Natural Resource Management in Agriculture : The Analysis and Understanding

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ABSTRACT

In today's world, agriculture is quite exploitive in nature as far as the uninterrupted use of inorganic fertilizers and pesticides as well as unsustainable use of natural resources are concerned. It is a gospel truth that due to the rising population more and more food grains are necessary, but we must keep in mind that agricultural production and productivity cannot be increased by taking nature at a stake. This paper is prepared through extensive desk research, proper topical development and analysis of the found facts. By the use of several latest eco-friendly and climate smart agricultural methods like conservation agriculture, precision farming, low input farming, roof top gardening etc. the agricultural production and productivity can be increased without harming or exploiting the nature.

Key words: *Climate smart agriculture; Conservation agriculture; Precision farming; Roof top gardening;*

Land serves as storage for water and nutrients required for plants and other living micro-macro-organisms. The demand for food, energy and other human requirements depends upon the preservation and improvement of the productivity of lands, which is not only inelastic but also heterogeneous in different parts and regions of the country with a definite set up, capabilities, suitability for different land resources. Integrated Nutrient Management Conservation of land resources can promote sound land use to match with the land capabilities or suitability and to initiate correct land resources, development/suitability in the country. The increasing human and animal population has reduced the availability of land over the decades. The per capita availability of land has declined from 0.89 hectare in 1951 to 0.27 hectare in 2011 and per capita availability of agricultural land has also reduced from 0.48 hectare to 0.15 hectare during this period and again reduced to 0.12 hectare in 2016. Crop production is subjected to considerable instability from year to year due to its dependence on rainfall, which is slightly erratic and variant in space and time.

Together, social protection and agriculture can more effectively reduce poverty and hunger in rural areas as well as boost economic growth. In fact, agriculture and social protection can complement and mutually reinforce each other. On the one hand, smallholder agricultural interventions improve access to natural resources, productive inputs, technologies, financial services and markets, and increase employment opportunities for small family farmers. On the other hand, social protection provides cash or in-kind support to poor family farmers. This allows them to invest more time and resources in productive activities, increase their participation in social networks and strengthen their capacities to better manage risks. Combining the two sectors can help protect and promote the welfare of poor small family farmers, leading to more sustainable livelihoods, rural development. However, challenges exist. Ministries in charge of agricultural and social protection programmes do not always coordinate efficiently. This means there is space for doing more. FAO facilitates dialogue among governments and other partners around pro-poor policies and programmes for maximizing the impacts of coordinated strategies for rural development. FAO provides specific technical expertise and knowledge on agriculture to design productive interventions complementing social protection measures and it raises awareness on why agricultural and social protection linkages are crucial to accelerate

progress towards achieving zero hunger and combating poverty.

Theoretical Concept : Natural resource management, or natural resources management, (NRM) is the management of natural resources such as land, water, soil, plants and animals, with a particular focus on how management affects the quality of life for both present and future generations (stewardship).Natural resource management deals with managing the way in which people and natural landscapes interact. It brings together land use planning, water management, bio-diversity conservation, and the future sustainability of industries like agriculture, mining, tourism, fisheries and forestry. It recognises that people and their livelihoods rely on the health and productivity of our landscapes, and their actions as stewards of the land play a critical role in maintaining this health and productivity. Natural resource management specifically focuses on a scientific and technical understanding of resources and ecology and the life-supporting capacity of those resources. Environmental management is similar to natural resource management. In academic contexts, the sociology of natural resources is closely related to, but distinct from, natural resource management.

Some aspects of natural resource management :

Conservation Agriculture : A useful measure of natural resource management -An overview of CA : Conservation agriculture (CA) can be defined by a statement given by the Food and Agriculture Organization of the United Nations as "a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment" (*FAO, 2007*).

Agriculture according to the New Standard Encyclopaedia is "one of the most important sectors in the economies of most nations" (*New Standard, 1992*). At the same time conservation is the use of resources in a manner that safely maintains a resource that can be used by humans. Conservation has become critical because the global population has increased over the years and more food needs to be produced every year (*New Standard, 1992*). Sometimes referred to as "agricultural environmental management", conservation agriculture may be sanctioned and funded through conservation programs promulgated through agricultural legislation, such as the U.S. Farm Bill.

Presidion farming : Precision agriculture (PA), satellite farming or site specific crop management (SSCM) is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. The goal of precision agriculture research is to define a decision support system (DSS) for whole farm management with the goal of optimizing returns on inputs while preserving resources.

Among these many approaches is a phytogeomorphological approach which ties multi-year crop growth stability/characteristics to topological terrain attributes. The interest in the phytogeomorphological approach stems from the fact that the geomorphology component typically dictates the hydrology of the farm field. The practice of precision agriculture has been enabled by the advent of GPS and GNSS. The farmer's and/or researcher's ability to locate their precise position in a field allows for the creation of maps of the spatial variability of as many variables as can be measured (e.g. crop yield, terrain features/topography, organic matter content, moisture levels, nitrogen levels, pH, EC, Mg, K, and others). Similar data is collected by sensor arrays mounted on GPS-equipped combine harvesters. These arrays consist of real-time sensors that measure everything from chlorophyll levels to plant water status, along with multispectral imagery. This data is used in conjunction with satellite imagery by variable rate technology (VRT) including seeders, sprayers, etc. to optimally distribute resources. However, recent technological advances have enabled the use of real-time sensors directly in soil, which can wirelessly transmit data without the need of human presence.

Organic farming : Organic farming is an agricultural system which originated early in the 20th century in reaction to rapidly changing farming practices. Certified organic agriculture accounts for 70 million hectares globally, with over half of that total in Australia. Organic farming continues to be developed by various organizations today. It is defined by the use of fertilizers of organic origin such as compost manure, green manure, and bone meal and places emphasis on techniques such as crop rotation and companion planting. Biological pest control, mixed cropping and the fostering of insect predators are encouraged. Organic standards are designed to allow the use of naturally occurring substances while prohibiting or strictly limiting synthetic substances. For instance, naturally occurring pesticides such as pyrethrum and rotenone are permitted, while synthetic fertilizers and pesticides are generally

prohibited. Synthetic substances that are allowed include, for example, copper sulphate, elemental sulphur and Ivermectin. Genetically modified organisms, nano materials, human sewage sludge, plant growth regulators, hormones, and antibiotic use in livestock husbandry are prohibited. Reasons for avocation of organic farming include advantages in sustainability, openness, self-sufficiency, autonomy/independence, health, food security and food safety.

Organic agricultural methods are internationally regulated and legally enforced by many nations, based in large part on the standards set by the International Federation of Organic Agriculture Movements (IFOAM), an international umbrella organization for organic farming organizations established in 1972. Organic agriculture can be defined as an integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity while, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones.

Since 1990 the market for organic food and other products has grown rapidly, reaching $63 billion worldwide in 2012.25 this demand has driven a similar increase in organically managed farmland that grew from 2001 to 2011 at a compounding rate of 8.9 per cent per annum. As of 2018, approximately 71,500,000 hectares (177,000,000 acres) worldwide were farmed organically, representing approximately 1.5 per cent of total world farmland.

Low Input Farming and Sustainable Agriculture : Low input farming means to have higher production and productivity by exploiting minimal amount of natural resources in the form of farming inputs. Sustainable agriculture is an effect of low input farming. Sustainable agriculture is farming in sustainable ways, which means meeting society's present food and textile needs, without compromising the ability for current or future generations to meet their needs. It can be based on an understanding of ecosystem services. There are many methods to increase the sustainability of agriculture. When developing agriculture within sustainable food systems, it is important to develop flexible business process and farming practices. Agriculture has an enormous environmental footprint, playing an outsized role in causing climate change, water scarcity, land degradation, deforestation and other processes; it is simultaneously causing environmental changes and being impacted by these changes. Developing sustainable food systems, contributes to the sustainability of the human population. For example, one of the best ways to mitigate climate change is to create sustainable food systems based on sustainable agriculture. Sustainable agriculture provides a potential solution to enable agricultural systems to feed a growing population within the changing environmental conditions.

Water Management : The main challenge confronting water management in agriculture is to improve water use efficiency and its sustainability. This can be achieved through an increase in crop water productivity (an increased in marketable crop yield per unit of water transpired) through irrigation, a decrease in water losses through soil evaporation that could otherwise be used by plants for their growth, and an increase in soil water storage within the plant rooting zone through better soil and water management practices at farm and area-wide (catchment) scales. Tracking and quantifying water fluxes at different spatial and temporal scales within the plant rooting zone remains a formidable challenge because of the interactions between water sources from rainfall, irrigation and subsurface water on plant uptake, soil evaporation, plant transpiration (water transpired by plants) and runoff or drainage losses from crop-growing areas. The use of isotopic and nuclear techniques to investigate the relative importance of soil and irrigation management factors that influence these interactions will greatly assist in the development of water management packages that involve the consideration of soil nutrient status, type of crops grown, growth stages and the overall agro-ecosystems to minimize not only water but also nutrient losses from the farmlands and enhance water and nutrient use efficiencies in agro-ecosystems under both rainfed and irrigated conditions. Many nuclear and isotopic techniques are being employed in soil water management studies. The soil moisture neutron probe is ideal in field-scale rooting zone measurement of soil water, providing accurate data on the availability of water for determining crop water use and water use efficiency and for establishing optimal irrigation scheduling under different cropping systems especially under saline conditions. The use of oxygen-18, hydrogen-2 (deuterium) and other isotopes is an integral part of agricultural water management, allowing the identification of water (and plant nutrients) sources and the tracking of water movement and pathways within agricultural landscapes as influenced by different

irrigation technologies, cropping systems and farming practices. It also helps in the understanding of plant water use, quantifying crop transpiration and soil evaporation and allows us to devise strategies to improve crop production, reduce unproductive water losses and prevent land and water degradation.

Roof Top Gardening: A Latest Concept : Roof gardening can also be defined as 'environment or nature in the sky'. It is an art and science of growing plants on the fallow spaces within, surrounding or adjacent to the roof of the residence. Other conventional areas of roof gardening include atrium, balcony and window boxes. Across the world, the rooftop gardens are a common feature of the modern city. To reduce pollution and noise, the absorption of CO_2 emissions and controlling the urban heat, need to contribute to the biodiversity enhancement in the urban environment, meeting the scarcity of vacant land for cultivation. The idea of Rooftop Gardening is the only proven an effective measure being practiced and developing day by day throughout the globe. The concept of ecological citizenship uses the metaphor of "ecological footprint". Though the history and existence of rooftop gardening are very ancient, today rooftop gardening covers one in every ten buildings in Europe and America. One of the important advantage to have the rooftop gardening is that the women of the family can have a good opportunity to utilize their leisure period in one way and in other way they can keep generating some family income. Another advantage is that rooftop gardening being an elevated cultivation process, it will keep the microclimate cool and add the air buffer. Plants in rooftop gardens can help to mitigate climate change by sequestering carbon in the atmosphere, insulating buildings, and microclimate cooling. Green roofs also offer an opportunity to promote inner-city biodiversity on underutilized, empty roofs and to address food security issues through the production of food. Productive green roofs combine food production with ecological benefits, such as reduced rainwater run-off, temperature benefits such as potential reduction of heating and cooling requirements, biodiversity, improved aesthetic value, and air quality. Rooftop gardening can be placed on individual homes, institutional and office buildings and roofs of restaurants and serve either home consumption, use of fresh produce in restaurants or institutional kitchens or commercial production. Overheating cities of due to the dense concentration of asphalt (including rooftop and pavements) and global warming that absorbs solar radiation. Rooftop gardening is undoubtedly is much more essential and viable method especially for the cities overcrowded. Today, successful income- generating rooftop horticulture experiences have been reported in a number of countries, including Senegal, Peru, Egypt, China and India. In the face of urbanization & population explosion per capita availability of agricultural land has been squeezed to 0.8/ha due to unplanned construction of concrete jungles here and there throughout the globe as well as in India and West Bengal. The availability of per capita land in West Bengal again is the lowest in India, which is around 0.8 ha/family against a national average i.e.1.41 ha/ family. Due to the scarcity of land and population explosion, people mostly like to utilize the land other than cultivation. To meet sufficient nutritious food a huge quantity of green vegetable in required to 3rd world countries like India where the average income of common people is so poor. In order to avail and cater to the high potential export market for vegetables, flowers, herbs, etc. Due to the concentration of people in urban areas needs transport for food production and supply. It is considered that urban enforcement as a source of a possible organic and universal growing substrate using only local urban waste for a productive rooftop. A sufficient number of green roofs would result in an improvement in environmental conditions, contributing to a reducing pollution and cushioning the effects of climate warming. Keeping ecology resilient and incubated the space management to a new elevation rooftop gardening is one of the viable options to mitigate all above crisis. The brunt of climate change can be reduced by creating or covering this space with greeneries and it will repress the induction of air conditioners and likewise it can stop the emissions of greenhouse gases from usage of air conditioners. This study was conducted for elucidating the operational and conceptual analogy with income generation vis-à-vis future prospects and the potential benefits of a rooftop garden. If rooftop gardening comes with a plethora of advantages like sustainable production, decreasing family monthly costs, improving the quality of air in roofs and providing healthy nutritious vegetables straight from roofs to plates, it certainly deserves some efforts.

Environmental Stewardship: A resilience based eco system approach : Environmental stewardship refers to responsible use and protection of the natural

environment through conservation and sustainable practices.

There are 3 types of environmental stewards: doers, donors, and practitioners. Doers go out and help the cause by taking action. For example, the doers in an oil spill would be the volunteers that go along the beach and help clean up the oil from the beaches. A donor is the person that financially helps the cause. They can do anything from donating their money, to hosting public events to raise funds. They are typically governmental agencies. Lastly there are practitioners. They work on a day-to-day basis to steer governmental agencies, scientists, stakeholder groups, or any other group toward a stewardship outcome. Together these 3 groups make up environmental stewards and with the help keep the ecosystem running healthily.

*Some worldwide approaches towards NRM in agriculture with special reference to Indi*a :

Israel : Israel's agriculture is characterized by high technological level, pressure irrigation systems, automatic and controlled mechanization and high quality seeds and plants. Israel meets most of its food requirements through domestic production to produce over 5 million tons of field crops, 1.15 billion litters of milk, 1.6 billion eggs and 1.2 billion flowers for export (*Ministry of Agriculture, 2006*). The total area of arable land is 377, 300 hectares with 78% under cultivation. Water scarcity is the main limiting factor in Israeli agriculture and the country depends on irrigation to increase its crop yields; about 50 per cent of the land is irrigated. Of the 1,129 million cubic meters (MCM) of water used by agriculture per year, some 30 per cent of agricultural water is treated wastewater (TWW) for drip irrigation of orchards and non-food crops, while another 16 per cent is saline water. The Ministry of Agriculture and Rural Developments is a key driver of plans supporting sustainable development and reducing environmental hazards stemming from agriculture, while on the other hand, positioning agriculture as an environmentally friendly solution for treated sewage. Along with other government bodies, the Ministry is dedicated to increasing the efficient use of water and treated wastewater and promoting water recycling. Restructured pricing in the water sector provides incentive to farmers to utilize more treated wastewater. Next generation Subsurface Drip Irrigation (SDI) is more suitable for treated wastewater and results in even more efficient water use and crop growth than surface drip irrigation methods. However, continued research is required to ensure the success of recycled water in agricultural production. The Ministry is also dedicated to upgrading existing branches of agriculture, such as dairy and poultry farms to make to them more sustainable and less polluting. Biological pest control is being encouraged to reduce pesticide use. Despite the fact that Israel strengthened its efforts to address sustainable development processes, the risk of soil degradation and desertification is persistent there is a continuous need to promote soil conservation programs. At the heart of the agricultural sector is the ability to wisely balance financial incentives, government regulation and free-market forces to improve the agricultural sector and make it more sustainable. In addition the unique climate of Israel has necessitated close collaboration between government institutions, scientists, farmers, and localized agricultural concerns in order to maximize the growth and sustainability of agricultural output in an area with limited natural resources.

United States of America : Some farming practices can degrade natural resources and the environment; other practices can preserve and enhance our natural heritage and provide substantial benefits through careful management of agricultural land. USDA's (United States Department of Agriculture) conservation programs help agricultural producers improve their environmental performance with respect to soil quality, water quality, air quality, wildlife habitat, and greenhouse gas emissions. ERS (Economic Research Service) examines the relationship between agriculture and environmental quality by analysing the use and efficacy of conservation practices; environmental impacts of production practices and management decisions; and the role of Federal programs and policies. Consumer demand for organically produced goods has shown double-digit growth for well over a decade, providing market incentives for U.S. farmers across a broad range of products. Growth in organic agricultural production is occurring in both developed and developing countries worldwide, and the competition for major consumer markets in developed countries, particularly the United States and Europe, is increasing. ERS research on organic agriculture looks at these issues, and the chapter on organic trade has been updated with this release.

European Union : Resource efficiency is a key policy issue for the European Union. In this context, this project

will provide independent expert advice on issues relating to sustainable management of natural resources. More specifically, the project focuses on water resource management and the management of resources used for agriculture. Scientific, technological and best practice solutions are identified and assessed for their potential to improve the sustainability of water management and agriculture. These issues are analysed in terms of their funding from other EU policies, their potential socio-economic benefits, opportunities for better integration in the EU, possible barriers to uptake and knowledge transfer as well as other environmental impacts and remaining research gaps.

Ecologic Institute is part of a consortium of 3 institutes led by Institute for European Environmental Policy (IEEP), working on a framework contract for the Science and Technology Options Assessment (STOA) unit of the European Parliament.

The main objective is to assess the potential role that scientific research, technologies, and best practices play in ensuring the sustainable use of natural resources in the EU. The impacts of these technologies and best practices on other environmental media such as soil, air and biodiversity are analysed. As a secondary objective, the project aims to assess which agriculture and land management issues can be approached with technology, and which issues can be better tackled by promoting non-technological options.

African Countries : Despite wide recognition of its potential benefits, sustainable land management (SLM) has not yet been widely implemented across the continent. *Liniger et al. (2011)* define SLM as "the adoption of land use systems that, through appropriate management practices, enable land users to maximize the economic and social benefits from the land while maintaining or enhancing the ecological support functions of the land resources." It includes management of soil, water, vegetation and animal resources. SLM is increasingly recognized in African countries' development plans but, with the exception of some countries, 16 this has not yet been translated into effective and significant policies or programmes.

Until recently, strategies for the sustainable management of forest resources in Africa have relied on three main instruments—protected areas, sustainable timber exploitation and, to a lesser extent, community-based forest management. The forest area designated primarily for biodiversity conservation has increased by about 5 million hectares since 1990. The increase has been even higher for forests in protected areas, which has reached 13.4% of total forest areas *(FAO, 2010*). Over the last ten years, the sustainability of timber exploitation has increased, in particular due to significant growth in areas with a forest management plan. Finally, the process of decentralizing forest resources management to local communities is under way in many African countries. It still, however, accounts for a very small proportion of forest areas. These strategies, which have often been combined since the late 1990s into integrated conservation and development projects, have only marginally reduced the rate of deforestation. Indeed, while effectively recognizing the need for conservation success to benefit local people, the integrated conservation and development approach has relied on naïve theories of change, in particular the assumption of automatic synergies between conservation and local development. In addition, these strategies have not paid enough attention to the drivers of deforestation and forest degradation that are outside the forest sector. Neither have they been able to materialize in monetary terms the value of standing forests. These challenges have started to be addressed through the recent engagement of African countries in REDD+, 18 which emphasizes agricultural intensification and strengthening the sustainability of the wood fuel value chain as key strategies.

Some programmes for NRM in India :

National Mission for Sustainable Agriculture (NMSA) : NMSA is envisaged as one of the eight Missions outlined under National Action Plan on Climate Change (NAPCC), NMSA aim at promoting Sustainable Agriculture through climate change adaptation measures. The major thrust is enhancing agriculture productivity especially in rainfed areas focusing on integrated farming, soil health management, and synergizing resource conservation. Besides, NMSA also a committed target to fulfil National and International commitments on Sustainable Development Goals (SDG) and Intended Nationally Determined Contribution (INDC). All the components of NMSA such as Rainfed Agriculture, Soil Health Management, Organic Farming, etc. have significant role in achieving SDGs and INDC.

NMSA as a programmatic intervention caters to Mission Deliverables that focuses mainly on conservation agriculture to make farm sector more productive, sustainable, remunerative and climate

resilient by promoting location specific integrated/ composite farming systems; soil and moisture conservation measures; comprehensive soil health management and mainstreaming rainfed technologies.

Rainfed Area Development (RAD) : RAD focuses on Integrated Farming System (IFS) for enhancing productivity and minimizing risks associated with climatic variability's. Under this system, crops/cropping system is integrated with activities like horticulture, livestock, fishery, agro-forestry, apiculture etc. to enable farmers not only in maximizing farm returns for sustaining livelihood, but also to mitigate the impacts of drought, flood or other extreme weather events with the income opportunity from allied activities during crop damage.

Pradhan Mantri Krishi Sinchai Yojana (PMKSY) : The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) was launched during the year 2015-16 with the motto of 'Har Khet Ko Paani' for providing end-to end solutions in irrigation supply chain, viz. water sources, distribution network and farm level applications. The PMKSY not only focuses on creating sources for assured irrigation, but also creating protective irrigation by harnessing rain water at micro level through 'Jal Sanchay' and 'Jal Sinchan'.

Other than these three several other initiatives have been taken in India to improve the resilience of agriculture to climatic variations and to make agriculture more adaptive reported PIB. In the course of these attempts are made to cut down the carbon emissions. Here, the major initiatives involve crop diversification program under Rashtriya Krishi Vikas Yojana (RKVY), Bringing Green Revolution to Eastern India (BGREI), National Food Security Mission (NFSM). According to PIB report, under one of the eight National Action Plan for Climatic Change (NAPCC) missions, the National Mission for Sustainable Agriculture (NMSA), many supporting programs including Paramparagat Krishi Vikas Yojana (PKVY), Soil Health Card (SHC), Mission Organic for Value Chain Development for North East (MOVCD), National Bamboo Mission (NBM), Sub-Mission on Agroforestry (SMAF) are being implemented.

There are some of the practices which help in cutting down the carbon emissions include:

a) Providing an alternative to transplanted paddy by increasing System of Rice Intensification (SRI) area.
b) Using zero tillage drill machine and other residue management machines to plant rabi crops in the residue of rice crop without having to burn them.
c) Rice cultivation by direct seeding, alternate wetting and drying, integrated nutrient management, using slow release nitrogen fertilizers, using super granules of urea, applying nitrogen based on leaf colour chart etc.
d) Making Neem coating of urea mandatory.
e) Promotion of micro irrigation under Pradhan Mantri Krishi Sinchai Yojana (PMKSY)-Per Drop More Crop.
f) Planting trees under NBM, BGREI, SMAF, NFSM schemes.
g) Development of 45 Integrated Farming system (IFS) models for replication in Krishi Vigyan Kendras (KVKs) and in States for climate resilient agriculture facilitation.

Development of one climate resilient village in each of the 151 districts by the Indian Council of Agricultural Research (ICAR). Preparation of a climate vulnerability atlas under National Innovations in Climate Resilient Agriculture (NICRA). Development of district agriculture contingency plans for 633 districts to provide agro advisories in real time and help overcome risks related to climate.

In November of 2017, the Ministry of Power brought a policy for using biomass for generating power. According to this policy with the exception of units having tube and ball mills, all the private and public fluidized bed and pulverized coal units across India would assess technical and safety aspects and try to use 5-10 per cent blend of agricultural residual based biomass pellets along with coal. In line with this, the Central Electricity Authority (CEA) also issued an advisory to the power plant utilities, power equipment manufacturers, State Governments and other stakeholders promoting utilization of biomass pellet.

In the meeting held on November 15th 2018, the Ministry of Power decided that Haryana and Punjab states would bid for all coal based thermal power plants to use 5 to 10% of biomass pellets fired along with coal.

To support Haryana, Uttar Pradesh, Punjab, NCT of Delhi government efforts in addressing air pollution related issues as well as subsidizing the machinery needed for in-situ crop residue management, Rs. 591.65 crores for 2018-19 and Rs.560.15 crores for 2019-20, totalling to Rs. 1151.80 crores from Central funds has

been allocated towards the newly launched Central sector scheme on 'Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the States of Haryana, Uttar Pradesh, Punjab and NCT of Delhi'.

During 2018-19, Rs. 269.38 crores funds have been released to the Government of Punjab, Rs. 137.84 crores to Government of Haryana and Rs. 148.60 crores to the Government of Uttar Pradesh. These funds are released for undertaking Information Education and Communication activities for raising awareness among the farmers, distributing machinery to farmers on subsidy for in-situ crop residue management, establishing Custom Hiring Centres (CHCs) for the machinery to manage in-situ crop residue.

Through the various efforts under the Central Sector Scheme on 'Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue in the State of Uttar Pradesh, Punjab, Haryana and NCT of Delhi, compared to 2017, the paddy residue burning events have reduced by 29.5% in Haryana, 24.5% in Uttar Pradesh, 11% in Punjab as per satellite data.

*Importance of NRM in agricultur*e : According to the article "The role of conservation agriculture and sustainable agriculture", the layer of mulch that is built up over time will become like a buffer zone between soil and mulch and this will help reduce wind and water erosion. With this comes the protection of the soil's surface when rain falls on the ground. Land that is not protected by a layer of mulch is left open to the elements (*Gupta. R et al. 2007*). This type of ground cover also helps keep the temperature and moisture levels of the soil at a higher level rather than if it was tilled every year (*FAO, 2007*). This study shows that the conventional method of crop cultivation is really needs a revise as the natural resources are becoming at a stake because of the unthoughtful and unmitigated exploitation of the soil, air, water etc.

The exploitation of ecosystems by humans has long-lasting consequences for the future provision of natural resources and ecosystem services *(Groom, M. J., Meffe, G. K. and Carroll, 2006)* and this may negatively affect the provision of food, increase health hazards and risks of natural disasters, and more. The main cause of concern is degraded ecosystems may be slow to recover or may not recover naturally even after their exploitation stops *(Scheffer. J et. al.,2015)*. Likewise, the availability of natural resources such as food, clean air, and other ecosystem services, may be adversely impacted for extended periods if the ecosystems providing these resources become degraded. For example, the emission of greenhouse gases may affect the global climate for centuries *(Stern,2007)*. .Apart from these some invasive species and diseases may irreversibly damage ecosystems *(Coomes, Allen, , Forsyth, Lee, and Hulme , 2003)* as well as the non-sustainable harvest of fisheries and forests may leave these systems degraded for decades *(Groom, Meffe, Carroll, 2006)*,or even lead to their irreversible and permanent degradation *(Barnosky, 2012)*. Since natural resources are limited, it has been widely recognized that a transition to sustainable harvest is necessary (*Bringezu and Bleischwitz, 2009*). What the optimal pathway and speed are for this transition, however, constitute the focus of an ongoing debate. For example, it has been suggested that an abrupt transition may slow economic growth in developing countries and may negatively affect production *(Xepapadeas, 2005)*, and that rapid emission cuts may create energy deficits before we manage to develop viable substitutes.

Conservation Agriculture : The third principle is the practicing diverse crop rotations or crop interactions. According to an article published in the Physiological Transactions of the Royal Society called "The role of conservation agriculture and sustainable agriculture," crop rotation can be used best as a disease control against other preferred crops. This process will not allow pests such as insects and weeds to be set into a rotation with specific crops. Rotational crops will act as a natural insecticide and herbicide against specific crops. Not allowing insects or weeds to establish a pattern will help to eliminate problems with yield reduction and infestations within fields (*FAO, 2007*). Crop rotation can also help build up soil infrastructure. Establishing crops in a rotation allows for an extensive build up of rooting zones which will allow for better water infiltration. Organic molecules in the soil break down into phosphates, nitrates and other beneficial elements which are thus better absorbed by plants. Ploughing increases the amount of oxygen in the soil and increases the aerobic processes, hastening the breakdown of organic material. Thus more nutrients are available for the next crop but, at the same time, the soil is depleted more quickly of its nutrient reserves (*Hobbs et al. 2007*).

Precision farming : An article of *Anil K. Rajbanshi*

(2013) tried to show that precision agriculture can help farmers in developing countries like India. Concluded that Precision agriculture reduces the pressure on agriculture for the environment by increasing the efficiency of machinery and putting it into use. For example, the use of remote management devices such as GPS reduces fuel consumption for agriculture, while variable rate application of nutrients or pesticides can potentially reduce the use of these inputs, thereby saving costs and reducing harmful runoff into the waterways. So, in these studies we can clearly see that the method of precision farming can be a trouble shooter as far as the management of natural resources are concerned.

Organic farming : According to *Poul John (2006)*, Agriculture was practiced for thousands of years without the use of artificial chemicals. Artificial fertilizers were first created during the mid-19th century. These early fertilizers were cheap, powerful, and easy to transport in bulk. Similar advances occurred in chemical pesticides in the 1940s, leading to the decade being referred to as the 'pesticide era'.

Some new agricultural techniques like usage of artificial fertilizer while beneficial in the short term, had serious longer term side effects such as soil compaction, erosion, and declines in overall soil fertility, along with health concerns about toxic chemicals entering the food supplying the late 1800s and early 1900s, soil biology scientists bega*n* to seek ways to remedy these side effects while still maintaining higher production *(Stinner D.H, 2007)*.

As a study of *Conford, P. (2001)*, in 1921 the founder and pioneer of the organic movement Albert Howard and his wife Gabrielle Howard, accomplished botanists, founded an Institute of Plant Industry to improve traditional farming methods in India.

Among other things, the aforesaid duo have brought improved implements and improved animal husbandry methods from their scientific training; then by incorporating aspects of Indian traditional methods, developed protocols for the rotation of crops, erosion prevention techniques, and the systematic use of composts and manures *(Yeshwant D. Wad,2013)*.

*I*n 1924, Rudolf Steiner gave a series of eight lectures on agriculture with a focus on influences of the moon, planets, non-physical beings and elemental forces (*Poul John, 2013*). They were held in response to a request by adherent farmers who noticed degraded soil conditions and a deterioration in the health and quality of crops and livestock resulting from the use of chemical fertilizers *(Diver, 1999)*. The lectures were published in November 1924; the first English translation appeared in 1928 as The Agriculture Course *(Poul John, 2011)*.

In July 1939, Ehrenfried Pfeiffer, the author of the standard work on biodynamic agriculture (Bio-Dynamic Farming and Gardening), came to the UK at the invitation of Walter James, 4th Baron North Bourne as a presenter at the Betteshanger Summer School and Conference on Biodynamic Farming at North Bourne's farm in Kent *(Poul John, 2011)*. One of the chief purposes of the conference was to bring together the proponents of various approaches to organic agriculture in order that they might cooperate within a larger movement.

In 1940 Howard published his An Agricultural Testament. In this book he adopted North Bourne's terminology of "organic farming." (Paull, John, 2006). Howard's work spread widely, and he became known as the "father of organic farming" for his work in applying scientific knowledge and principles to various traditional and natural methods (*Stinner, D.H ,2007*).

Increasing environmental awareness in the general population in modern times has transformed the originally supply-driven organic movement to a demand-driven one. Premium prices and some government subsidies attracted farmers. In the developing world, many producers farm according to traditional methods that are comparable to organic farming, but not certified, and that may not include the latest scientific advancements in organic agriculture. In other cases, farmers in the developing world have converted to modern organic methods for economic reasons *(Paull, John, 2007)*.

Low input farming and sustainable agriculture : As the global population increases and demand for food increases, there is pressure on land as a resource. In land use planning and management, considering the impacts of land use changes on factors such as soil erosion can support long-term agricultural sustainability, as shown by a study of Wadi Ziqlab, a dry area in the Middle East where farmers graze livestock and grow olives, vegetables, and grains (*Mohawesh, Yasser; Taimeh, Awni; Ziadat, Feras , 2015)*.

Looking back over the 20th century shows that for people in poverty, following environmentally sound land practices has not always been a viable option due to many complex and challenging life circumstances (*Grimble, Robin , 2002*).

Currently, increased land degradation in developing countries may be connected with rural poverty among smallholder farmers when forced into unsustainable agricultural practices out of necessity (*Barbier, Edward B.; Hochard, Jacob P., 2016*)

Converting big parts of the land surface to agriculture have severe environmental and health consequences. For example, it leads to rise in Zoonotic disease like the Corona virus disease 2019, by degrading natural buffers between humans and animals, reducing biodiversity and creating big groups of genetically similar animals (*Carrington, Damian, 2020*).

Land is a finite resource on Earth. Although expansion of agricultural land can decrease biodiversity and contribute to deforestation, the picture is complex; for instance, a study examining the introduction of sheep by Norse settlers (Vikings) to the Faroe Islands of the North Atlantic concluded that, over time, the fine partitioning of land plots contributed more to soil erosion and degradation than grazing itself (*Thomson, Amanda; Simpson, Ian; Brown, Jennifer, 2005*).

The Food and Agriculture Organization of the United Nations estimates that in coming decades, cropland will continue to be lost to industrial and urban development, along with reclamation of wetlands, and conversion of forest to cultivation, resulting in the loss of biodiversity and increased soil erosion (*FAO, world agriculture towards 2015/2030, 2008*).

In modern agriculture, energy is used in on-farm mechanisation, food processing, storage, and transportation processes (*FAO, world agriculture towards 2015/2030, 2008*).

Oil is also used as an input in agricultural chemicals. The International Energy Agency projects higher prices of non-renewable energy resources as a result of fossil fuel resources being depleted. It may therefore decrease global food security unless action is taken to 'decouple' fossil fuel energy from food production, with a move towards 'energy-smart' agricultural systems including renewable energy.

In some areas sufficient rainfall is available for crop growth, but many other areas require irrigation. For irrigation systems to be sustainable, they require proper management (to avoid salinization) and must not use more water from their source than is naturally replenishable. Otherwise, the water source effectively becomes a non-renewable resource. Improvements in water well drilling technology and submersible pumps, combined with the development of drip irrigation and low-pressure pivots, have made it possible to regularly achieve high crop yields in areas where reliance on rainfall alone had previously made successful agriculture unpredictable. However, this progress has come at a price. In many areas, such as the Ogallala Aquifer, the water is being used faster than it can be replenished. According to the UC Davis Agricultural Sustainability Institute, several steps must be taken to develop drought-resistant farming systems even in "normal" years with average rainfall. These measures include both policy and management actions *(What is Sustainable Agriculture? — ASI, 2013*)

Water Management in Agriculture : In the last 50 years or so we have come to recognize the movements in all Earth's layers, including the plates at the surface, the mantle and the core as well as the atmosphere and ocean. The momentum and acceleration of the impacts of business as usual threaten to tip the complex Earth System out of the environment in which everything living on this Earth has evolved and developed. Some call this new geological period the Anthropocene *(Crutzen , 2002)*. Water is becoming a central issue in this new period. This applies not only to freshwater systems but also to the oceans, their levels and what lives in them. The interdependency between social or human ambitions on the one hand, and availability and quality of our natural resources and the environment on the other is obvious; it determines the kind of development that is realistic and stable.

The expansion in the production and supply of goods and services in the recent past has meant more jobs, income, and, generally, greater possibilities for a better life. It has also meant an increase in the use and pollution of natural resources. The adverse effects on water and other vital components of the Earth System are evident. Many river basins in the world are labelled as "closed" or are on the verge of being closed; their flows no longer reach the oceans.

An estimated 1.4 billion people live in closed basins *(Smakhtin, 2008)* with more limited development options. The development of potential flood zones along rivers and coastlines has increased the incidence and impact of flood related damages. According to the *World Health Organization, 2007*, during the last decade of the last century about two billion people were victims of natural disasters, 85 per cent of which were floods and droughts. There is no escape from the fact that the

need and demand for finite and vulnerable water will continue to expand and so will competition for it. More uncertainty in water availability, higher frequency of extreme weather events, and more rapid return flows of water to the atmosphere are expected in the future. Given the changes in the hydrologic cycle as a result of land use and climate changes and the closed character of many basins, allocations to, and patterns of future water use, will deviate from past trends.

Research is needed to better understand how these complex interactions may develop over the coming decades and the associated social, political, and environmental implications. Clearly, water issues will become even more important in the lives and activities of people (*Cosgrove and Rijsberman, 2000*).

Given today's accelerated pace of technological development and the slow pace of social developments, it seems likely that the biggest issue or constraint in the future will remain what it is today: namely the human component of water management, not the technical one. Improving our governance policies and procedures takes even more time than obtaining the funding needed to improve our infrastructure systems. This time lag is especially troubling given the consequences of not meeting the world's demands for water (*IFPRI, 2009, 2010, 2012*).

Achieving effective water governance involves a wide range of issues that have been studied by many investigators. One proposed way of achieving improved water management is the implementation of integrated water resources management (IWRM). This has been defined as "a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner, without compromising the sustainability of vital ecosystems" (*Global Water Partnership, 2000*). As is the concept of sustainability, IWRM is more of a goal, than of the achievement of a given set of criteria.

Information on IWRM is limited and it is even less accessible to partners in the developing world. Obtaining new skills requires improved access to information, sharing capacity (e.g., as when trainees become trainers) and its application. Information materials, training materials, knowledgeable capacity builders and experts are part of the inputs to a capacity building program, and online platforms of open content education and training materials can help facilitate these processes. This is particularly the case with IWRM, which requires a cycle of responsiveness to capacity development needs coming from different target groups around the world, along with and adaptive knowledge management systems. *OECD (2011)* recognized that integrated water resources management as adopted by many countries cannot be properly implemented without considering a broader governance framework. This would include not only sustainable water policies but also measures governing scientific, educational, and technological issues, as well as communication and participation *(Carr et al., 2012)*.

Humans have difficulty dealing with future water problems, particularly at a global level. This is illustrated by the slow evolution of the positions adopted by international organizations at an international level. Two decades ago, water was not even an issue discussed in the final declaration of the UN Conference on Environment and Development held in Rio de Janeiro in 1992 (*United Nations, 1992*).

Water only started to be considered as a crucial element of sustainable development since 1998, when the UN Commission on Sustainable Development adopted the text "Strategic Approaches to Freshwater Management" (*UN, 1998*).

Recently, the concept of effective water governance has grown in importance and has led to the widening of the water agenda, so as to include the consideration of social and political institutions and processes, corruption, and power imbalances between poor and rich countries and between rich and poor peoples.

Roof top gardening : The roof top gardening is a growing approach for the modern age NRM. Increasing literature on rooftop gardens refers to the importance of these spaces in the context of urban consumption. Urban gardens on rooftops are part of a range of different systems in urban areas such as plots on public land assigned to individuals or families, community gardens in abandoned and/or vacant areas and individual or common gardens in either yards, balconies and the rooftops of buildings *(Orsini et al. 2016)*. Furthermore, in countries such as South Africa or the United States, limited urban space and poverty have been the reasons behind rooftop projects where the growing of vegetables provides inexpensive food to building locals (*Lt. Governor Simon Awards, 2012; Johannesburg Rooftop, 2015*). Meanwhile, a number of research

papers argue that the rate of urbanization is increasing over time and that food production sites should be increasingly located near main consumption centres *(Orsini et al. 2016).*The concept of ecological citizenship uses the metaphor of 'ecological footprint' in which people are responsible for taking up a certain amount of ecological 'space' (both for resource use and capacity burden), expressed as a personal footprint left on the Earth. Rooftop gardens for urban consumption are also sites for collaboration between artists and community in the growing of food. In some instances, the creative structural elements of the garden are designed and built by local artists using recycled and reclaimed materials, while the sharing of knowledge on how to grow food is seen to have an educational and community impact as a result of spaces that bring people together and teach them about production systems. Rooftop gardens producing food, on institutional and office buildings in higher density developments have notably been the particular focus of research on urban agriculture within built environments. Integrating rooftop gardens in urban developments could provide significant social, environmental and economic values for the users and urban residents. Unused roof spaces in such structures are utilized effectively to recreate meaningful and easily accessible places for users while regenerating ecologies of lost green open spaces successfully within denser urban environments. Rooftop gardens in institutional and office buildings are seen to create places where people engage in different ways in various activities enhancing place making. People from different socio-economic backgrounds work together in a social networking space growing food to improve community engagement. Even viewing a roof with green grass for forty seconds could enrich mental concentration as found in the University of Melbourne, Australia study *(Lee et al. 2015).*Urban design theories highlight that image ability of a city is primarily cognitive and is based on peoples' perception, reasoning and rational thinking *(Lynch, 1960)*. Responsive design of physical environments could affect people's choices for seven different qualitative aspects of built environments.

So, as the reviews are indicating, roof top gardening can be a wonderful and creative measure for natural resource management, but it has some definite constrains particularly in Indian context. It can be done for aesthetic purpose or kitchen gardening. For large scale cultivation, this technique has surely a long way of improvement.

Environmental Stewardship : The Environmental stewardship is also a very good approach now a day. Resilience-Based Ecosystem Stewardship emphasises resilience as a basic feature of the changing world as well as ecosystems that provide a suite of ecosystem services rather than a single resource, and stewardship that recognises resource managers as an integral part of the systems they manage. This approach is very simple and easy. Anybody can be an environmental steward by being aware and knowledgeable of the world around them and making sure they do as little as possible to negatively impact our world (*National Research Council, 2008*). Without these groups it would be hard to get any sort of sustainability in our increasingly industrially based world. With biocultural conservation perspective, *Ricardo Rozzi and collaborators (2015)* have proposed participatory intercultural approaches to Earth Stewardship which call attention from the south of the Americas to the potential that Long-Term Socio-Ecological Research (LTSER) sites have to coordinate heterogeneous local initiatives with global networking to implement bio culturally diverse forms of earth stewardship.

Role of Agricultural Extension and Advisory services in NRM following the Agricultural Innovation System approach : The Agriculture Innovation System (AIS) is "a network of organisations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organisation into economic use, together with the institutions and policies that affect their behaviour and performance," (*World Bank, 2006*) that is, the way different agents interact, share, access, exchange and use knowledge. The AIS approach emphasises the need to consider and create interactions throughout the entire value chain including beyond the farm gate. The AIS therefore includes people, linkages, infrastructure and institutions *(Klerx, 2015).*

For successful AIS system A common language six aspects are important, those are A shared vision, Clarity about costs and benefits, Support for collaboration, Processes for managing conflict and allow the network to develop with a balance of open interaction, and Opportunities to develop trust (*Agricultures, 2016*). The modern age agricultural extension is basically focuses on the approach of maximum output from a minimum input. To use every drop of water, to squeeze every particle of fertilizer and to exploit the nature as less as one could, is the first and

foremost objective of today's extension. There are some of the extension approaches for doing agriculture sustainably and to use the natural resource minimally. The key role players for natural resource management following AIS method are FPOs, AKSTs, Rural organizations, Farmers' organization etc.

*The continuous depletion of natural resources :*The total cultivable area in India is 1,945,355 km² (56.78% of it total land area), which is shrinking due to population pressures and rapid urbanisation. India has a total water surface area of 360,400 km². India's major mineral resources include Coal (4th largest reserves in the world), Iron ore, Manganese ore (*7th largest reserve in the world, 2013*) (*Indian Express, 2013*) Mica, Bauxite (*5th largest reserve in the world, 2013*), (*Reuters, USA, 2013*) Chromite, Natural gas, Diamonds, Limestone and Thorium. India's oil reserves, found in Bombay High off the coast of Maharashtra, Gujarat, Rajasthan and in eastern Assam meet 25 per cent of the country's demand (*Datt, Bhojani, Sundaram, 2007*)

A national level agency National Natural Resources Management System (NNRMS) was established in 1983 for integrated natural resources management in the country. It is supported by Planning Commission (India) and Department of Space, *2013*). India's land area includes regions with high rainfall to dry deserts, coastline to mountainous regions. Around 24.02 percent of the total geographical area consists of forests. Due to variations in climatic conditions and differences in altitude, different types of forest are present in India including tropical, swamp, mangrove and alpine. Forests are the main source of firewood, paper, spices, drugs, herbs, gums and more. Forests contribute a significant amount to the nation's GDP (*Planning commission, GoI,2018*). Growth doesn't always come at a price. But it did when it comes to India's economic growth, which took a toll on its natural assets like forests, food, clean air, etc. A report on environment accounts released by the Ministry of Statistics and Programme Implementation has revealed this state. In fact, it says that when the average growth rate of gross state domestic product (GSDP) during 2005-15 for almost all the states was around 7-8 per cent, 11 states registered a decline in their natural capital. While 13 states showed a marginal growth in the range 0-5 per cent, just three states saw their natural capital increase by more than 5 per cent. This model of economic growth may not let the country sustain the rate of development for long. Monitoring the natural capital is important and should be one of the determiners for sustainable development, says the report. The natural capital are those elements of the nature that provide valuable goods and services to humans, such as the stock of forests, food, clean air, water, land, minerals, etc. The natural capital accounting (NCA) method has been used, in this report, to account for income and costs associated with natural resource used, based on a framework approved by the United Nations in 2012 called the System of Environmental Economic Accounts (SEEA). The report also reveals few positive trends. For example, Andhra Pradesh, Gujarat, Jharkhand, Kerala, Maharashtra and Odisha show an increase in parameters such as transition of fallow land to farmland, increase in forest cover along with growing carbon stock and new sources of minerals. It, however, shows alarming effects of climate change, urbanisation and decline in forest resource.

Climate change has had a huge impact on water resources. The report shows a 24 per cent decline in the area under snow and glacier in some states and also notes the impact of climate change on wetlands/ water bodies in Himachal Pradesh, Sikkim and Jammu Kashmir. Moreover, unsustainable extraction of groundwater resources for agriculture and consumption purpose is causing a decline in the water levels in Tamil Nadu, Chhattisgarh, Goa, Odisha and Rajasthan. Down to Earth's State of India's Environment 2018 – In figures had talked about increasing dependency and unsustainable use of groundwater resources. It had revealed that in 2013, the country used 62 per cent of the net available annual groundwater, which is a 58 per cent increase from 2004. Now as far as the forests are concerned in the last 6 years, the rate of growth of forest stock has reduced by more than 10% in almost all states. From 2006-07 to 2010-11, all states, except Goa and Sikkim, have shown such a decline. However, from 2010-11 to 2015-16, even though there was a marginal change in forest cover in Assam and Uttarakhand, growing stock has reduced by more than 10 per cent. But in the case of Jharkhand, Madhya Pradesh, Maharashtra and Rajasthan, despite a marginal change in forest cover, growing stock has significantly increased by more than 10 per cent. In the northeast, total growing stock has decreased from 1122.12 million cubic metres (cum) in 2006-07 to 958.34 million cum in 2015-16. Arunachal Pradesh and Assam, which

contribute around 58 per cent of growing stock in the northeast, have shown a significant reduction in growing stock within the forest. The country is dependent on imports wood and wood products to fulfil its domestic demand. So the growing stock is a crucial forest resource, the decline of which may be a harbinger of trouble for the economy.

Exploitation of natural resources for agriculture : In recent times the agricultural production is stagnating and factor productivity is declining due to degradation of natural resources; increasing biotic and abiotic stresses; poor seed replacement rate; damage to natural ecosystem resulting in excessive and indiscriminate use of pesticides/ fungicides; changing soil microbial dynamism; unavailability of suitable and quality germplasm; lack of low input-highly profitable concept of technologies and lack of holistic approaches to address the problems .To tackle such problems particularly in tropical islands where the resources are limited, farming system approach has been widely recognized and has been in practice as one of the tool for harmonious use of inputs and their compounded response to make the production system sustainable. Integrated farming system consists of a range of resource-saving practices that aim to achieve acceptable profits and high and sustained levels of production, while lessening negative impacts of intensive farming and preserving the environment which are highly necessary in island ecosystem. It integrates various agricultural enterprises, viz. cropping, animal husbandry, fishery, forestry and horticultural crops to obtain higher farm productivity and lowering risk factors to attain sustainable agriculture. The IFS system is very useful approach to mitigate the impact of abiotic stresses through resource recycling and diversification. In the tropical islands agriculture is prone to biotic and abiotic stresses and natural disasters, therefore, IFS approach is followed to provide stability and sustainability to the production system.

Coconut, areca nut, black pepper and tree spices are important plantation crops in these islands. The coconut based farming systems involving cultivation of compatible crops in the inter spaces of coconut and its integration with other enterprises such as dairy, poultry etc. leads to considerable increase in production and productivity per unit area, by more efficient utilisation of sun light, soil, water and labour. For example, in hilly areas of tropical islands plantation based farming systems involving crop + dairy + backyard poultry found to increase the production and productivity of the farm. Growing of spices including black pepper, clove as intercrop in plantation is the best possible option for such areas. Similarly in the medium upland areas of Andaman and Nicobar islands plantations are intercropped with banana and pineapple. Soil erosion, poor water retention and low soil fertility are common. Little modification of the existing cropping system and integration of components such as dairy + poultry + fish or dairy + goat + poultry + fish along with crops gave an additional net income of about USD 1700 and employment generation of 198 man days/ha/year.

Recommendations: From the above discussion and discourses, we can bring forth some recommendations that would be suitable for the policy maker and concerned authorities to put forward-

- Mobilization of local people for NRM that is formation of community task force for mitigated and optimum use of natural resources.
- Continuous monitoring, auditing and stewardship at the local level for successful NRM.
- Creation of the data base on NRM through both participatory and non-participatory method. For example- data base on local water bodies, local bio diversities, local tribal communities etc.
- PBR (people's biodiversity registrar) can be and should be maintained by the local authorities to compare and cognate the gradual changes.
- Creation of "climate managers", biodiversity, water and livestock stewardship at community level.
- Creation of the community gene bank for the maintenance and protection of both crop and livestock bio diversity.
- Inventorization of indigenous technical knowledge, indigenous technical wisdom, traditional practices and praxis for managing natural resources in a sustainable and effective manner.
- Community centred decentralized planning involving panchayats, local NGOs, schools and local governing bodies.
- Promulgation of both micro and macro level policies for the protection, regeneration and re discovery of bio diversity including restoration of hidden and lost lineages.

· Application and executions of community based land scape management and community based natural resource management with the application of PRA and PLA tools and techniques.

CONCLUSION

Civilisation germinates out of natural resources, mentored by good earth and being destroyed by 'Wrong Civilization'. We the people are the saviour and have to be the saviour of resources gifted by nature, but with a condition, conserve it, use it and regenerate it!

NRM has got both methodological and operational approach. Conservation agriculture can be one of such approaches; while others are natural farming, landscape management, stewardship to save and procreate and, of course, leveraging ecological resilience. If we remain stoic in containing soil erosion, refraining water pollution and regenerating floral and faunal diversity, we have to face the untimely apocalypses.

While we remain busy to produce 75 per cent our food out of 20 species only and 80 per cent of animal source of protein from only 30 animal species, we no longer remain happy with allowing humongous erosion of biodiversity. Every year 16 tons of top soils are eroded from one ha. of land , then it's no wonder that our national food production has been swinging around 275 (+/-) 15 million tonnes with a sultry inelasticity to offer our food security a kind of policy claustrophobia So, we have to go, not by choice, but by compulsion, to our good earth by natural resource management, in case a day's delay may claim few more thousands diversity and destiny both.

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