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Alternate land use systems for resource conservation

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Abstract
Small and marginal farmers account for 83 percent of Indian agriculture. As a result, farmers practise subsistence farming with little or no marketable surpluses, resulting in poverty, food insecurity, and malnutrition. About 64 percent of India's cultivable land is in the dry land zone, which is characterised by an insecure environment, which can result in low agricultural returns due to drought or flood. Low, unreliable, and uneconomic yields arise from farming on such dry areas, especially on tiny and marginal lands. Alternative land use systems give a more secure approach of stabilising farmers' output and earnings while also offering other complementing options. The need for food, fodder, and fuel is increasing, which may be met by an appropriate land use system. Improving degraded lands by implementing acceptable alternate land use systems can protect soil and water resources, which are essential inputs for increasing agricultural yield.

Keywords: agriculture, alternate land use system, resource, IFS, sustainability

1. Introduction
The word "land usage" is used to describe how people use land. It depicts the economic and cultural activities (such as agricultural, residential, industrial, mining, and recreational uses) carried out in a certain location. The United States Department of Agriculture (USDA, 1972) [33]. In order to develop better land use policy, forecast transportation and utility demand, identify future development pressure points and areas, legislators, planners, and State and local governmental officials need to know the current distribution and area of such agricultural, recreational, and urban lands, as well as information on their changing proportions. effective regional development plans. Accurate, useful, and current data on land usage are critical in this dynamic context. Reliable information is essential if governmental agencies and commercial groups are to understand what is going on and make effective plans for future action. As (Clawson and Stewart, 1965) [7] The range of land use and land cover data requirements is enormous. Federal, state, and local authorities also require land use and land cover data for water resource inventory, flood control, water supply planning, and waste-water treatment. To better the administration of public lands, several Federal agencies require updated thorough inventories of existing activities on public lands, as well as the present and changing uses of neighbouring private property. Land use data is also needed by federal agencies to assess the environmental impact of energy resource development, to manage wildlife resources and reduce man-wildlife ecosystem conflicts, to compile national summaries of land use patterns and changes for policy formulation, and to prepare environmental impact statements and assess future impacts on environmental quality.

2. Agriculture Land use in India (1950-2017) is depicted in fig 1: As per the Ist survey of land-use in India after independence, fallow lands were 10% whereas area not available for cultivation and net sown area was 17% and 42%, respectively In 2016-17, net sown area was 45%, forest area was increased from mere 14% (in 1950-51) to 23% in 2016-17. (Directorate of Economics $ Statistics, 2019) [10]

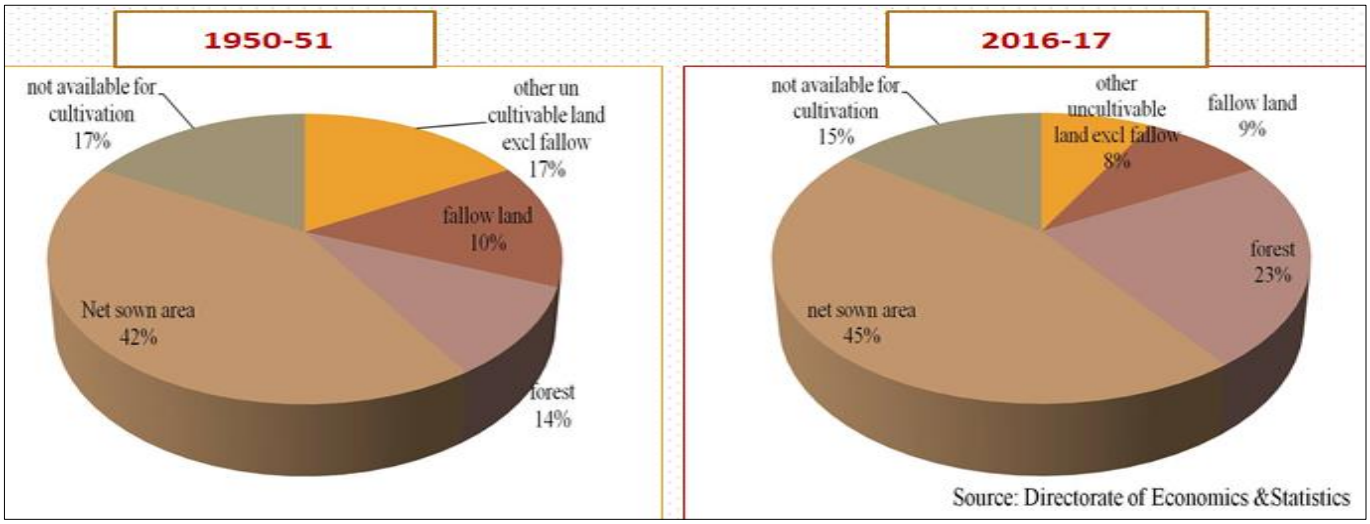

Fig 1: Agriculture land use in India

3. Integration of Alternate land use systems: The various land use systems or how the land is integrated and what kind of integration it has is largely determined by a variety of factors such as the area's livestock population, physical environment, infrastructure, demographics, employment system, employment generation opportunities, and various social and economic factors (Reddy, 2011) [27]. When land is put under an alternative production system in order to better suit its potential to the new land use and achieve superior long-term biological and economic productivity, it is referred to as alternative land use. In arid, semi-arid, and sub-tropical climates, planting trees alongside crops or near bunds/fences could help provide protection from climate extremes. Different alternate land use systems may be the most essential option for developing nations' sustainable development, since they may be utilised to address three major issues: low productivity, soil erosion, and fuel wood. To meet the expanding demand for food, fodder, and fibre as the human and livestock populations grow, more marginal and sub-marginal lands are being cultivated. These places cannot sustain productivity, and cultivating them generates environmental imbalances. In order to meet demand for food and fodder while conserving natural resources, a diverse land use system must be established in different agro ecological zones of the country as an alternative to conventional agricultural systems.

4. Global land use for food production

Figure 3 depicts the current situation of global land area and illustrates worldwide land utilisation for food production. Glaciers cover 10% of the earth's surface, while barren land-deserts, arid salt flats, beaches, sand dunes, and exposed rocks – make up the remaining 19%. This leaves us with "habitable land," as we call it. Agriculture takes up half of the world's livable land. Agriculture takes up half of the world's livable land. This leaves only 37% for forests, 11% for shrubs and grasslands, 1% for freshwater coverage, and 1% for built-up urban areas, which comprise cities, towns, villages, highways, and other human infrastructure-a much less percentage than many people think. Furthermore, there is a significant disparity in land utilisation between cattle and crops for human use. Livestock accounts for 77 percent of worldwide farming acreage when grazing pastures and cropland for animal feed are combined. Despite the fact that livestock utilises the majority of agricultural land, it only produces 18% of global calories and 37% of total protein. One of humanity's most major environmental impacts has been the spread of agriculture. Agriculture has transformed habitats and is one of the most serious dangers to biodiversity: agriculture poses a threat to 24,000 of the 28,000 species listed as endangered by extinction on the IUCN Red List. However, we also know that dietary changes, such as replacing some meat with plant-based alternatives, and technology developments can help to offset these consequences. Crop yields have risen considerably in recent decades, allowing us to preserve a lot of land for agriculture: we only need 30% of the world acreage to produce the same amount of food as we did in 1961. If consumers and producers work together to develop answers, we have a critical opportunity to return some of this cropland to forests and natural ecosystems (FAO, 2019) [15].

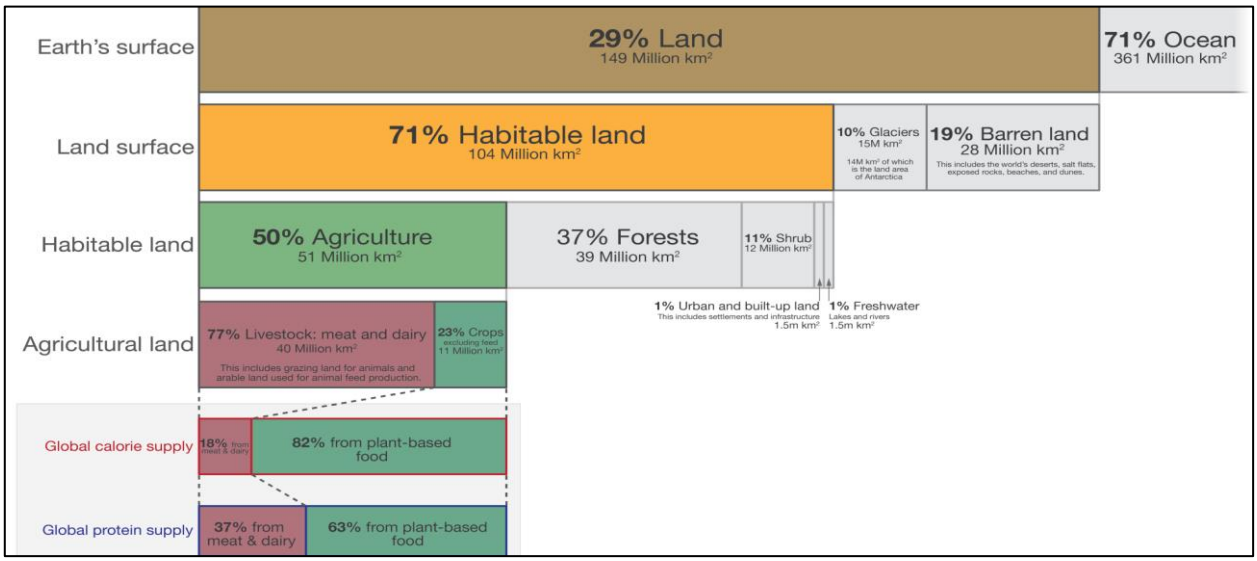

Fig 3: Global land use for food production (*Source*: UN Food and Agriculture Organization 2019) [15]

5. Why we need to go for alternate land use system

Small and marginal farmers are the backbone of India's agriculture. More than 83 percent of small and marginal farmers were recorded in the agriculture census in 2010-11. Since 1970-71, the size of operational holdings (ha) has decreased to 0.38 and 1.38 for marginal and 0.41 and 1.44 for small farmers, respectively. Increased population and a lack of agricultural land growth have resulted in a decrease in the per capita availability of operational holdings. Due to their small land holdings, most of these farmers practise subsistence farming with few or no marketable surpluses. As a result, they have struggled with poverty, food insecurity, and malnutrition.

Aside from low operational holdings, practically all of India is covered by a dry land zone, which is accompanied by an unpredictable climate that can lead to low farming yields due to drought or flood. As a result, there is an urgent need to identify alternative land use options and to combine limited land under various agriculture enterprises in order to obtain food, fodder, fuel, furniture wood, fruits, fibre, and other products from the same land, which would help to ensure proper land use, food security, job creation, and thus alleviate poverty. This would also help to mitigate the current climate threat by incorporating various kinds of crops or plants. (Kadam *et al.*,2020) [17]. Agro-forestry is a land use strategy in which wood perennials, such as shrubs, trees, and bamboos, are used to produce food are grown in association with crops or pastures simultaneously or in a rotation, or both; there are usually both ecological and economic interactions between trees and other components of the system. Depending on the type of the component in the system, it can be categorised as agri-silviculture, agrihorticulture, silvi-pasture, horti-pasture, and alley cropping.

5.1 Agri-silviculture system

It is recommended for land capability class IV with annual rainfall of 750 mm. In Alfisols and Vertisols, a considerable number of tree-crop combinations, particularly of N-fixing trees with sorghum, peanuts, castor, and pulses, were examined. In semi-arid tropical locations, short-duration dryland crops such as pearlmillet, blackgram, and greengram have been proven to be compatible with widely spaced tree rows of Hardwickia binata (Anjan tree). (Devaranavdgi *et al*, 2005) [11].

5.2 Agri-horticultural systems

In terms of economic benefits to farmers, the agri-horti system is the most important among several land use systems**.** This system is ideal for a variety of soil types. Agriculture crops such as cereals and pulses are cultivated alongside fruit trees in this system. (Dwivedi *et al*, 2007) [14] calculated the overall returns from an agri-horticultural system in Jhansi and discovered that the Aonla + Groundnut (K) + wheat (R) based agri-horti system had the best overall returns, followed by citrus and Ber based agri-horti systems.

5.3 Horti-pastture system: Fruit trees and pasture or fodder grasses are combined in the Horti pasture system. It's an excellent method for reclaiming degraded land. In the orchard, cenchrus, stylo, and other grasses grow among the fruit trees. The fruit orchard provides high returns to the farmers, as well as food for their cattle. The addition of legume pastures such as stylo improves soil fertility and helps to prevent soil erosion. (Kadam *et al*, 2020) [17].

A Study was conducted by (Ahmad *et al*, 2018) [1] and it was found that trunk girth(cm) trunk cross sectional area and fruit yield was recorded maximumin in Red clove + Apple its due to introduction of legumes crop (Table 1)

Table 1: Growth and yield attributes of apple cv. Red Gold as affected by forage intercrops in Kashmir

Treatments	Trunk girth (cm)	Trunk cross sectional area (cm^2)	Fruit Yield (Kg/tree)	Yield efficiency (Kg/cm^2)
T1: White clover+ Apple	38.20	116.18	30.45	0.262
T2: Red clover + Apple	39.20	122.34	31.20	0.255
T3: Tall fescue+Apple	37.10	109.59	27.45	0.253
T4: Orchard grass+Apple	38.00	110.18	27.78	0.252
T5: Tall fescue+White Clover+ Apple	37.20	110.97	28.75	0.256
T6: Tall Fescue+red clover+ Apple	37.40	110.18	28.65	0.260
T7: Orchard grass+white clover+Apple	38.00	111.37	28.46	0.256

T8: Orchard grass+ white clover+ Apple	37.20	110.18	28.84	0.262
T9: Control (Clean cultivation)	36.10	103.76	26.45	0.254
CD 0.05	0.06	0.33	0.09	0.001

5.4 Alley Cropping: Alley cropping has been proposed as a replacement for shifting cultivation in the humid tropics, as well as a way to improve soil fertility (Kang *et al*., 1985) [18]. Because mulching alleys with hedgerow prunings does not consistently boost crop output in India's semi-arid regions, the main benefit of alley farming is fodder production during the dry season (Singh *et al*., 1988) [30]. As a result, agroforestry systems contribute to sustainable land use and soil improvement in a variety of ways. To achieve global food security and environmental sustainability, soil fertility must be maintained and improved. For example, intercropping and mixed arable-livestock systems can increase agricultural production sustainability while reducing on-site and off-site repercussions, resulting in sustainable agriculture. Planting stem-cuttings and floods, for example, resulted in greater biological N2 fixation of 307 and 209 kg N/ha by Sesbania rostrata and Sesbania cannabina, respectively, in a field experiment to evaluate N fixation efficiency. By planting the stem-cuttings under flooded conditions, Sesbania rostrata can be used as a green manure (Patel *et al*., 1996**)** [25].

5.5 Ley Farming: Ley-farming methods based on self-regenerating annual legumes cultivated in rotation with annual crops help to overcome some of the issues raised by environmentalists (Crews *et al,* (2016) [8] The pasture phase adds organic matter and reduces tillage, resulting in less erosion, fertiliser, and pesticide use. Because of their importance in addressing the needs of modern agriculture, these systems are essential. They're based on ecological systems. Adapted to subsistence agricultural operations and marginal farmland. To promote soil nutrition and fertility, use biological mechanisms. Tillage should be done less frequently. Farmland biodiversity should be improved.

6. Resource Conservation: Agronomic management conserves and even improves the resources that are essential for sustainability. Organic matter in the soil is an example of an ecosystem resource that can quickly diminish if not managed properly. Soil organic matter levels drop rapidly in almost all agricultural systems after first cultivation, often to 40–60 percent of original levels within a few decades. Organic matter in the soil, on the other hand, is a valuable resource that provides habitat and energy for soil organisms, as well as a soil structure that promotes plant development and water retention, as well as a chemical structure that promotes nutrient retention. (Robertson and Grandy, 2006) [28]. Crops grown in high-organic-matter soils have a better water and nutrient environment than crops grown in low-organic-matter soils, and hence may require less external inputs to achieve the same output level. Furthermore, low-organic-matter soils protect downstream habitats from agricultural effects by reducing runoff and reducing soil erosion. Although biological nitrogen fixation by native legumes such as clover (*Trifolium* spp.) may be a key source of fixed nitrogen in a nitrogen-deficient native ecosystem, current cropping systems rely almost exclusively on industrially fixed nitrogen provided as inorganic fertiliser. (Robertson and Vitousek, 2009) [29].

7. Major threats to Resources

7.1 Shifting Cultivation: Jhuming, or shifting cultivation, is a step in the transition from food gathering or hunting to food production. This age-old practise is still prevalent in this area. Farmers in this approach burn the cleared vegetation and cultivate areas of virgin forest land until crop yields fall below subsistence levels. Demand for food and fuel has increased as a result of the population growth, while land availability for cultivation has decreased. As a result, the jhum cycle has been decreased from 10-15 years to 3-5 years (Yadav *et al.,* 2020) [34] Hilltops are the primary supply of water; deforestation of this hilltop resulted in the loss of a water source. In reality, top soil was lost as a result of this. In addition, deforestation substantially diminished the soil's retentive capacity.

7.2 Land Degradation: The level of management determines the extent of land degradation that occurs as a result of the usage of forest lands for agriculture. There is considerable nutrient loss in addition to the soil loss that occurs with land removal and the early stages of plantings Deforestation, soil erosion, loss of production, ecological imbalance, and land degradation have all resulted from the relocation of such a huge region. The degraded land can't be used for anything productive. (Yadav *et al*., 2020) [34].

7.3 Over exploitation of forest: The indiscriminate use of forests contributes to soil erosion on hills and floods in downstream areas. The scarcity of fuel worsens. This means that forest area will be further encroached upon, resulting in greater deforestation, environmental degradation, and the loss of biological soil and vegetation components. As a result, a vicious spiral may emerge. Excessive grazing by livestock can also harm the environment.

8. How we can conserve resources

We can conserve resources by adopting various methods like alternate land use systems, agronomic measured, conservation agriculture, organic farming and intergrated farming systems etc.

8.1 Natural Resource Conservation Through Agroforestry

Agroforestry practises aid in the protection of soil, water, nutrients, and biodiversity (Grewal. 1993) [16] (Dhyani *et al*., 2005) [12] (Pandey. 2007) [24] (Palsaniya *et al.* 2011a) [23] Under various agroclimatic situations, agroforestry was found to reduce run-off and soil loss, as well as improve soil nutrients, when compared to agriculture or cultivated fallow land use regimes.

8.1.1 Nutrient Conservation: There are two ways that agroforestry conserves nutrients. Agroforestry minimises dissolved nutrient losses by reducing run-off. Second, trees collect nutrients from leaching water and deeper layers, store them in biomass, and then return them to the soil through recycling mechanisms. According to studies conducted in the Shiwaliks, average nutrients losses with run-off water were much lower in various agroforestry systems than in agricultural systems (Grewal 1993) [16].

8.1.2 Water Conservation: Agroforestry trees conserve water by lowering runoff and boosting infiltration and percolation, thereby replenishing the groundwater aquifer. Infiltration is also aided by rotting roots, which act as pathways for water to pass through. Trees can help to increase water storage capacity by improving soil qualities. In the Kangra watershed of the Himalayas, (Srivastava *et al*, 2003) [31] found that silvipasture combined with trees and shrubs on the agricultural landscape influences adjoining microclimate (temperature, RH, light, wind), changes the surface energy balance and alters the water requirement, actual water use, water use efficiency and productivity of adjacent crops or intercrop contour trenching at 1 m vertical intervals preserved 227–424 m^3 /ha run-off. Eucalyptus is widely recognised as a biodrainage species for regulating rising saline water tables. Incorporating multipurpose tree species into an existing farming system also provides adequate drainage control and salinity reduction (Dunin 2002) [13].

8.1.3 Agronomic Measure: The agronomic measured referred Practices of growing vegetables on mild sloppy lanks to cover them and minimise erosion from there in living plants above the soil surface diminishes the craving the strength of agents such as water or wind (Tidemann, 1998) [32]. According to (Mati, 2005) [20]. Mixed cropping, Strip cropping, mulching, contour ploughing, crop rotation, conservation tillage, intercropping, and agroforestry are the key agronomic soil and water conservation strategies.

8.1.4 Strip cropping: Is a method of agronomy in which conventional crops are planted or farmed in small strips over the land slope. Close-growing, erosion-resistant crops should always be used to divide the crops on these strips since they are built in such a way. Strip cropping minimises surface runoff by forcing it to soak into the soil and concentrate precipitation (Morgan, 2005) [22].

8.1.5 Contour tillage: Refers to all tillage operations and mechanical treatments such as planting, tillage, and intercultural that are applied over the land slope near the contour of the area (Meine & Bruno, 2000) [21]. Due to the prolonged duration of concentration, more precipitation penetrates through the soil profile to recharge groundwater, conserving soil. Ploughing in the summer allows the soil to absorb the first rains more readily (Deborah, 2003) [9].

8.1.6 Mixed/Intercropping: The growing of two or more crops on the same field at the same time is known as intercropping (Andersen, 2005) [3] Intercropping can be done using a variety of crops. Climate change can be mitigated by growing a variety of crops alongside the primary crops, such as millets and various legumes.

8.1.7 Mulching: Mulches are ground covers that keep the soil from washing away, minimise evaporation, promote infiltration, and keep undesired weeds at bay (Deborah, 2003) [9]. Mulch can be made up of organic agricultural debris, pebbles, or polythene sheets. Mulching prevents the hard crust from forming after each rain. When organic mulch decomposes, it adds plant nutrients to the soil.

8.1.8 Conservation tillage: CT is any sort of soil cultivation that leaves last year's crop residue on fields before and after planting the current crop to reduce soil erosion and runoff while also giving other benefits such as carbon sequestration. Tillage techniques that increase soil fertility and soil water conservation are used to reduce labour in land preparation. Four basic concepts govern conservation tillage: 1) no or minimal soil turning, 2) permanent soil cover, 3) stubble mulch tillage, and 4) crop choices and rotations are all recommended (Biamah *et al*., 2000) [5].

8.1.9 Crop rotation: CR is when cereal crops are alternated with legume, pulse, or oilseed crops. This sort of rotation generates a variety of residue volumes and varieties, making crop residue and debris management easier.
As a result, in reduced tillage systems, a rotation is essential for success, as it decreases soil erosion and allows for climate change adaptability (Ailincai *et al*., 2009) [2].

9. The Role of Agronomic Practices on Soil and Water Conservation (SWC)

From the viewpoint of soil and water conservation Agronomic practises preserve the environment. This is accomplished through the plant canopy's protection of soil, the litter effect, and the mechanical lowering of runoff velocity by the runoff barrier function. Kilewe *et al*., 1988). [19] (Young, 1989) [35]. This protects the soil surface from direct raindrop impact, which can result in splash and sheet erosion, soil structure collapse, surface sealing, and reduced infiltration rates. (Morgan. 2005) [22] and (Young. 1989) [35] are two examples of this. Grass strip, farmyard manure, and mulch reduced soil erosion by 79, 12 and 98 percent, respectively, and runoff by 42, 8.8 and 75.5 percent, respectively, compared to no grass strip, farmyard manure, and mulch (Birru *et al.*, 2012) [6]

9.1 Integrated Farming System: The IFS, according to (Bahire *et al*., 2010) [4] is the technique of raising various yet dependent firms, and while different enterprises are dependent, they are primarily complementary and supplemental to one another. The Integrated Farming System (IFS) plays a crucial role in increasing profit and productivity in order to meet nutritional needs while also ensuring food security with minimal investment. It is more profitable for farmers to be able to produce more through maximising resource use, recycling waste materials, and employing family labour. According to (Poorani *et al.*, 2011) [26] in the Palladam district of Tamilnadu's Western Zone, the IFS enhanced productivity, profitability, and employment generation by 48, 40, and 45 percent, respectively, over the previous conventional agricultural system.

10. Conclusion

Increasing biological production and profitability to optimise resource utilisation. preserving and improving the resource base's quality. Crops (both arable and pastoral) and cattle are integrated. Crops (both arable and pastoral) and cattle are integrated. reducing agriculture's reliance on non-farm inputs Improving the overall quality of farm life and generating employment opportunities Water harvesting and the expansion of water areas by employing runoff water have both been successful. Choosing appropriate fruit, vegetable, fodder, and fuel trees with for soil binding, a suitable root system is desirable.

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