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Bioresource and Stress Management

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Preface

In the twenty-first century, new approaches of environmental and social advocacies and bio-resource management have been formulated at the national and international level for preserving the environment and management agendas. It is well understood. One of the most significant needs of the day is to manage the natural resources sustainably vis-a-vis disseminating the knowledge to impart awareness. In this book, we have outlined the consolidated efforts and findings of the researchers, scientists, academicians and scholars engaged in addressing a series of questions and framework on resources management and combating of biotic and abiotic factors for keeping our mother Earth safe for all.

Here, an outline of series of questions, concepts and line-up plans pertaining to the bio-resource and stress management has been drawn. These natural bio-resources have an impact on economic, cultural, aesthetic, scientific and educational segments of the society. Thus, the preservation of this prestigious heritage by conserving or managing in sustainable manner is far more important as these are at danger rather shrinking at a faster rate. The combined and interacting influences of over-exploitation, pollution, modification, destruction or degradation of the native habitats amplify the vulnerability of bio-resource. All these factors are pushing the crease and forcing natural biota to attain a smaller size with every passing day. Immediate attention is next to the door; as the prerequisites are rarely met. The human use of the goods and services provided by nature is necessary; however, continued attempts are to be made to check the genetic erosion. Thus, these alarming notes urge the necessity of adoption of a compromising agenda in management and conservation of bio-resource. These may provide a viable long-term solution, a new paradigm for conservation.

Promoting biodiversity-sensitive management is of equal priority. The land use practices must be compatible with the maintenance of the bio-resource. Nevertheless, the problem of soil fertility degradation may be relieved by the proper use of organic and inorganic fertilizers or by adoption of integrated nutrient management strategies. Some of the chapters enlighten the research contributions encompassing the organic amendments in increasing the nutrient uptakes, microbial activities, etc.

This book not only emphasizes on the general conceptual approaches by different users but also methods on integrated conservation, utility and importance of bio-resource. It has focused with the prime goal of contribution towards the construction of a range of attributes, conservation or management

of resources and indicates, at the same time, the areas or topics where further research will be useful under the present scenario of climate change. To elucidate some of the effects and research highlights, an attempt has been made to discuss the wide range of themes for framing out considerable management aspects.

It is also interesting to overview the current perspective to assess the level of depletion or exploitation on bio-resource over the years. The chapters herein encompass the research contributions in the fields of genetics, biotechnology, water conservation, abiotic and biotic stress, seed technology, postharvest physiology, natural resource management, climate change, etc. This has called for the expansion of research over vast corridors looking ahead the necessity of enrichment of inter- and intra-disciplinary research.

Despite the astounding importance of various bio-resources and their abundance on our planet, the degree of their degradation and extinction is elevating owing to the ever-increasing pressure of population growth, urbanization, industrialization, deforestation and other aspects enhancing the level of greenhouse gases. The global impact of these gases is evidenced as the global warming and greenhouse effects. Projections highlight the food crisis to be seen in the forthcoming years with the burgeoning populace, deforestation and land degradation. The large-scale release of these greenhouse gases or burning of fossil fuels, intensive agricultural systems and residual effects of the indiscriminate pesticide use, microbial degradations, industrial effluents and gases into the atmosphere and hydrosphere are exuberating their impact to a much larger extent. Though significant achievement has been obtained in crop improvement, molecular biology and other disciplines, very little progress has been made in increasing crop productivity under sustainable agriculture in the farmers' fields.

This scope of diversity of research activities that prevailed provides an advantage rather than challenges in compiling and editing this book, moreover to indicate a wide range of affordable perspectives. Such typical fields of scientific research endeavour the development of suitable strategies for efficient and reliable management of bio-resource.

The chapters are well organized by broad topics describing the research highlights, with an overall context and concluding summary enlightening the future areas of research. Most of these synthetic chapters are drafted by contributing authors. The editors have stimulated these highly productive research highlights mostly from the 2nd International Conference on Bio-Resource and Stress Management held during 7–10 January 2015 at PJTSAU and ANGRAU, Hyderabad, India. These studies cover a wide scope of disciplinary perspectives, from agronomical to physiological and biochemical right down to the molecular level. Each equipped with their particular set of experimental tools has successfully approached their object of study to provide us with fresh information that will prove useful, in at least two ways. For one thing, those whose interest lies in designing their own research will find in this chapter inspiring ideas on questions of utmost urgency. On the other hand, those who are interested in the general area of stress in plant systems from an ecological point of view – as it may concern global climate change in particular ways in which it threatens ecosystem

stability, for example – will find the material most valuable to build on current working models explaining interactions between living organisms and a rapidly changing physical environment and the prospects of evolution of the ecosystems thereupon.

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Social Necessity of an Efficient Management and Conservation of Bio-resource and Stress Management

1

Ratikanta Maiti and Aruna Kumari

Abstract

The growth and economy of a society is highly dependent on profitable utilization of bio-resource, plants and animals for livelihood and survival. This chapter discusses the efficient utilization of native plants, trees and other bio-resources as well as various abiotic stress factors affecting crop productivity under sustainable agriculture. Various innovative techniques, agrotechnology and organic fertilizers need to evolve for increasing productivity under sustainable agriculture. The reserve of organic carbon fixed in the soil by soil microorganisms is the long-term carbon that is released into the environment by increased burning of fossil fuels. It helps to limit the global changes that are continuously increasing due to rapid changes in the amounts of greenhouse gases. Certain tree species have the capacity to capture about 50 % of carbon, viz. *Leucophyllum frutescens*, *Forestiera angustifolia*, *Bumelia celastrina* and *Acacia berlandieri* which may be recommended for planting in highly contaminated areas to reduce pollution and carbon dioxide load in the atmosphere. This chapter urges the necessity for judicious utilization and conservation of native species and also the ethnic knowledge on plant uses inherited from generation to generation.

Nature provides us a variety of goods and services, and for every moment of our life, we use the resources that it has provided. The air encircling the earth enables us to breathe; the plants grown in the soil provide the food to eat, shelter to animals, vegetation and pastures. The energy provided by the sun, coal or fossil fuels are used for several purposes. In a similar manner, the water that falls to the ground in the form of rain is used for irrigation and to meet the various day-to-day needs. It is thus evident that we are dependent on nature to a large extent to meet all of our basic needs – air, food, water, shelter, energy, etc.

The growth and economy of a society is highly dependent on profitable utilization of

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bio-resource, plants and animals for livelihood and survival. Native plants or trees and crops supply food, medicines, timber for furniture, firewood and various domestic necessities. Besides, we are highly dependent on honeybees for honey, fish and animals for meat, leather, wool, etc. There is a great necessity for efficient utilization of bio-resource and its genetic improvement. Efficient management of bio-resource contributes to improve the economy of mankind worldwide. Therefore, the conservation and efficient utilization of bio-resource is a great necessity for the economy of our society.

With respect to native plant species, there is a great necessity to develop efficient techniques for breaking seed dormancy and propagation of plants and trees. No efficient techniques are available except traditional methods. In this regard, in Northeastern Mexico, few native species such as *Agave lechuguilla*, *Yucca* spp., *Euphorbia antisyphilitica* and wild chilli (*Capsicum annuum*) are overexploited by the semiarid farmers for their economic importance, which may lead to the extinction of these species in the long run. Many cactus species are endangered and becoming extinct. Though simple techniques are available, no attempts are being made by scientists. It urges the necessity for judicious utilization and conservation of native species and also the ethnic knowledge on plant uses inherited from generation to generation.

Since ancient times, many medicinal plants are being used to alleviate various diseases in rural villages as well as in urban areas. This knowledge on the use of medicinal plants is inherited from generation to generation. Many medicinal plants are used to cure a large number of diseases. Systematic studies on the macro- and micronutrient contents of these medicinal plant species are limited. Our research is thus being confined to the selection and identification of the native tree species having a high efficacy of accumulation of macro- and micronutrients into their biomass. These medicinal plants have high nutraceutical values as sources of supplementing the macro- and micronutrients in medicines to the desired in curing a particular disease.

There is a great necessity of interdisciplinary research on medicinal plants as ethnomedicine. In order to have a truly sustainable society, there is a need to understand the impacts of anthropic factors on the nature and the resources that are provided. Decisions are to be made in such a way that the impacts on these bio-resources are minimized, and these which are forming a part of our natural systems are continued to meet the requirements of the future generations too. Scientists, academicians, environmentalists, ecologists and biologists all over the globe are working together in finding better ways of management of the bio-resource as soil, water, vegetation as well as biodiversity.

Soil forms the basis of life and survival of plants. Millions of insects, bacteria, fungi, actinomycetes and algae reside in the soil. Certain fungi as mycorrhiza help plants to retrieve phosphorous from the soil. Certain nitrogen-fixing bacteria such as *Rhizobium*, *Azospirillum* and *Azotobacter* enrich the soil nitrogen content. Certain phosphorous-solubilizing bacteria such as *Pseudomonas* and *Bacillus* and fungi *Aspergillus* and *Penicillium* enrich the soil phosphorus contents. Certain bacterial species such as *Pseudomonas* are useful in phytoremediation in removing the oil spills and other metal contaminants from the soil and water surfaces. Likewise, some bacterial and fungal species like *Bacillus* and *Trichoderma* are effective biocontrol agents against a number of harmful pests. Certain nematodes and mites also reduce the pest species by feeding on them.

Developed and developing worlds are facing ever-increasing problems. Overcropping or abuse of mineral fertilization and pesticides is leading to the destruction of our soils, a valuable resource which is scarce. Nevertheless, this problem of soil fertility degradation may be relieved by the proper use of organic and inorganic fertilizers or by adoption of integrated nutrient management strategies. The organic residues not only enrich the soil microbial population but also influence the soil structure and the nutrient turnover, increase biodiversity and influence many physical, chemical and biological parameters. Nowadays,

a very interesting subject of investigation is the use of organic amendments so that the biological properties of the soil are properly maintained in enabling in the maintenance of soil functioning and structure. Indiscriminate use of fertilizers and pesticides are degrading the soil environment leading to its pollution. The soil biological activity is being lost due to significant amounts of contaminants that are accumulated in the soils. Organic manures or organic amendments can enrich the soil microflora and lead to a build-up of microbial biomass and increased microbial activity. The soil enzymes are very important and several researches have highlighted the increase in the soil enzymatic activities with the addition of organic amendments. In dry areas, the presence of soil fauna, litter decomposition and soil chemical and biochemical properties are very important in the organic resource management.

Under the present conditions, there is a need for a transition towards durable and sustainable relations between humans and nature. An advance in scientific knowledge has given a platform for the efficient management of our natural bio-resource such as soil, water and biodiversity. An important agricultural and environmental component of soil is soil organic matter. It helps in the maintenance of plant nutrition, protects the soil quality and also controls the fate of contaminants in the soil. It is the only reservoir of organic carbon. The largest amounts of organic carbon on the earth's surface are reserved in the soil. Thus, this reserve of organic carbon in the soil is potentially capable of fixing the long-term carbon that is released into the environment by increased burning of fossil fuels. It helps to limit the global changes that are continuously increasing due to rapid changes in the amounts of greenhouse gases. Thus, the science of sustainable management of bio-resource offers enormous opportunities for scientific development for the base interventions or formulation of policies for the conservation of these valuable resources or the adoption of a green technology, and sustainability of agro-environment is the need of the present day apart from meeting the demands of the increased population.

Climate change is occurring due to increase of CO_2 and other greenhouse gases, which have a direct impact on the growth, development and survival of tree species of a forest. The climatic factors prevailing in different semiarid, tropical and temperate regions affect the growth of trees. The change in climatic factors related to atmospheric condition are the solar radiation, light, wind, temperature, precipitation, relative humidity and intensity of light. Climate determines the distribution of vegetation in a forest ecosystem. There exists a good relation of the climate with the conservation and development of forest. It is essential for the foresters to have good understanding of the climate changes and its impact on forest productivity and to take necessary measures to protect it. It is difficult to determine the changes of climate on plant growth and human activity and to adopt effective measures to mitigate climate changes. Global warming leads to melting of glaciers and swelling of sea levels thereby causing climatic disasters.

The earth receives radiant energy from solar radiation for its utilization by the plants for photosynthesis and other human activities. Short wave solar energy (visible) received from the sun passes through the atmosphere, thereby warming the earth's surface. Long wave thermal radiation is absorbed by a number of greenhouse gases (GHGs). These greenhouse gases accumulate in small amounts in the atmosphere and reflect long wave thermal radiation in all directions. The greenhouse gases cause the retention of heat to the lower atmosphere due to absorption and reradiation by clouds and other gases. Some of the radiation is directed towards the earth's surface. The amount of GHG in the atmosphere influence global temperature. The greenhouse gases affecting climate change in the earth surface are water vapour (H_2O), carbon dioxide (CO_2), nitrous oxide (NO_2), ozone (O_3), carbon monoxide (CO) and chlorofluorocarbons (CFCs). With an increase of agriculture, animal husbandry, overgrazing and an increase in human population indirectly the levels of these greenhouse gases are increasing. Increased global warming is endangering the security of persistence of life of

humans, plants, animals and so on. Over and above, an incessant logging of trees for timber has direct impact in the increase of greenhouse gases. An increase in the accumulation of GHG has direct effect on forest growth and productivity.

In this context, increasing global warming owing to an increase of greenhouse gases associated with drought and other abiotic stresses are causing great concern in endangering plants, animals and other beneficial native microorganisms. This in turn is affecting crop productivity under sustaining agriculture affected with drought, salinity and other abiotic stresses. This is associated with tremendous increase of human population leading to increased hunger and poverty. Under this situation, there is a great necessity of research on the conservation of native animal and plant species or trees with special reference to trees and economic plants, on the one hand, and adopting suitable technologies to increase crop productivity in stress-prone areas under sustainable agriculture, on the other hand. Increasing global warming has direct impact on wild animals endangering their survival. High temperature has detrimental effects on the growth of plants, animals and their survival. Efficient utilization of animal or plant resources is essential for strengthening rural economy. This urges the necessity of protection, conservation and judicious utilization of plant and animal resources.

Trees in the forests are saviours of our lives. These give us food, shelter and daily necessities and supply oxygen for our respiration. Protecting forests is a great necessity for our existence. We are very much concerned about how the human activities such as the burning of fossil fuels, conversion of forests to agricultural lands and other illegal activities cause significant increase of carbon dioxide and other greenhouse gases in the atmosphere. On the other hand, deforestation and the increased use of forest products and burning of fossil fuels are contributing to the gradual increase of greenhouse gases in the atmosphere. Fortunately, the trees and forest with their ability to fix CO_2 and carbon into their biomass provide an opportunity to mitigate climate change through carbon sequestration.

Forest tree species have the capacity to fix CO_2 load from the atmosphere, thereby reducing the exposure to noxious CO_2 gas by humans protecting our health and saving our lives. This in turn leads to the accumulation of carbon, the source of energy for fuel after combustion. This is important for wood industry of high commercial importance. The tree species having high capacity of carbon sequestration (carbon fixation) could have high potential for reducing the carbon dioxide load through the process of photosynthesis.

A large variability in macro- and micronutrient contents in leaves of several native woody tree species of semiarid Mexico has been observed. These species had the ability to capture high carbon of about 50 % and were found to be efficient carbon sequestrants (carbon fixers). The species capturing high carbon about 50 % were *Leucophyllum frutescens*, *Forestiera angustifolia*, *Bumelia celastrina* and *Acacia berlandieri*. These species may be recommended for planting in highly contaminated areas to reduce pollution. Plant species with high carbon sequestration could be planted during town planning to reduce carbon dioxide load in the atmosphere. In developed countries, this excessive carbon dioxide load build-up in the atmosphere, owing to continuous emission from burning of fossil fuels, is captured and then injected in the much deeper soil impervious layer, thereby reducing the carbon dioxide load from the atmosphere.

We have hypothesized that trees with open canopy are expected to be more efficient in photosynthesis for their capacity in the capture of solar radiation and greater carbon fixation. We have selected few tree species with open canopy with about 50 % carbon sequestration. Thus, these tree species with high carbon fixation capacity could be effectively used in planting in highly contaminated areas, factory sites and cities with high carbon load in the atmosphere.

In view of the above discussion, the following options may be effective for reducing the carbon load from the atmosphere: (1) the selection of native tree species with high capacity of carbon sequestration and the promotion of their plantation in polluted areas, in development planning

of townships; (2) selection of legumes, *Acacia*, and C_4 plants; and (3) preferably the selection of fast-growing species in particular for heartwood species. We feel that these potential lines of research to reduce carbon dioxide load from the atmosphere and concerted research inputs need to be directed in this direction. At the same time, incessant logging and other human activities and expansion of agriculture in logged areas need to be rigorously controlled by forest authorities. Rigorous training needs to be given to the forest rangers to control this menace. Conservation of forest health and its growth can save our lives from the menace of contamination in the atmosphere. There is necessity to develop efficient techniques to propagate native plant species and trees through seed germination.

With respect to crop productivity, thanks to the efforts of plant breeders, plant protection scientists and biotechnologists for developing high-yielding crop cultivars with increased substantial yield under high-input situations, but little progress has been achieved with respect to increased yield under sustainable agriculture where several abiotic stresses affect the crop productivity drastically. High-input cultivars cannot adapt under this condition. It may be mentioned here that biotechnologists contribute a lot in the development of crop cultivars resistant to insects such as Bt cotton and other crop species, but they failed to increase productivity under sustainable agriculture especially in poor farmers' field in rural areas where high-input crops fail to adapt. There is a great necessity in the transfer of technology from the lab to the farmers' field and to convince farmers with the benefit of the technology better than their traditional methods. We cannot impose our technology, rather convince them with the results and try to modify their traditional procedures.

In this venture, there is a necessity of concerted research activities in multidisciplinary team including breeders, physiologists, plant protection specialists, soil scientists, agronomists and biotechnologists to address this problem in an attempt to increase crop productivity under these stress-prone areas. Crop cultivars tolerant to salinity, drought and heat stress have great potential to increase productivity under these stress-prone areas. In this aspect, we adopted a novel strategy to screen high-yielding crop cultivars which were tested over multilocation trials for their adaptation and good yield by the seed companies and research institutes and then select crop cultivars for tolerance to salinity and drought with good success. Various resources management as land water, plants are particularly focused on strategies of management in such a way that the quality of life of the present and the future generations is not affected. The long-term implications of actions should take into account the future prospects while making any decisions about the land or agriculture or bio-resource that are being managed. The main ultimate goal of bio-resource management is to have sustainability – balancing social, economic and environmental factors in making sure that our future generations can equally be benefited from the goods and services of the various bio-resources. Our economical, social and environmental well-being is dependent on the sustainable management of these resources.

In this respect, crop physiologists may contribute to develop low-cost technology to screen high-yielding pipeline crop cultivars and select crop cultivars tolerant to these stresses. Simple low-cost technologies have been developed by us to screen and select crop cultivars tolerant to drought, salinity and other abiotic stresses. We developed these technologies and were successful in several field crops such as cotton, sunflower, maize, pearl millet, rice, castor and few vegetable crops. We feel that using these low-cost technologies is possible to increase crop productivity under sustainable agriculture in collaboration with agronomists, soil scientists, breeders, etc. who can contribute their innovative technologies in this venture.

We also developed simple priming technique in India for enhancing flowering and increasing the productivity of several vegetable crops such as tomato, chilli, bottle gourd, watermelon, cucumber, bitter gourd and other cucurbits. This needs to be confirmed in other countries.

In this juncture, we are aware that strenuous efforts of the breeders, molecular biologists and other scientists have contributed to the significant achievements in attaining increased crop productivity under high-input situations, but a little progress has been achieved in increasing productivity under sustainable agriculture in the farmer's fields. High-input, high-yielding crop cultivars cannot thrive well under low-input situations. In this respect, we adopt a strategy to develop simple low-cost technology to screen a large number of pipeline varieties or hybrids of few field and vegetable crops and finally select cultivars for tolerance to salinity and drought. Later, these cultivars could be handed over to molecular biologists for its validity. There is a great necessity of an interdisciplinary research team consisting of breeders, physiologists and soil scientists to address the issue and develop a strategy to increase crop production under sustainable agriculture in the farmers' fields. There is a great necessity of breeding and selection of crop cultivars tolerant to abiotic stresses such as salinity, drought and heat stress, etc. which have high potential in increasing crop productivity under sustainable agriculture in the farmer's field.

In the Second International Conference on Bio-resource and Stress Management, ANGRAU & PJTSAU held in Hyderabad, India, 7–10 January, 2015, a large number of papers (980) are presented dealing with management of bio-resource and stress management. Brief account of the research highlights in the bio-resource and stress management are presented herewith: Bio-resource and Stress Management: A Perspective.

Socioeconomy of Bio-resource and Stress Management

2

Samares Kumar Das and Ratikanta Maiti

Abstract

The chapter discusses the role of plants and animals in the socioeconomic condition of human beings. The economy of the society depends on proper utilisation of bio-resources, such as food crops, medicinal plants, fibres for clothes, firewood, etc. which are affected by abiotic and biotic stresses. Emphasis has been made on the role of women in society. Technology transfer for upliftment of socioeconomy and utilisation of various natural resources by human beings and also suggests specific strategy for rural development.

2.1 Role of Bio-resource in Socioeconomy of Rural People

Plants and animals play an important role in the socioeconomic condition of human beings. The well-being of the society depends on proper utilisation of bio-resources, such as food crops, medicinal plants, fibres for clothes, firewood, etc. In the Second International Conference on Bio-resource and Stress Management, several papers were presented. Here, we give a brief summary of these papers.

Manipur harbours a rich diversity of different plant species which also includes several dye-yielding species. The study was undertaken during 2010–2012 in different parts of Manipur, and 30 species were recorded for dye-yielding plants. Kikim et al. (2015) documented 30 species used for dye-yielding plants in Kangchup hills of Senapati district in Manipur state (India). Meiteis and Meitei Pangal (Muslim) communities have been using species like *Strobilanthes flaccidifolius*, *Lithocarpus dealbata*, *Bixa orellana*, *Tectona grandis*, *Parkia javanica*, *Osbeckia chinensis*, etc. traditionally in combination with other plants for extraction and preparation of dye-utilising indigenous process.

We depend on various plant resources, food crops and vegetables for our livelihood and economy which are affected by abiotic and biotic stresses. We are mentioning here a few of biotic

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and abiotic stresses affecting crop productivity and the economy of rural people.

Nandeshwar et al. (2015) studied the economics of vegetable production and marketing in Akola district of Maharashtra (India). Channels of vegetable marketing were (i) producer-wholesaler-retailer-consumer, (ii) producer-retailer-consumer and (iii) producer-consumer. Producer's share in consumer's rupees was highest in channel (iii). However, channel (i) was found to be the most important channel of distribution.

Chakma and Sharma (2015) conducted a study for the assessment of production and marketing of cabbage in the district of West Tripura (India). Sixty farmers were sampled following multistage-stratified random sampling. In the case of the selected farmers of Teliamura Block, farmers were found well familiar with the cabbage production technology knowledge; however, they lacked the knowledge regarding seed treatment methods, seed rate in nursery technology, biofertilisers in fertiliser technology, etc.

Diseases reduce crop productivity owing to climatic effects. Tomato is an important vegetable whose productivity is affected by disease infection. Bhat et al. (2015) observed prevalence of tomato diseases across semiarid regions of Karnataka. High rainfall and humidity coupled with moderate temperature triggered late blight. The amount of rainfall and number of rainy days also affected the appearance and severity of bacterial spot, buckeye rot, powdery mildew and *Septoria* leaf spot.

Abiotic stress such as salinity reduces crop productivity in rural villages, thereby affecting rural economy. Bhagyashree et al. (2015) did a comparative study of sugar beet and fodder beet in salinity stress tolerance. Salinity stresses were imposed in these two varieties after the attainment of two-leaf stage. They inferred that fodder beet variety CALIXTA is much more tolerant to salinity stress than sugar beet variety SZ-35; hence, fodder beet can be grown much more efficiently in saline track.

Insects attack food products, thereby reducing their quality; the study by Deepthi et al. (2015) aimed to carry out the feeding aversion behaviour of rose-ringed parakeet (*Psittacula krameri*) 'by choice' and 'no-choice' method to different concentrations of various plant products. Crude extract of *Annona squamosa* showed promising results. Therefore, it may be used to reduce crop damage by rose-ringed parakeet in crops like sunflower, sorghum and other minor millets.

A study was undertaken by Meena (2015) in *Acacia* for understanding germination, establishment and juvenile growth during the natural regeneration of vegetation. It is concluded that seedling establishment of *Acacia* is technically feasible, and it provides a viable methodology useful for restoration of barren and degraded lands.

Chauhan et al. (2015) successfully reared bumble bees (*Bombus haemorrhoidalis* Smith) without undergoing hibernation for more than 15 months in Himachal Pradesh (India).

2.2 Role of Women in Society

In rural society, women play an important role both in the domestic and outside field and construction works. Women work hard in carrying heavy load leading to skeletal disorder and other problems. The most common of these were a lack of sleep, back problems, worrying about work, irritability and feeling down. This may be either due to incorrect design of the equipments used or due to improper design of the workstations. Agriculture is the highest employer of women's labour to the extent of 76 % in India. Work-related musculoskeletal disorders are the most prevalent illnesses among informal sector workers in India. Based on the feedback received from the farm women through participatory rural appraisal, Tiwari et al. (2015) carried out research to reduce the drudgery of farm women by introducing women-friendly farm equipment.

Kale et al. (2015) studied constraints faced by farm women in dairy farming and was undertaken in Kalmeshwar Tahsil of Nagpur district in Vidarbha region of Maharashtra State with sample size of 100 dairy farm women from

15 villages. In India, women's involvement in livestock management is a long-standing tradition, and dairy farming has been an integral part of homestead farming system. Constraints are the circumstances or the causes which prohibit the dairy farmers from adoption of the improved management practices. The constraints faced by farm women while dairy farming were high cost of quality concentrate feeds (98.00 %) and high cost needed for purchasing crossbred animals and veterinary medicine (95.00 %), followed by decline in performance of exotic animals due to the high temperature (94.00 %), low water profile, lack of irrigation facilities (85.00 %), inadequacy of green fodder round the year (82.00 %) and nonremunerative price for milk (80.00 %).

Thakur (2015) emphasised mainstreaming of gender concerns in agriculture for inclusive growth of the society at large. Women are the backbone of agricultural-based economy owing to the fact that men mostly migrate to the urban areas for search of better jobs. Worldwide, women play a vital role in food production in the developing world. They contribute as much as 60 % of labour on family farms, but they often have no control over farm income or agricultural resources such as seeds, fertiliser and land. Evidence shows that if women farmers across the developing world had the same access as men do to resources such as land, improved seed varieties, new technologies and better farming practices, yields could increase by as much as 30 % per household, and countries could see an increase of 2.5–4 % in agricultural output. In order to ensure inclusive growth of the society at large, mainstreaming of gender concerns in agriculture should form the core area of the developmental process so that the world could be freed from the scourge of global hunger.

Chavan et al. (2015) assessed training needs of farm women in storage of food grains and their constraints selecting randomly 120 respondents from Raigad district of Konkan region. More than half of the respondents (55 %) expressed training need in the 'use of fumigants at stored place' followed by the 'use of preventive measures at stored place' (46.67 %), followed by 'identification of stored grain pest and its nature of damage and control measures' (40 %). Major constraints in food grain storage practices were high cost of improved storage structure (85 %), lack of knowledge in identification of stored grain pest (69.16 %) and unavailability of different storage structures (56.66 %).

Kumari et al. (2015) interviewed randomly selected 23 women representatives from two blocks of Samastipur district in Bihar (India) to assess the extent of empowerment and associated problem of elected women members in Panchayati Raj institutions. The findings revealed that 21.73 % of respondents were with high empowerment in respect of health welfare and development of public property. The association between empowerment and age was negative but highly significant at 1 % level of probability.

2.3 Technology Transfer for Upliftment of Socioeconomy

Kadam et al. (2015) suggested strategies for documentation and validation of indigenous technological knowledge (ITK) in bio-resource management. Four steps were identified by them for inclusion of ITK in technology generation, assessment and adaptation process. They are documentation, validation, refinement and integration. Story, survey, participatory rural appraisal (PRA) or rapid rural appraisal (RRA), observation, documentary evidence, etc. were considered by them for documentation and validation of ITK.

Lotha and Sharma (2015) studied 60 households engaged in tea cultivation in six villages of Dimapur district in Nagaland (India). It was found that tea growers were well aware of the importance of planting methods, improved variety, land preparation, manures and fertilisers, plant protection measures, plucking and processing. They adopted the recommended practices for tea plantation. Formation of cooperative societies may help tea growers obtain higher price of produce and accelerate the adoption of recommended technology as well. Emphasis may be

given to reduce the gap between the farming system and extension system in order to enhance the dissemination of information on recommended technology and better farming practices. Department of Horticulture and Agriculture may give high priority to provide the farmers of the study area more technical guidance through conducting demonstrations, training, field days, seminars, workshops, etc. on plant protection measures and processing. The most prominent constraints perceived by the respondents were lack of proper credit facilities, transportation and proper marketing facilities. In order to overcome such problems, government and concerned sectors may give emphasis on establishment of cooperative societies and extension of credit. Formation of cooperative societies in the study area may support the tea growers for obtaining higher price of the produce; it may also accelerate the adoption of recommended technology as well.

Reddy and Reddy (2015) studied the economics of direct-seeded rice (DSR) in Andhra Pradesh (India). About 40 % labour saving was observed at field in DSR compared to traditional transplantation method. Additional revenue due to adoption of DSR was much higher in unfavourable season compared to normal season.

Ajrawat et al. (2015) identified potential of information technology (IT) in agriculture and rural sector. Most applications of ITs in agriculture and rural sector were related to trade of inputs and outputs through *e-Choupal*, extension and training activities for rural people, advantages of agritourism, knowledge transfer from cities to villages through e-kiosks and geographical information system for management of natural resources.

2.4 Natural Resource as Source of Livelihood

Loktak Lake, the largest freshwater wetland and a Ramsar Site located in Manipur, is the source of livelihood and the lifeline for more than 50 villages located in and around the lake. The lake is the habitat of the endemic brow-antlered deer or Sangai deer (*Rucervus eldii eldii*) protected under Schedule I of Indian Wildlife Protection Act, 1972, and listed in endangered category in IUCN Red List of Threatened Species. The lake is rich in bio-resource which provide livelihood to the local population. Dey and Laishram (2015) conducted a questionnaire survey to understand the participation of women living in and around the lake in sustainable livelihood and also the level of conservation awareness among them.

In Cameroon, day by day the natural resources which are highly essential in agriculture like water, land, animal and vegetation are being degraded, eroded and dwindling. Therefore, the farmers should be trained to judicially utilise these resources. Management of natural resources beyond watershed areas, particularly in irrigated areas, is very important due to the nonavailability of a proper scale to measure watershed farmer's attitude towards natural resource management; it was thought necessary to construct a scale for the purpose. Paul and Marie (2015) described entrepreneurship development programme followed in rural Cameroon. The programme has two components: 12-module classroom course and follow-up work.

2.5 Strategy for Rural Development

Well-defined strategy needs to be formulated for the development of agriculture and economy of rural people. Sharma (2015) mentioned policy for development of agriculture in Northeast India. An analysis has been taken into consideration of the regulation of agricultural markets, introduction of legislative measures, maintenance of demand – supply balance, price support, and regulation of external trade. However, owing to the skewed nature of agricultural development underdeveloped regions such as the northeastern region remained neglected and became reliant upon the developed regions for requisite supplies of the basic commodities. To provide a big push to agricultural development and hence upliftment of the region, the role of the government and the corporate sector has great significance, while

the nongovernment organisations (NGOs) voluntarily can come forward to fabricate its social network owing to cultural diversity and inherited backwardness that pose big barriers on the individuals' mindsets.

Shuya et al. (2015) conducted a survey on 50 piggery farmers in Nagaland who availed loan from the commercial banks. Major problems faced by the bankers were nonrepayment, supervision, uneven distribution of the borrowers and misutilisation of funds. While major problems faced by the borrowers were cost and availability of piglet, feed, interest rate, lack of scientific knowledge, disbursement of loan, supervision, certificates and guarantor, lengthy and slow bank procedures, marketing, disease and loan amount.

Sangeetha et al. (2015) studied productivity and economics of rice (*Oryza sativa* L.) and black gram (*Vigna mungo* L.) in rice-black gram cropping sequence as influenced by organic manures conducted at Tamil Nadu Agricultural University, Coimbatore, during *rabi* and summer seasons of 2007 and 2008. They studied the effect of organic sources of nutrients (enriched FYM compost, vermicompost, FYM + neem cake, enriched FYM compost + vermicompost + FYM, composted poultry manure and enriched poultry manure compost) and recommended NPK fertilisers on productivity and economics of rice and black gram in rice-black gram cropping sequence. The results revealed that the application of enriched poultry manure compost on equal N basis (2.3 t ha^{-1}) recorded higher yield attributes and grain yield of rice (4,675 kg ha^{-1} in 2007 and 4,953 kg ha^{-1} in 2008), which was however comparable with composted poultry manure.

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Climate Change: Its Impact on Bio-resource and Sustainable Agriculture

3

Aruna Kumari and Ratikanta Maiti

Abstract

Climate change is a complex alteration of climate, which is subtle and continuous, yet extremely important through its consequences for vegetation of various types that thrived under constant or relatively unchanged climates. Potential adaptation strategies for management of the impact of climate change—viz developing cultivars tolerant to heat and salinity stress and resistant to flood and drought, modifying crop management practices, improving water management, adopting new farming techniques such as resource-conserving technologies, crop diversification, improving pest management, better weather forecasting and crop insurance, and harnessing the indigenous technical knowledge of farmers—are briefly discussed. The chapter makes a brief assessment of research undertaken on the effects of global warming and climate change on various aspects—(1) impact of climate on agricultural production and forestry; (2) crop production; (3) impact of an increasing level of carbon dioxide on security of life; (4) impact of climate change on food inflation; (5) suggestion of various mitigation strategies for climate change; (6) carbon sequestration technology to reduce carbon pollution; (7) climate-smart agriculture; (8) conservation practices under rain-fed agriculture; (9) intercropping; (10) genotype × environment; and (11) impact of climate on livestock production—and discusses technologies that need to be adopted to combat climate change.

3.1 Introduction

Global warming, or climate change, has been strongly attributed to greenhouse gases (GHGs) in the Earth's atmosphere, like carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2) and chlorofluorocarbons (CFCs). These GHGs absorb the thermal radiation emitted by the Earth's surface. Thus, the rising concentrations of GHGs in the atmosphere could lead to a change

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