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Agro-Forestry for Revolutionising Agriculture Sector

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Abstract – **The share of agriculture to the Indian economy is declining consistently on one hand and farmer's resentment due to economically unviable farming is growing on other. How to protect, sustain and develop agricultural sector, which still support major population, is a big challenge. Improving productivity in perpetuity without environmental harm, encouraging high productive agro-forestry, horticulture and herbal plant cultivation along with agriculture and animal husbandry; expanding network of industries for procuring produces of the farmers at door, and decentralising rural markets and banking systems are critical to bring new green revolution in the country. Multi-pronged strategies such as improving the productivity and profitability of land holdings, expanding network of markets in the rural landscape to procure farm-produces at competitive market, and promoting opportunities for the service sector to expand in a manner that triggers the technological and economic upgradation of farm operators and confer the power and economy of scale among farmers are key to achieve the goal of transforming agriculture as a robust and giant economic sector.**

Keywords – **Agro-Forestry, Farm-Forestry, Sustainable Agriculture, Sustainable Farming, Productivity.**

I. INTRODUCTION

The international conventions and agreements, including recently held Rio +20 Conference emphasized the need for mainstreaming sustainability in all areas of development. The economically and ecologically sustainable agriculture with a new ever-green revolution is the only pathway available to India for meeting the need of growing population and bio-resources raw material demand for the industries (Swaminathan 2013)[1]. The new approach implies productivity improvement in perpetuity without environment harm. The technology provided trigger for agricultural productivity and also tree productivity for some species such as *Eucalyptus* sp. and *Populus* sp. In future also, the technology has to be a prime mover for the new evergreen resolution, which may result into emergence of a giant farm based economic sector, integrating agriculture, horticulture, animal husbandry, agro-forestry, herbal industries, wood and other bio-resources based industries.

With progress of market economy and policy favouring other sectors, the share of agriculture and its allied sectors in the Indian economy has declined consistently from over 50 % in 1950s to about 15 % at present. This trend is always observed in any developing economy. But in countries such as India, where agriculture produces are input to several industries, the sick agriculture sector weakens the foundation of the economy, and increases unemployment and inequality. Agricultural sector is the most decentralised as two third of the Indian population is still dependent on farm and allied sectors. India has great advantage of the strong rural economy, because wide spread and decentralised primary production sectors, strongly rooted in rural areas, resisted major recession of the economy when entire world faced the great market depression. The scale of artificial, false and manipulative national and global economy is now relatively high and cycle of economic recession may become frequent in future. If primary production sectors such as agriculture are weak, scope of market manipulation by the artificial and false economy becomes high. To continue with the advantage of rural economy in the country, the expansion and scaling up the restructured agriculture sector is necessary.

The present economic growth, driven by industries and mining, is unsustainable due to growing environmental problems. It is debated and agreed upon globally that development process should protect sanctity of the four natural resources-land, water, natural ecosystems and air for its sustainability. Agro-forestry addresses these problems as a major role for agroforestry is emerging in the domain of environmental services and sustainable agriculture.

At present, the farmer's conditions is pathetic as price of products they purchase, including education of their children, is relatively higher than the agricultural produce they sell in the market. Majority of the farmers incur loss in farming because input in agriculture is higher than the output. The introduction of the Mahatma Gandhi National Rural Employment Guarantee Act (MGNAREGA) has created scarcity of labour for agriculture during the peak season, increasing input cost to the farmers (Swaminathan 2013)[1]. At present, majority of new generation of farmers are losing interest in farming and they prefer labour works in cities than engaging themselves in uncertain farming. In several cases, they are trapped in debt and are compelled for suicide. There had been farmer's movements to raise grievances but such movements failed to take a shape to bring major political transformation. Before such forces organise and erupt in form of violent action, it is now time to revolutionize this sector for making India a robust and giant economic power. How to protect, sustain and develop agricultural sector is a big challenge. Growing traditional agricultural crops with use of chemical fertilisers and pesticides and without animal husbandry and other land based practices is not a viable economic activity as the prevailing market forces may not permit sustainability of such agriculture. To make it attractive and viable, this sector should be treated as raw material supplier to agro-industries, dairy, food processing industries, wood and herbal based industries.

II. TRANSFORMING TWO DIMENSIONAL TO THREE DIMENSION CULTIVATION

In this paper, cultivation of agricultural crops such as wheat and paddy are considered two dimensional land-use

practice because process of solar energy trapping for primary produce is restricted on the surface of lands up to certain crop height, normally below one meter. When tree or horticulture cultivation is done in same land with agriculture, it becomes three dimensional cultivation because such arrangement provide opportunity to the plants for trapping solar radiation from ground level to the top of tree canopy. The agricultural plants convert solar energy into biomass in form grains, oil seeds, vegetables, fruits, fodder etc., which form major energy source for human beings and the livestock. The grains, pulses, oil seeds and vegetables provide protein, carbohydrates, vitamins etc. to people. The food products prepared using fruits grown on the tree canopies also supplement to the food of human beings. With growing bio-industries, every biomass has potential of trading in the market to generate economy. The new approach should be to evolve the land-use systems to maximize qualitative and quantitative production of biomass to generate maximum economy to the farmers. In two dimensional cultivation, trapping solar energy into biomass in the process of primary production has limitation but can be increased substantially, if crop at the surface of land and the tree canopy at the top levels jointly work in a evolved system to improve efficiency of conversion of solar energy in biomass energy in a fashion that the farmers earn maximum income.

In an area, relationship between solar energy input and primary productivity depends on soil and moisture conditions, and type and character of vegetation. On earth, transfer of solar energy into Gross Primary Productivity varies from 0.2 % to 5.0 % with average of 1.0 % (Odum, 1971)[3]. The agricultural system with application of modern technology should aim to achieve a goal of maximum conversion of solar energy into biomass energy by maintaining ideal condition of soil and moisture. The production of different kind of biomass should be such that it gives maximum return to farmer with high degree of security. Also, some of the biomass become inputs to secondary farm house practices such as animal husbandry for milk or meat production.

Rate of energy flow and primary production in agricultural system can be manipulated and enhanced to the optimum level by maintaining nutrients, moisture level and using good quality seeds or planting materials. Also, the quantity and types of primary production should be such that they provide maximum return to the farmers. This can be achieved by developing market driven land-use systems in different agro-climatic zones so that farmers get maximum money in addition to his own consumption.

III. AGRO-FORESTRY

Agro-forestry is defined as a land use system which integrate trees, shrubs and herbal plants with agricultural crops on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. It is a dynamic ecological biomass production and natural resource management system that, through integration of woody perennials and herbal plants on farms and in the agricultural landscape, diversifies and sustains production, improves farmer's income and builds social and financial institutions (Anon 2014)[2]. The Government of India has already notified the National Agro-forestry Policy in 2014. It is perhaps the only alternative to achieve the target of increasing forest and tree cover as envisaged in the National Forest Policy 1988 and to address emerging domain of environmental services, particularly to mitigate the climate change effects. Agroforestry systems offer means to address to a significant extent the present challenges of food, nutrition, energy, raw material shortage, employment, economic conditions of farmer's and environmental security (Anon 2014)[2].

The traditional knowledge of agro-forestry has been continuously in the Indian villages. The National Agricultural Policy (2000) stresses that "farmers will be encouraged to take up farm/agro-forestry for higher income generation by evolving technology, extension and credit support packages, and removing constraints to develop agro-forestry. Major policy initiatives, including the National Forest Policy 1988, the National Agriculture Policy 2000, Planning Commission Task Force on Greening India 2001, National Bamboo Mission 2002, National Policy on Farmers, 2007, Green India Mission 2010, and National Agro-forestry Policy 2014 emphasize the role of agroforestry for efficient nutrient cycling, organic matter addition for sustainable and profitable agriculture and for improving vegetation cover. Agroforestry systems offer means to address to a significant extent the present challenges of food, nutrition, energy, raw material for wood based industries, employment and environmental security along with improving income of the farmers. It can become an important tool to build resilience of farmers and rural people against threats of climate change and natural calamities.

Agro-forestry is now turning a major supplier of raw material for paper, rayon, plywood, veneer, packing and herbal industries. The advancement of clonal technology of the two tree species-*Eucalyptus* sp. and Poplar (*Populus* sp) has brought tremendous impact on tree productivity. Farmers are growing these two species in a large scale in several states such as Haryana, Punjab, Uttarakhand, Gujarat, and Andhra Pradesh under the social forestry programmes. At present, *Eucalyptus* is the main source of paper and rayon industries whereas popular is extensively used in match box and packing industries. Nationally, there are about one and half dozen tree species, namely Mango (*Mangifera indica*), Neem (*Azadirachta indica*), Deshi babool (*Acacia nilotica*), *Ailanthus excelsa*, Nariyal (*Cocuss nucifera*), Khair (*Acacia catechu*), *Areca catechu,* Teak (*Tectona grandis*), *Eucalyptus* sp., *Populus* sp., Subabul (*Leucaena sp.) Casuarina sp.*, *Dalbergia sissoo*, *Anacardium occidentale, Borassus flabelliformis, Pinus roxburghi, Butea monosperma, Hevea brasiliensis* and Bamboo which are preferred by the farmers for raising them on their lands. Three of them are fruit bearing species, and *Pinus roxburghai* and *Butea monosperma* are present on the farm land in a good number due to their

historical link with the forest land (Anon 2013)[4]. Except two species (*Eucalyptus* sp. and *Populus* sp.), selection of clones and their technological development is poor or inadequate in other one dozen agro-forestry species as listed above. In addition to the above species, clonal selection and technological development for about other half dozen species such *Bambex ceiba*, *Gmelina arborea* should be taken up in line of *Eucalyptus* sp. and *Populus* sp.

As per the recent India Status of Forest Report (2013) of the Forest Survey of India, about 3,731 million trees grow in agricultural or farm lands with growing stock of about 1,124 million cubic meter. The first top one dozen species, having highest tree population and growing stock on farm lands, constitute over half of the total tree population in agro-forestry/farm forestry systems in India (FSI 2013)[4]. Thus, tree development programme should be focused by the research institutions intensively for about one and half dozen species which have scope to transform agro-forestry in the country.

Region and state wise analysis indicate that less than half dozen species constitute major growing stock in a state. For example, about 184 million trees (61.1 % of Trees Outside Forest-TOF) grow on the farmlands in Gujarat. The top ten tree species in the state constitute about 64.7 % of the total TOF and half dozen of them-Neem, Deshi babool, *Eucalyptus,* Mango, Teak and *Ailanthus excelsa* constitute over half of the total growing stock (Singh, 2013)[5]. Thus, initially, each state has to focus on about half dozen tree species for clonal selection, tree development and supply of high quality planting stock to enhance agro-forestry productivity.

The consumption of wood other than fuel-wood takes place in many sectors such as housing and construction, furniture and fixtures, agricultural implements, plywood and veneer industries, match box, paper pulp and rayon industries, packaging, sports goods etc. The wood consumption in the industries is growing with economic development. Due to restrictions in tree felling in the forest areas, timber production has shifted and shifting fast towards farm/agro-forestry. At present, major part of about 48.0 million cubic meter of round timber consumption in the country comes from the farm sector (FSI 2013).

Trees Outside Forest (TOF) in about six to seven dozen districts in the country, having irrigations or good rainfall, are major supplier of timber. In Gujarat State, seven districts have tree density over 30 trees/ha in the non-forest lands, and four of them-Anand, Tapi, Mehsana and Gandhinagar support the TOF density over 50 trees/ha. Anand (66.1 trees/ha) has highest density of the TOF in the state. As per a study in 2013, about 22.7 million trees in the non-forest area in Mehsana district generate an annual economy of Rs 5,270 million from wood and fodder (Singh 2013)[6]. Thus, all four districts with high density of the TOF generate almost same level of annual economy to the farmers. Anand is internationally known for agriculture, dairy industries. Timber production is also highest in Anand in Gujarat, although forest land is absent. The three sectors-agriculture, agro-forestry and animal husbandry in the district are beautifully integrated in a fashion that annual economy per unit area may be one of the highest in the country. Anand model of agro-forestry needs to be replicated in other districts in the country.

IV. Herbal Plant Cultivation

Majority of the herbal plants are wild and their over exploitations deplete them in the forests. As a result, several species have reached to the verge of extinction. For sustaining supply and also for conserving medicinal plants, it is necessary to take up their cultivation.

The last three decades have seen substantial growth in herb and herbal product markets across the world and it is now a major force in the global economy. The global trade of herbal products was estimated US$60 billion in 2002, and China had major share in it. This has further increased during the recent years. Cultivated material is more suitable for large scale uses, such as the production of drugs by pharmaceutical companies, which require standardized products of guaranteed or known content and quality. These quality requirements are becoming increasingly important as drug regulations become more stringent in many countries. Cultivation of medicinal plants is highest in China and it is expanding consistently (FAO 2013)[7]. In 2001, about 827,000 hectares was under medicinal plant cultivation in China. India is far behind, although *Ayurvedic* system of medicine is the oldest in the world. This underlines the Chinese leadership in the sector. Research and development on the chemical composition and identification of bio-chemical in the plant responsible for medicinal value is key for bio-technological development. Through application of biotechnology, the subspecies or variety or clones of herbal plants should be identified and developed for providing regeneration material to farmers for cultivation as it will provide a good return to the farmers.

Most of the herbal products tested were of poor quality, including considerable product substitution, contamination and use of fillers. These activities dilute the effectiveness of otherwise useful remedies, lowering the perceived value of all related products because of a lack of consumer confidence in them (Steven *et al* 2013)[8]. It is suggested that the herbal industry should embrace DNA barcoding for authenticating herbal products through testing of raw materials used in manufacturing products, and it may provide a method for 'best practices' in the manufacturing of herbal products. This would provide consumers with safe, high quality herbal products (Steven *et al* 2013)[8]. In India, most of the herbal industries procure raw material from the forests. Wood, plywood and paper & Rayon industries were totally dependent on forest for raw material in the past. Gradually, over a period, they shifted their procurement from the farmers, and at present, agro-forestry is major supplier of wood for industries in the country. For authentic supply of quality raw material for quality *Ayurevedic* products, and also to compete in the global market to generate national economy and employment, the herbal industries have to shift their procurement of herbal material from farm lands. The industries have to work with farmers for supplying quality

herbal regeneration stock and technology for growing them on the farm lands as a part of agro-forestry. The primary processing units should be established in villages for value addition.

V. LINKING FARM SECTOR WITH INDUSTRIES

For sustaining farm sector as most relevant sector in the Indian economy, it is necessary to link it with market generating industrial sectors. Every kind of biomass produced on the farm land can be marketable at attractive price. Agriculture, a monsoon dependent sector, should be transformed into monsoon less dependent through linking it with tree or horticulture crops to avoid the suicidal conditions of the farmers during drought. If crop fails, other components such as animal husbandry, fruit and wood production may generate enough economy to meet the minimum requirement of a farmer.

Driven by the technology and attractive markets, the mind set of farmers can be changed in favour of growing varieties of biomass-multi-product. Strengthening and setting of network of markets and business models for the following farm products (Table-1) is necessary in the villages throughout India.

Table 1: Integrated farm sector production and utilisation

Primary farm-production	Consumption and marketing	Waste recycle and environmental benefits
Grains, oil seeds, pulse and vegetables	House hold use and supply to market and agro-industries	Wastes for bio-fertiliser and reduction in chemical use
Fodder- feed for domestic animals	Milk, meat production and other animal products-house hold consumption and supply to dairy and other industries	Dung and urine as input for bio-fertiliser and reduction in chemical use
Fruits	House hold consumption and supply in market or fruit processing industries	Waste for bio-fertiliser and reduction in chemical use
Fibre	Household use and supply to fibre industries	Waste for fuel-wood or bio-fertiliser
Herbal biomass	Raw material supply to herbal industries	Herbal waste for bio-fertiliser
Timber, poles and wood	House hold consumption and supply to the wood based industries-furniture, plywood, veneer, paper & pulp, rayon, match box, packing industries and poles for constructions. Firewood for domestic cooking and local energy source.	Biomass waste for domestic use (fuel wood) or for bio-fertiliser and reduction in chemical use
Agro-forestry ecosystems	Environment services such as water conservation, carbon sequestration, pollution reduction and biodiversity conservation	Environmental services should generate income or subsidy to farmers-farmers should be compensated for global environmental services

The emergence of robust rural sector is possible when every primary and secondary produce has attractive markets in the rural areas. Every farmer should grow vegetation in integrated manner to produce at least three primary produces as mentioned above. A medium and large farmers may opt four to five types of primary production for maintaining their robust economy. If a farmer is engaged in crop production only, he may land in financial trouble during drought. This is the main reason for suicide of farmers in the village. If a farmer has integrated three-four primary production activities, he can sustain his minimum economy from the allied activities such as animal husbandry, agro-forestry and horticulture when monsoon fails. Raw material supply-milk, fruits, fibre, herbal produce, wood, meat-should form a strong components of the farm sector driven by network of following industries in the rural area.

(i) Food processing industries
(ii) Oil seed based industries
(iii) Sugar cane industries
(iv) Dairy-milk based industries
(v) Fruit processing units
(vi) Herbal industries
(vii) Saw mills, plywood, veneer and timber industries
(viii) Furniture industries
(ix) Market yard for poles, timber and fuel wood
(x) Paper and rayon industries
(xi) Packing and match box industries
(xii) Bio-energy units

Before exploring robust farmer's economy, it is necessary to discuss some of the examples practiced in different parts of the country. Farmers in some areas have diversified economic activities because some of the above industries have taken roots there. Almost all districts in Gujarat have established dairy which procures milk from majority of villages in the state and export milk to other states. Farmers are primary beneficial of Amul Dairy, a cooperative sector and a robust rural bio-resource based industries. Why such success is not replicated in other industries mentioned in Table-1. Dairy has been a key factor for prosperity of farmers in several districts in Gujarat. Thus, it should be very strong component of farm sector and should form major share in the farmer's economy. Milk collection facilities morning and evening

should be created in every village for supplying to the dairy. The fodder from agriculture and trees should form an input to animal husbandry managed at the farmland. Every biomass produced from the land should be used or marketed or recycled. The dung, urine and biomass waste should farm input for bio-fertiliser which in turn become input to the land for maintaining and improving fertility, and also reducing use of chemical fertilisers and pesticides.

About 1100 saw mills and veneer industries have been established in the two districts-Anand and Kheda (earlier one district before bi-furcation). These timber based industries purchase standing trees from farmers at competitive rates. This is the main reason that almost every farmer has planted trees along the boundary of farms in the districts and sells standing trees as and when he needs money. In fact, timber agents keep record of available trees for harvest and they maintain contact with farmers to purchase immediately when they agree for sell. Anand Amala, a superior variety of Amla fruit, is also grown in the district. The processing units purchase Amla from the farmers for supplying to Ayurvedic industries and also to produce Amla products. The agro-forestry in these two districts generate annual economy over 1000 crore in form of wood and fruits, and the farmers have major share in it. Agriculture, agro-forestry and dairy are three integrated pillars for prosperity of the district.

The boundaries of every farm land in Mehsana, a low rainfall district, are lined by Neem, *Ailanthus excelsa* or other trees. About 6.11 million trees of Neem and 2.35 million trees of *Ailanthus excelsa* grow in the non-forest areas in district (Anon 2013)[6]. Component of animal husbandry and dairy is very strong as majority of the farmers in the district supply milk to the dairy. During drought, the fodder shortage becomes a serious issue in Saurashtra and Kachchh regions in the state but not in Mehsana district which has highest buffalo population because leaves of Neem turn major supplier of fodder. Over 85 % Neem trees in Mehsana are lopped every year and some of them are lopped twice in a year. In fact, about one fourth to one third of fodder supply in the district is from tree leaves. Lopped branches are used as firewood. The sustained supply of fodder and fuel wood, monsoon independent produces, lay foundation of strong rural economy in the district. Logs of *Ailanthus* – soft wood is in a great demand for plywood, veneer and packing industries, and agents of industries keep contacting farmers for purchasing standing trees when farmers agree. Due to development of market for *Ailanthus* wood, the number of *Ailanthus trees* increased four folds in the district in a decade (Singh 2013).

Farmers in Junagadh have started planting *Sitafal*, a non-browsable fruit bearing species around the farm lands. Ice Cream Industries in Junagadh purchase ripened *Sitafal*. Demand of *Sitafal* seedlings at the Social Forestry nurseries is very high. Junagadh Agriculture University has developed a clone of a good variety of *Sitafal*. As a result, supply of high quality seedlings started from the nurseries. Being a small tree, shading effect of boundary trees is absent or less on farm lands. The farmers get additional income by supplying fruits in the assured market created by the Ice Cream Industries, without having any impact on agricultural crops. Similarly, farmers in some taluka in Junagadh and Amreli are rich due to raising orchards of Keshar Mango for supplying mango fruits in national and international markets.

J & K Paper Mills at Songadh in Gujarat with capacity of one lakh tone consumption of raw material used bamboo for forests. Bamboo supply from the forest depleted. To address the problem of raw material availability, the industries focused on farmlands. The Paper Mill established clonal plant production centres for *Eucalyptus* and Subabool for supplying to farmers at reasonable rate for raising agro-forestry plantations. The Forest Department also established one and half dozen clonal *Eucalyptus* plant production centres to produce over 20 million clonal plants annually. The paper industry made certain projection and has started working to scale up production by five times very shortly. The entire raw material supply of about 5 lakh tone of wood is expected from the farm sectors. During the Vibrant Gujarat 2011, the Forest Department and J & K Paper Mills entered into an agreement for expanding plant capacity and purchasing wood from farmers at the support price. The support price for standing green wood biomass in plantation during 2014 was Rs 3000 to 3500 per tonne, depending on species. The farmers sell standing crops to the industries at the support price which increases, adjusting price index. Farmers are free to sell wood to others, if he gets high price.

A large scale plantation of *Populus* sp. by the farmers in the north-west India for supplying soft wood for match box and packing industries is another example. There is strong symbiotic relationship between development of agroforestry and wood based industries that provide domestic markets for farm grown timber. Punjab, Haryana, western Uttar Pradesh and plains of Uttarakhand now have more than 1900 plywood and veneer making units due to large scale agroforestry plantations of poplars and *Eucalyptus* raised since 1984 onwards (Anon. 2012). For expanding capacity of existing wood-based industries and establishing new units based on wood from agroforestry plantations should be encouraged by liberalizing rules for holistic growth of agroforestry. These examples reveal that assured attractive market drive farmers for raising the productive tree crop.

VI. How to Revolutionize Farm Sectors?

Transforming farm sector profitable to farmers is a big challenge. Encouraging agro-forestry, expanding industries for procuring agricultural produces, fruits, milk, herbal material and wood at competitive market, and decentralising rural markets and banking systems are critical to bring new green revolution in the country. Three-pronged strategies: (i) improving the productivity and profitability of land holdings through appropriate land use, technologies, and market linkages, (ii) enlarging the scope for the growth of agro-processing, agro-industries, agri-business and bio-resource based industries such as

wood and herbal industries, and (iii) promoting opportunities for the service sector to expand in a manner that will trigger the technological and economic upgradation of farm operators and confer the power and economy of scale among farmers are key to achieve the goal (Swaminathan 2013)[1]. The government should work on followings intensively and extensively to link farm sectors with decentralised markets at door.

(i) Development of agro-forestry models: High productive agro-forestry models –combination of trees with inter-cultivation – are need in every agro-climatic region. The evolved model of three dimensional trapping of solar energy, aiming maximum biomass production, should turn profitable to farmers. Models of growing shade bearing agricultural or herbal crop between lines of trees or under shade or treeline at boundary of a farm should be developed and demonstrated for different areas.

(ii) Developments of superior clones and supply of quality planting stock: Development of superior clones or tree stands is in progress with some success but it is very slow. The success is restricted to a few species such as *Eucalyptus* and *Populus.* Forest Research Institutions and private sectors should work on mission mod to develop high productive clones or variety for about one and half dozen tree species preferred in agro-forestry. Like in agriculture or fruit orchards, it is necessary to supply quality seedlings to farmers. Certification process for seed, seedlings and planting stock should be established and practiced throughout the country. Technological advancement for tree productivity should be a continuous process.

(iii) Expanding network of agro-forest industries: Agro-industries for processing, preserving, packing and marketing of end products should be established in rural areas so that it generate competitive market for the agricultural produces. A mechanism of minimum support price for each produce should be evolved in a manner that farmers get maximum benefits from the new arrangements. Fruit processing, preserving and marketing industries should be available within cluster of villages. Processing of onion to produce dry onion powder to make it available in all seasons to avoid unnecessary market fluctuation may be an example to mention here. Similarly, processing and preserving ripen mango fruits to produce mango juice or drink for its supply in all seasons is already practiced. Such fruit based industries may avoid wastage of produce, maintain supply in all seasons and generate additional employment. Facilities of cold storage should be established in the rural areas.

(iv) Expanding network of timber market yards: Timber and poles procurements by the industries have been established in some districts but major part of the country lacks such arrangement. The government policies facilitate private sectors to establish network of industries to generate market for timber. In some rural areas, especially tribal areas, where competitive for wood is absent, timber yards to procure it at minimum support price should be established by the Forest development Corporations or cooperative sectors.

(v) Raw material supply for paper pulp and rayon and wood based industries: Wood based industries should be developed throughout country to create market for wood produced on farm lands. Paper & pulp and rayon industries should procure entire raw material from the farm lands by declaring minimum support price. Dependency of industries for timber and poles should be totally on farm sectors. Every farmer in the country should have opportunity to sell wood in the market at reasonable price – above support price as and when he desires. A timber cooperative sector in line of Amul Dairy should be established in all districts.

(vi) Replacing chemical fertilisers by bio-fertiliser: At present, chemical fertiliser and pesticide are very costly for farmers. The farmers should be trained to manufacture bio-fertilisers and bio-pesticide at the farm to replace chemical fertilisers and pesticide. Every farmer should be given soil health cards. MGNAEGA fund should be used in agro-forestry, horticulture and manufacture of bio-fertilisers. Every farmer should be treated as MGNAREGA beneficiary for producing bio-fertilisers. The government programmes should encourage bio-fertiliser manufacturing in the villages.

(vii) Animal husbandry: Animal husbandry and dairy should be very strong sector in rural area. A system, as it exist in majority of villages in Gujarat, should be established for each village in the country for procurement of milk in morning and evening for supplying to the dairy. Every district should establish at least one milk dairy.

(viii) Herbal plants and Ayurvedic industries: High variety of herbal plants containing rich desirable bio-chemical should be identified and selected, and planting material should be developed for its cultivation so that farmers get maximum benefits, and herbal industries get assured quality raw material. Herbal industries should engage farmers for cultivation of superior varieties of herbal plants for genuine supply for *Ayurvedic* industries which have great global market. If China can cultivate herbal plants in nearly one million hectare area, why it cannot be done in India?

(ix) Applied research and extension: Modern technology such as application of biotechnology in improving bio-resources or genetics of the plants should be used extensively for all biological resources that produced on farm lands. The focus should be on indigenous crops, breeds and clones. This science can improve productivity to maximise benefits to farmers. For conservation of traditional indigenous crop varieties, the government should pay subsidies to group of farmer or all cultivators from villages for conserving the variety through cultivation.

(x) Spreading rural banking network and credit systems: The Government of India has already initiated process to establish rural banks. Every farmer should be given money transfer cards. Banking facilities should be available within 3 - 4 kilometers from the village. The *Pradhan Mantri Jan Dhan Yojana* has already been launched and it is expected that each family in rural area will have bank account and debit card. This will help farmers to establish financial business activities related to

sell of farm produce and purchasing of anything from the market.

(xi) Developing modern agricultural machineries and tools and supplying them to farmers at reasonable price: The shortage of labourers is very acute during the peak season. New modern agricultural tools and machines should be developed and supplied to farmers. The industries engaged in manufacturing agricultural tools and machines should be freed from the taxes so that the farmers get these tools and machine at low cost. While growing trees and replacing chemical fertilisers by bio-fertilisers, the farmers provide environmental service to the society for which they should be paid.

VII. CONCLUSION

The present unviable and unsecured agricultural practice in large parts of the country increase agony of farmers. The new integrated approach implies productivity improvement in perpetuity without environment harm, and industries driven strong market of farm sector produces. Through integrating agro-forestry, herbal cultivation, horticulture and animal husbandry with farming, the agriculture sector should be transformed as major supplier of raw material for several industries to generate economy and employment in the villages and also to make farming ecologically and economically sustainable and viable. Rate of energy flow and primary production in agricultural system can be manipulated and enhanced to the optimum level by maintaining nutrients, moisture level, using good quality seeds or planting materials and technology. Also, the quantity and types of primary production should be such that they provide maximum return to the farmers. This can be achieved by developing market driven land-use systems in different agro-climatic zones so that farmers get maximum financial return in addition to his own consumption.

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