999 and 2000, respectively.

Saha et al. (1999) result revealed that the organic carbon content was higher (2.5 g kg\(^{-1}\)) in the silvi-pastoral system than in the cropped land (1.5 g kg\(^{-1}\)). Available phosphorus increased remarkably in the pure Bhabbar plot (14 kg ha\(^{-1}\)) relative to others (7.5 kg ha\(^{-1}\)). Available potassium varied from 78 kg ha\(^{-1}\) to 113 kg ha\(^{-1}\) moisture percentage was greater in Pure Eucalyptus, Pure Bhabbar grass and Eucalyptus + Bhabbar plots than other systems.

Yadav et al. (2006) reported that the evaluation after eight years of the implementation is revealed that severely eroded upstream site of dam was stabilized by established vegetative barrier of Saccharum munsa on contour trenches. The silt retained behind these barriers had 20 and 6 times more available K than eroded portion in 0-5 and 5-15 cm depth. Annual silt deposited at surface had same organic carbon contents. Sub-surface had its four times more accumulation. Jamun plantation with gypsum application in basins and popular based silvi-pastoral system reclaimed the alkali and water logged saline soils, respectively.

Solanki et al. (2005) observated that the different tree species practice also reduces runoff and soil loss considerably to the tune of 6-10 tonne/ha/year vegetative barriers are cheap and
effective barriers are cheap and effective as compared to mechanical measures on mild slopes.

Guinea Bhabar Khus grass reduced the runoff by more than 18 per cent and soil loss by more than 18 per cent and soil loss by more than 78 per cent compared to cultivated fallow on 4 per cent and slope in Doon valley.

Majumdar et al. (2004) reported that the all inorganic P fractions in various farming systems were found to be in increasing order from top to lower slopes portion. Possibly due to seepage and runoff losses from upper to lower slope. The solid P ocluded P and Ca-P fractions were relatively higher in FSW1, FSW4 and FSW6 thought the slope due to added P fertilizer and manures in these systems.