

*Full Length Research*

# Natural Resource Conservation and Management: Role of Microbiology and Biotechnology Pathways

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The most relevant natural resources to the people are water, land, food, plants, animals, and soils. Natural resources may involve managerial activities such as controlling, preserving, and/or evaluating a natural resource or natural resources function, such as conservation, forest, rangeland, fisheries, and wildlife. Natural resources conservation and management professionals belong to engineering and allied background and have limited access and interactions with biologists. Modern natural resources management work requires knowledge and skill sufficient to interpret and apply biological science and research. Integrated natural resource management is a process of managing natural resources in a systematic way, which indulges multiple aspects of natural resource use (biophysical, socio-political, and economic) meet goals regarding production of producers and other direct users (e.g., food security, profitability, risk aversion) as well as goals of the wider community (e.g., poverty alleviation, welfare of future generations, environmental conservation). Poverty plays a highly important role in degrading the natural resources base and without poverty alleviation, it is hard to think of sustainable natural resources management in the world as well as in India. While poverty alleviation and sustainable NRM are generally compatible, difficult trade-offs may occur at several times. Nevertheless, the fact remains that without poverty alleviation, the environment in developing countries will continue to degrade, and without better NRM, poverty alleviation will be undermined. Microbiology and Biotechnology have some very promising advanced solutions for many NRM related conservation and management works which are almost impossible through the engineering methods. This review is specifically an effort to educate the NRM professionals for adoption and better synergy between both the disciplines for easing out some of the most gruesome problems relating NRM through biotechnological processes and pathways.

**Keywords:** Biodiversity, Biotechnology, Conservation, Ecology, Environment, Management, Microbiology, Natural Resources

Natural Resources Management deals with the sustainable utilization of major natural resources, such as land, water, air, minerals, forests, fisheries, and flora and fauna present on the planet. Together, these resources provide the ecosystem services that are responsible for human life on this planet (FAO, 2011). Natural Resource Management (NRM) is an integrated and multidisciplinary approach combining Earth-Science, Life-Science, Environmental Science, Social Science and Management Science to manage and restore natural resources and ecosystems. Natural Resource Management sustains and restores degraded resources within agricultural, wilderness, forestry, recreational, rural and urban areas (Lamb, 2005; Moreno-Mateos et al., 2010). Natural Resource Management helps to balance the needs of people and the economy with protecting the ability of ecosystems to support soil, water, forests, wildlife, fish, recreation, and other resources (Santon and Rawls, 2006; Ziegler et al., 2011; Zucca et al., 2014).

The natural-resources base in the world as well as in our country has come under heavy pressure from increasing population and higher levels of per-capita economic activity. During the period 50 years (1990 to 2030) the world's population is likely to grow by 3.8 billion. About 90% of this increase will occur in developing countries (Dubois, 2011). Over the next few decades Sub-Saharan Africa's population is expected to touch a rise in population from 500 million to 1.4 billion while as Asia's from 3.1 billion to 5.1 billion, Latin America from 450 million to 750 million and India from 130 million to 150 million. The distribution of people between rural and urban areas has important implications for the types of stress placed on the environment. In 1990 most people lived in rural areas, but by 2030 the urban population in India is expected to be twice the size of the rural population. Developing countries and cities, as a group, are expected to grow by 160% over the period, whereas rural populations will grow by only 10% (Bolwig, 2002).

Integrated natural resource management is a process of managing natural resources in a systematic way, which indulges multiple aspects of natural resource use (biophysical, socio-political, and economic) meet goals regarding production of producers and other direct users (e.g., food security, profitability, risk aversion) as well as goals of the wider community (e.g., poverty alleviation, welfare of future generations, environmental conservation) (Rey, 2005). It focuses on sustainability and at the same time tries to incorporate all possible stakeholders from the planning level itself, reducing possible future conflicts (Bravo and Silenzi 2002; Chirwa, 2014). Poverty plays a highly important role in

degrading the natural resources base and without poverty alleviation, it is hard to think of sustainable natural resources management in the world as well as in India. While poverty alleviation and sustainable NRM are generally compatible, difficult trade-offs may occur at several times. Nevertheless, the fact remains that without poverty alleviation, the environment in developing countries will continue to degrade, and without better NRM, poverty alleviation will be undermined.

## NATURAL RESOURCES MANAGEMENT

The natural resources that are most relevant to the people are water, land, food, plants, animals, and soils. Natural resources work may involve administrative or managerial duties, such as controlling, preserving, and/or evaluating a natural resource or natural resources function, such as conservation, forest, rangeland, fisheries, and wildlife (Lamb et al., 2005). The work may have specific geographic boundaries (for example, management of a national wildlife refuge). The natural resources management work requires knowledge and skill sufficient to interpret and apply biological science and research (Grande et al., 2005). The work further requires knowledge of one or more of the following: 1) management concepts, principles, and practices; 2) biological, agricultural, natural, and pertinent aspects of social, behavioral, cultural, and economic sciences; 3) theories, concepts, and practices of conserving, utilizing, and sustaining natural, physical, and cultural resources of forests and associated land and water; 4) fire ecology; and 5) public recreational needs in terms of cultural, sociological, educational, and historical factors. Examples of this type of NRM related works are: 1) protecting sensitive habitats; 2) • managing wildlife and fisheries; 3) protecting threatened and endangered species and sensitive plants; 4) managing wildland fire programs; 5) managing recreation programs; and 6) managing forests; 7) ensuring that activities on public land, such as hunting and boating are conducted in accordance with applicable laws; 8) developing environmental reports and impact statements; 9) developing and implementing land use plans; 10) identifying problems associated with public and private land use, such as mining and drilling operations, utility corridors, road and highway development, or telecommunications facilities; 11) managing and issuing permits; 12) monitoring construction, production, and reclamation activities to ensure compliance with environmental plans and stipulations; 13) coordinating the surveying, monitoring, analyzing, and evaluating of

natural resources to permit multiple land uses while preserving the area's ecological viability; 14) managing special areas, such as Congressionally designated wilderness, wild and scenic rivers, national recreation areas, and national scenic trails; and 15) preparing or advising on natural resources regulations and guidance; respectively.

## RISK HAZZARD MITIGATION

Apart from normal activities related to NRM, there are some very important Risk Hazzard Mitigation and Management which erupt all of a sudden and engulfed unaware population resulting into heavy casualties. Such significant natural resources management functions are; flood management, drought management, earth quake management, forest fire management, fire program management, land slide and mass wastage, land slips and rock slippages, and recreation management (Bai, 2008). The world, including India almost annually faces one of the most severe fire hazards that need concerted efforts for its prevention, control and sustainable management. Fire management program involves advising on, administering, supervising, or performing professional fire management work (Benayas et al., 2009). In addition to a foundation knowledge in the biological and natural sciences, this work requires knowledge of fire behavior, firefighting techniques, and wild land fire management theories, concepts, principles, and standards. For example, the most typical fire program management activities are:

- assessing actual and potential fire effects on riparian areas, soil erosion, air quality, wildlife habitats, and cultural, commercial, and recreational resources;
- protecting and restoring ecosystems from fires;
- developing incident management strategies and tactics;
- developing fire management plans;
- implementing prescribed fire or fire use plans;
- conducting field inspections before and after fires;
- planning and coordinating fire protection programs and fire responses with other Federal agencies, state and local agencies, and private commercial interests; and
- analyzing the ecological role of fires in fire protection programs. Recreation management involves advising on, administering, supervising,

## NATURAL RESOURCES MANAGEMENT FOR RECREATION

The recreation management involves advising on, administering, supervising, or performing

professional recreation work (Barrett-Lennard, 2002). Typical recreation management activities are:

- assessing the effect of recreation on wilderness, timber, range, soils, water, and wildlife;
- assessing recreational use compatibility with commercial activities, such as mining, surface mineral excavation, and grazing;
- balancing competing public and private goals for recreational development, commercial development, and natural resources preservation;
- planning and managing appropriate public access and facilities for recreation opportunities, while sustaining natural resources values;
- correcting damage caused by overused or unplanned recreation; and
- guiding public recreation users on natural resources values and responsibility for land stewardship. Advisory Services – Both biological science and natural resources management functions may involve advising agency management, other scientists and professionals, and the public on natural resources matters.

## EMERGING TRENDS IN AGRICULTURE AND NATURAL RESOURCES MANAGEMENT GLOBAL PERSPECTIVE

Historically, the agricultural sector has been the driving force of economic growth in India. In low-income countries like India, production of food, fiber, and animals typically employs three-quarters of the labor force, contributes half of the net national product, absorbs two-fifths of capital formation, and generates three-fifths of exports (including manufactured agricultural products). These characteristics not only reflect both the importance of agriculture in the total economic life in our country, but also indicate the relatively modest level of economic development our country has achieved (Abrol et al., 1988; Navado et al., 2020)). A combination of improved incentives and policies, reinvigorated institutions, and increased investments must occur if agriculture is to develop and the benefits are to be spread widely. However, without improved technologies, practices, and policies, few development programs will move very far or have lasting effect (Jackson et al., 2007). Improved technologies, adapted to farmer needs, capabilities and profitability, are a necessary condition for agricultural and rural development as the Green Revolution, which revolutionized agriculture in India. The formulation of the Millennium Development Goals, building on the Rome Declaration of the World Food Summit, 7 takes as its first objective the alleviation of poverty and of hunger. It

would be a world where every person has access to sufficient food to sustain a healthy and productive life, where malnutrition is absent, and where food originates from efficient, effective, and low-cost food systems that are compatible with the sustainable use of natural resources. In the developing worlds, approximately 800 million people — about one person in six — remain undernourished (Altieri, 2004). It is estimated that about half of the world's hungry people are from smallholder farming communities, another 20 % are rural landless, about 10 % live in communities whose livelihoods depend upon herding, fishing, or forest resources, and the remaining 20 % live in cities. Within these communities, hunger disproportionately affects the most vulnerable groups, including children under the age of five, women of childbearing age, and mothers of babies, the sick, and the disabled (Yanoh et al., 2004).

### **NATIONAL PERSPECTIVE**

Close to two third of all our lands are under some form of degradation be it water, soil, vegetation or environmental. The situation is likely to worsen in days to come as our rate of population growth is close to 2.4 % per annum. The population from 50 million in 1950 has swelled to 1.3 billion people and if we may include unaccounted population, we are already close to 150 million people or 1.5 billion. In order to fulfill the demands of such burgeoning population of all kinds including safe and clean drinking water apart from traditional solutions we have to search for modern solutions for all purposes and biotechnology can help us immensely in this regard.

### **BIOTECHNOLOGY PATHWAYS AND PROTOCOLS IN NATURAL RESOURCES CONSERVATION AND MANAGEMENT**

Biotechnology is technology that utilizes biological systems, living organisms or parts of this to develop or create different products". Brewing and baking bread are examples of processes that fall within the concept of biotechnology (use of yeast (= living organism) to produce the desired product). Such traditional processes usually utilize the living organisms in their natural form (or further developed by breeding), while the more modern form of biotechnology will generally involve a more advanced modification of the biological system or organism. With the development of genetic engineering in the 1970s, research in

biotechnology (and other related areas such as medicine, biology etc.) developed rapidly because of the new possibility to make changes in the organisms' genetic material (DNA). Today, biotechnology covers many different disciplines (eg. genetics, biochemistry, molecular biology, etc.). New technologies and products are developed every year within the areas of eg. medicine (development of new medicines and therapies), agriculture (development of genetically modified plants, biofuels, biological treatment) or industrial biotechnology (production of chemicals, paper, textiles and food).

### **ADVANCED BIOTECHNOLOGICAL TOOLS AND TECHNOLOGIES FOR NRM**

Biological science attempts to understand the processes of living matter in all forms, but especially its origin, growth, structure, and function. Biological scientists study living organisms and their relationship to their environment. The studies provide insight into life processes and transitions, problems of living matter as they relate to human issues, and preserving and repairing the natural environment. The work may involve research and development, regulatory activities, testing and analysis of laboratory samples, or a combination of all of these activities. Research and development involve extending the body of scientific knowledge. Biological scientists plan and conduct research experiments using cells, laboratory animals, or greenhouse plants. Typical areas of experiments may involve:

- analyzing the structure and function of cells and tissues;
- isolating and characterizing viruses, parasites, bacteria, and fungi;
- clarifying the role of nutrition in blindness and visual impairment;
- identifying species based on anatomy, physiology, and behavior;
- investigating the relationships of life cycles and habitat requirements of vertebrates; and
- analyzing changes in forest biomass and health.

### **MICROBIOLOGY AND BIOTECHNOLOGY IN AGRICULTURE AND NATURAL RESOURCE BASE PROTECTION AND MANAGEMENT**

Biotechnology holds great promise for increasing yields (near term) and yield potential (longer term), especially under conditions of stress – both abiotic (including drought, water logging, soil acidity, salinity,

and extreme temperatures) and biotic (pests and diseases). Wider use of biotech based genetically modified crops largely depends on the development of technologies that specifically meet farmer needs in the regions. Where such technologies have been available, adoption has been rapid (e.g., Bt cotton in Asia, Roundup Ready Soybean in Brazil). However, use of genetically modified varieties in most of the regions will also depend on the development of appropriate regulatory capacity by the public sector to address food safety and environmental issues. Investment in technology appropriate for farmers and the establishment of effective, science-based regulatory capacity in the same regions and countries are closely linked.

Without functioning regulatory systems, the private sector is unlikely to invest in developing crops appropriate for developing countries. Yet without compelling technology being available, countries may find little internal demand for access by farmers or for development of related regulatory activity. Hence both areas of investment are important. Effective intellectual property regimes are important for any long-term investment, whether for internal innovations or in relation to those originating outside a country. Regional cooperation in intellectual property and biosafety has great potential for simplifying both technology access and agricultural trade. Nanotechnologies A new area is the development and application of nanotechnologies to agriculture and NRM. Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular, and macromolecular scales; Nanotechnologies are the design, characterization, production, and application of structures, devices, and systems at this level. They are being increasingly utilized in water treatment, energy storage, food processing and storage, vector and pest detection and control, agricultural productivity enhancement, and improving environmental management.

#### **POST HARVEST, VALUE ADDITION, FOOD QUALITY, PROCESSING AND FOOD SAFETY**

The main focus is on increasing the knowledge of food raw materials, understanding processes taking place in food raw materials and how these influences the quality and stability of the food products. Main research themes are given below:

- Marine lipids
- Proteins and peptides
- Biopolymers
- Metabolites and pigments

- Shelf life and quality of raw materials and products
- Quality changes through processing, main focus on seafood
- Food safety
- Biofilms
- Development of hygienic processing equipment
- Rest raw materials
- New raw materials (e.g little utilized resources (LUR) included seaweed)

#### **SUSTAINABILITY WITHIN THE FOOD VALUE-CHAIN DEPENDS UPON**

- Analysis and determination of the metabolic profiles of agricultural and industry relevant processes such as: food storage, food processing, animal health, bio-prospecting, plant biomass processing, byproduct reuse, waste water purification.
- The main focus of the lab is to determine how to best preserve the original quality of a product and to support the industry in finding novel use of bio-active compounds in various biological sources. Our lab is involved in several EU projects and within them we develop new protocols and analyses milk (raw, processed and milk industry waste), food industry waste (fish, beer, meat, sugar) and agricultural weeds.

#### **RESTORATION AND REJUVENATION OF DEGRADED/AGRICULTURAL LAND**

Restoration of agricultural land is important for sustainability of agriculture and environment. Land is under immense pressure due to ever increasing population thereby ensuing growing demand for food, fiber and shelter. Agricultural land is being deteriorated due to different anthropogenic and natural factors. The basic factors causing soil erosion-induced degradation are wind and water erosion. Acidification, compaction and salinization are some other causes of agricultural land degradation. The main causes of erosion on agricultural land are intensive cultivation, overgrazing, poor management of arable soils and deforestation. Restoration of eroded agricultural land is achieved through several agronomic and biological techniques. Crop rotations, agro-forestry, reduced tillage, cover crops, vegetative filter strips, residue, and no-till are important among these. Biological measures such as buffers, conditioner application in direct contact with the soil surface, crop residues using manure protect the soil from erosion. Restoration of saline agricultural land can be achieved through recharge stabilization and

reconstruction of saline land through fencing, retain remnant vegetation, revegetation, runoff interception earthworks, and water table lowering.

### **BIOTECHNOLOGY FOR ADDRESSING CAUSE AND EFFECT RELATIONSHIPS**

For every effect of degradation, there is an underlying cause. To restore degraded land the cause of the degradation must be identified and addressed. Agricultural land is unstable if the degrading influences are still active, as the condition of the land will continue to decline. For example, fencing off and planting trees in a dieback will not ultimately restore the health of the vegetation if the tree death is resulting from salinity or a lack of flooding. The fencing and revegetation may slow the rate of decline, but the site will be unstable and continue to degrade until the water management issues are addressed.

### **SITE STABILIZATION**

Once you know where to target your efforts, the degraded land should be stabilized by implementing action to remove the degrading influences. Removing the degrading influences help to reduce the rate of decline in condition at the site, and it can also initiate immediate improvement. However, stopping the active degradation will not necessarily restore a degraded land to its former condition. For instance, a clay pan caused by overgrazing will still be very slow to recover if it is fenced to exclude stock (Tiessen et al., 1994). In situations like this, additional work is required to fully restore the degraded land. Stabilization is the minimum level of restoration that should be undertaken in any degrading landscape to prevent the situation from becoming worse.

### **TREATMENT FOR RESTORATION OF SPOILED WATER BODIES**

Many rivers, estuaries, lakes, ponds and other water bodies across the globe are victims of urbanization and are polluted beyond their self-recovery capacity. (Nawada et al., 2020a; 2020b) Uncontrolled dumping of garbage, debris and sewage into water bodies leads to an influx of various pollutants including organic compounds, phosphates and nitrates, thereby adversely impacting the water quality. These pollutants lead to eutrophication of ponds and lakes by boosting growth of

algae and undesirable weeds like water hyacinth. Excessive algal growth, in turn, interferes with penetration of light and also leads to reduced dissolved oxygen levels in water bodies, thereby hampering the growth of other aquatic organisms and disruption of the balance of the aquatic ecosystem. Due to reduced dissolved oxygen, anaerobic degradation of organic matter takes place, which leads to the production of foul-smelling gases like ammonia and hydrogen sulphide, causing odour issues in the vicinity (Navada et al., 2020b).

### **BIOTECH SOLUTIONS FOR MANAGING THE CLEAN WATER CRISIS**

About a billion people lack enough water to meet their basic health and agricultural needs. Water-borne diseases cause nearly half of hospitalizations globally and kill millions each year. Aquifers around the world are being depleted. The lack of clean water fuels conflicts and threatens economic growth from California to the Middle East. As peak oil fears fade, water has emerged as the next resource crisis (Nawada et al., 2020b, Nawada et al., 2020c). While water supplies have always been huge, the cost to purify water (including waste and sea water) is too high to help the areas that need it most. Based on the extent of pollution, source of pollutants and other project-specific considerations, a tailored approach is followed to restore water bodies by a combination of the following processes:

- **Diversion and treatment of sewage:** To protect water bodies from deterioration due to ingress of untreated and poorly managed sewage streams, systematic diversion systems and sewage treatment plants are set up.
- **Physical cleaning of the water body:** It involves the removal of weeds and floating solid waste either through manual or mechanical means. In cases where it is desirable to augment the water holding capacity, mechanical desilting operation is also carried out.
- **Aeration:** Surface aerators, submerged aerators or a combination of both may be used to increase the dissolved oxygen in the water, which is used by microorganisms to degrade the pollutants. Aeration also aids in mixing the different thermal layers of the water body, resulting in destratification, exposing the lowermost layers to atmospheric air. The need and extent of aeration is calculated based on the water quality parameters, depth of water body, ambient temperatures, wind conditions etc.
- **Application of bio-product (bio-augmentation):** Concentration and frequency of dosing

of the microbial cultures is decided based on the volume of the water body, water quality parameters, ambient temperatures and extent of algal growth.

- **Continuous monitoring of water quality parameters:** Effwa's floating monitoring stations equipped with multi-parameter analysers are employed for uninterrupted scrutiny of the water quality.
- **Beautification of surrounding areas:** Development and beautification of the waterfront encourages recreational activities and enhances tourism.

### Phytoremediation to Clean the Water Instead of Chemicals

One of the biggest risks involved in environmental clean-up tasks is the threat of unintended consequences. Often, the addition of synthetic chemicals intended to neutralize or prevent the spread of contaminants results in crucial elements of the biological web being negatively affected, sometimes severely. In almost every case, natural clean-up processes provide a practical way to eliminate the threat of negative side effects. This is the inspiration behind BioHaven Floating Islands which utilize nature to deal with contamination. Biological activity and plant uptake clean the water instead of chemicals.

### Floating Island Science – Hydroponic Phytoremediation to Reduce Phosphorus and Nitrogen

How do BioHaven Floating Islands clean water? The scientific term for the process is called *hydroponic phytoremediation*. In plain English, phytoremediation is the use of plants to stabilize and reduce contamination in a variety of substrates, including soils, sludge, sediments, and water. On the other hand, hydroponics is a method of growing plants in solutions of water. (In the case of floating islands, the plant roots grow down through the planting holes that have some soil and peat. The roots push through the planting holes and matrix to hang down into the water.)

### ADDRESSING THE ENVIRONMENTAL HEALTH AND RECONSTRUCTION

Following stabilization and the removal of the degrading influences, works can be undertaken to restore the land to the desired condition. This is the environmental reconstruction stage. The extent and nature of the reconstruction works will depend on what you are trying to achieve for the site. Most restoration

projects will aim to achieve one of the following objectives:

- Improve agricultural production.
- Reconstruct natural environment and ecosystem.
- Partial restoration for a mix of production and environmental benefits

The extent of restoration will also depend on the resources available to commit to the project. In reconstructing a natural environment or ecosystem you should find out what the land, vegetation and habitat characteristics were like before degradation. This can be done by referencing similar vegetation communities and soil landscapes that are in good condition.

### MONITORING THE ENVIRONMENT AND ECOLOGICAL IMPACTS

For any restoration project, it is important that monitoring is undertaken to ensure that the degraded site is stabilized and improving in condition and that no new degradation is occurring.

### RESTORATION TECHNIQUES FOR WASTE LANDS AND SERIOUSLY POLLUTED AGRICULTURAL LAND

The self-reinforcing soil degradation process is strongly exacerbated by the interaction between processes, factors and causes of soil degradation. Processes include the mechanisms of soil degradation. Factors comprise agents of degradation related to natural or anthropogenic drivers such as climate, physiography, socio-economic or cultural parameters. Causes of soil degradation include specific activities which aggravate the adverse effects of processes and factors. Examples of specific causes include activities such as deforestation, land use conversion, extractive farming practices or over-exploitation, excessive grazing, excessive plowing among others. The process-factor-cause nexus is strongly impacted by site-specific conditions. Thus, understanding the nexus or connectivity is critical to restoring soil quality and mitigating degradation. One of the most powerful approaches to countering the negative impacts of agricultural expansion and intensification is ecological restoration. Ecological restoration aims to recover the characteristics of an ecosystem, such as its biodiversity and functions, which have been degraded, generally as a result of human activities.

## **RESTORATION OF PHYSICALLY ERODED AGRICULTURAL LAND**

Soil erosion is initiated when there is low vegetation cover on the soil surface. Wind erosion is the dominant force but water erosion can also cause significant degradation. Restoration of degraded agricultural land is achieved through several agronomic and biological techniques. Crop rotations, agro-forestry, reduced tillage, cover crops, vegetative filter strips, residue, canopy cover management and no-till are important among these. There are differences among these biological practices in relation to their mechanisms of restoration of agricultural land. Biological measures such as buffers, conditioner application in direct contact with the soil surface, crop residues using manure protect the soil from erosion. Using biotechnologically improved plant varieties; genetically engineered crops can restore the eroded lands quickly and effectively.

## **RESTORATION OF ECOSYSTEM SERVICES ON AGRICULTURAL LAND**

There is a range of possibilities to reverse the negative environmental impacts on agriculture land. Some of these options have the potential to both enhance biodiversity and ecosystem services including agricultural production, but others may enhance biodiversity and ecosystem services other than agricultural production. They can be considered within two major approaches:

### **LAND SHARING**

We can classify five types of intervention following this approach. Four involve extensive actions on agricultural land with a focus on productivity that is, making agriculture more wildlife friendly:

#### **A) ADOPTION OF BIODIVERSITY-BASED AGRICULTURAL PRACTICES:**

Conservation of existing biodiversity in agricultural landscapes and the adoption of biodiversity-based practices have been proposed as ways of improving the sustainability of agricultural production through greater reliance on ecological goods and services, and with less damaging effects on environmental quality and biodiversity (Jackson et al., 2007). Management of biodiversity, that is, the biota

dwelling in agroeco systems as well as habitats and species outside of farming systems in the landscape, can be used to benefit agricultural production and enhance ecosystem services. Examples of agrobiodiversity functioning at different hierarchical levels include the following:

- a) Genetic and population characteristics for example, the use of traditional varieties and wild species for continuing crop and livestock improvement for increased pest resistance, yield, and quality (Tisdell, 2003).
- b) Community assemblages that influence agricultural production, such as pest control based on toxin biosynthesis, crop mixtures, release of natural enemies, and pest suppression by a complex soil food web.
- c) Heterogeneity of biota in relation to biophysical processes within ecosystems, such as nutrient cycling and retention or carbon accumulation.
- d) Landscape-level interactions between agricultural and non-agricultural ecosystems that enhance resources for agriculture, and potentially, resilience during environmental change.

## **NATURAL RESOURCES CONSERVATION**

Agricultural biotechnology can have secondary effects that enhance natural resource conservation and protect the environment. By developing drought-tolerant crops, researchers can help farmers to conserve water resources. Crops that are genetically engineered to produce *Bt* toxin require less spraying of pesticides, and reduction in spraying reduces the potential environmental harm caused by pesticides. Agriculture accounts for more than 30 % of global greenhouse gas emissions (Badalucco et al., 2010); however, herbicide-resistant crops promote no-till cultivation practices which help to reduce soil erosion, emissions of greenhouse gases, and carbon loss (Battianao and Natare, 2000)

## **ECOLOGY AND ECOSYSTEM MANAGEMENT**

Ecosystem management that attempts to maximize a particular ecosystem service often results in substantial declines in the provision of other ecosystem services (Bergmeier et al., 2010) showed a positive relationship between biodiversity and provision of ecosystem services in restored versus degraded ecosystems in a wide variety of ecosystems. However, restoration of ecosystem services is not the same thing (Bullock et al., 2011). The restoration of degraded land. It is important to note that restoration of degraded agricultural land may require different techniques



depending on the agent of degradation and the restoration goals. For instance, techniques for restoration of eroded land may be different from those one would apply in restoration of saline land and the restoration techniques for purposes of increased agricultural production may be different those whose primary goal is to restore biodiversity and ecological services.

## **BIODIVERSITY CONSERVATION**

*Biodiversity* is a term used to describe the array of the world's species, the genetic variability in and among populations of a species, and the distribution of species among local habitats, ecosystems, landscapes, and whole continents or oceans. The number of naturally occurring species of plants and animals tends to be higher in many developing countries of the tropics than of industrialized countries of temperate climates. Preserving that biodiversity is important for maintaining the functioning of natural ecosystems, which provide part of the base of natural resources, such as water and pollinators, that supports such human activities as farming. Genes that confer resistance to diseases can often be found in the wild relatives of domesticated crops, and these genes may sometimes be used by conventional breeders and molecular breeders to enhance the characteristics of crops. The discovery of diversity in carbohydrate and carotenoid types in cassava is another example of finding valuable properties in plants that can improve human nutrition and health.

## **BIOTECHNOLOGY IN BIODIVERSITY CONSERVATION**

Biological diversity provides the variety of life on the Earth and can be defined as the variability among and between the living organisms and species of surrounding ecosystems and ecological complexes of their life support. It has been estimated that one third of the global plant species are threatened in different level according to the International Union of Conservation of Nature (IUCN). The major threat to rapid loss and extinction of genetic diversity due to habitat destruction, pollution, climate change, invasion of exotic species, human population pressure, ever increasing agricultural pressure and practices, life style change etc. are well-known. Biodiversity conservation is a global concern. All member states of the Convention on Biological Diversity (CBD) took measure to preserve both native and

agricultural biodiversity (Dwyer et al., 2010). The role of biodiversity in natural and managed ecosystems has multiple aspects. For example, some people may criticize industrialized models of agriculture and cited how genetically narrow monocultures place crops and agricultural systems at risk for devastation by disease. They advocate for more diverse agricultural production farming systems and greater genetic diversity in crops. Some may in turn suggest that applying new agricultural biotechnologies without disrupting the biodiversity in many developing countries presents a serious challenge (Noordjik et al., 2011). The capacity does not exist, they believe, to look critically at what may or may not be beneficial in particular settings. Several people express their concern about how the introduction of transgenic crops would affect gene flow, agricultural productivity, and the natural environment. Someone brings up the example of weedy rice, believed to be a natural hybrid of cultivated and wild rice species or a result of the de-domestication of cultivated rice. The flourishing of weedy rice in Thailand's central rice bowl reduced yields of cultivated rice, illustrating the risk of genetic exchange between cultivated and wild varieties and how they can have unpredictable outcomes. Because gene flow is unpredictable even in wild species, mechanisms of addressing biosafety concerns will need to be considered before transgenic crops are moved from the laboratory to the field to ensure that they do not reduce natural biodiversity (Gabriel et al., 2010; Dahle et al., 2020; Fossmark et al., 2020).

## **B) ADVANCED RESEARCH**

Advanced research that is under way is to develop safeguards to block gene flow; according to some, the technology already exists to prevent gene escape. University of Georgia, is developing plants that can produce sterile pollen or seeds (for example, sterile because of thiamine deficiency) and plants that can be engineered for male or female sterility. Biotechnology can be used for more than the creation of genetically engineered crops: it can be used to preserve biodiversity and aid in genetic resource conservation efforts (Jie et al., 2020; Lofthus et al., 2020; Le et al., 2020).

It was suggested that surveys are needed to determine the status of existing biodiversity, evaluate its value and importance, and identify endangered species and genes. On the basis of the survey results, he argued, measurable targets for the sustainable use and conservation of various species could be set. An overarching challenge is the lack of human capacity on the ground to monitor what happens to biodiversity when

new living systems are introduced, what happens in the long term, whether there are benefits, and whether there are serious disruptions of ecological life. Work is under way in several countries to characterize indigenous plant varieties and animal breeds with biotechnologies to document and safeguard biodiversity. The use of field-plot germplasm collections and in vitro tissue-culture methods gave residents a powerful tool to preserve regional biodiversity. This example illustrates how the techniques of biotechnology have been used to conserve biodiversity and the cultural heritage of native people.

### CONCLUDING REMARKS

In many developing countries, land degradation is often exacerbated by expansion onto fragile hillsides and wetlands under population pressure (FAO, 2011). Risks are also increased by excess removal of trees and shrubs in the landscape for fuel and feed. In other places, inadequacies of land tenure and governance have allowed destructive short-term timber, pulp or palm oil production to leave large areas of severely degraded lands behind, including high-carbon peatlands in Southeast Asia. The most severely affected areas include highlands, mountains areas under agriculture. Soil erosion has been recorded as a single major physical driver of agricultural land degradation in the country. The worst affected agricultural land (85 – 90 %) is in highland areas in the NEH region, Central Himalayan Highlands, North Western Himalayas, Nilgiris and Vindhyan region of India. The widespread prevalence of agricultural land degradation in India is a classic example of a downward spiral, is attributed to over exploitation, extractive farming, low external inputs, and improper management. Accelerated degradation is shrinking the finite soil resource even more rapidly in these regions of harsh climate and fragile soils. In this context, restoration is important to sustain soil fertility and agronomic productivity. Simply adding chemical fertilizers or improved varieties, as is often erroneously recommended even by well-intended advocates, is not enough. Biotechnology has the potential of fielding several techniques that may result into more effective treatment of land and water resources which otherwise would take not only relatively longer time frame but also highly costly and strenuous as well. It is therefore, strongly recommended that more research should be conducted to explore the hidden linkages between natural resources conservation and management and biotechnology so that the country should benefit and the

problems should be attended satisfactorily and effectively.

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