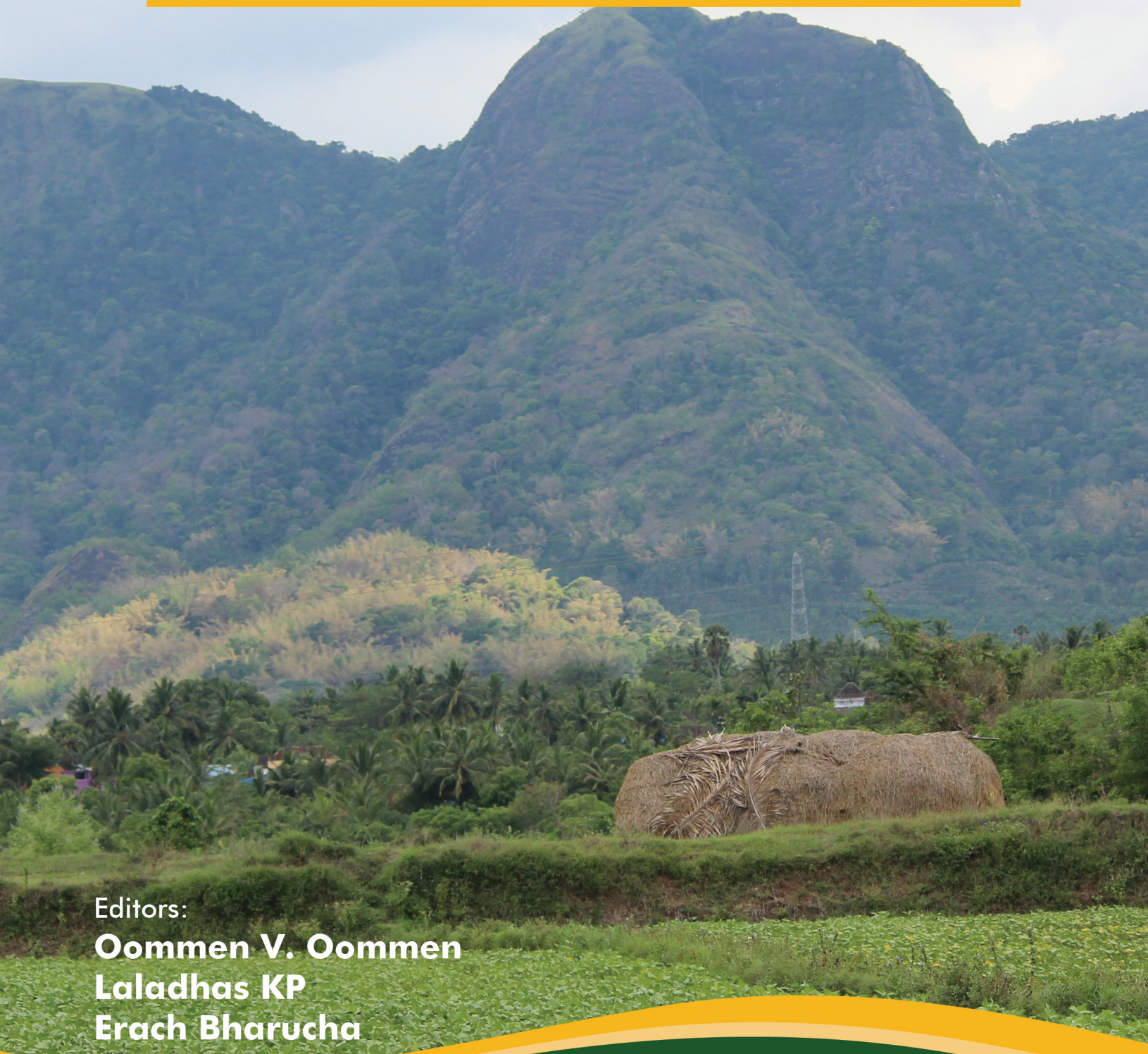
BIODIVERSITY AND LIVELIHOOD

LESSONS FROM COMMUNITY RESEARCH IN INDIA



Editors:
Oommen V. Oommen
Laladhas KP
Erach Bharucha

Bentham Books

Biodiversity and Livelihood: Lessons From Community Research in India

Edited by

Oommen V. Oommen
Department of Computational Biology and Bioinformatics,
University of Kerala, Kariyavattom,
Thiruvananthapuram-695581,
India

Laladhas K.P.
Department of Zoology,
St. Stephen's College, Pathanapuram,
Kollam, Kerala-689 695,
India

&

Erach Bharucha
Bharati Vidyapeeth Institute of
Environment Education and Research,
Bharati Vidyapeeth University,
Pune,
India

Biodiversity and Livelihood: Lessons From Community Research in India

Editors: Oommen V. Oommen, Laladhas K.P. and Erach Bharucha

ISBN (Online): 978-981-14-8215-1

ISBN (Print): 978-981-14-8307-3

ISBN (Paperback): 978-981-14-8214-4

need for a court order if at any point you breach any terms of this License Agreement. In no event will any delay or failure by Bentham Science Publishers in enforcing your compliance with this License Agreement constitute a waiver of any of its rights.

3. You acknowledge that you have read this License Agreement, and agree to be bound by its terms and conditions. To the extent that any other terms and conditions presented on any website of Bentham Science Publishers conflict with, or are inconsistent with, the terms and conditions set out in this License Agreement, you acknowledge that the terms and conditions set out in this License Agreement shall prevail.

Bentham Science Publishers Pte. Ltd.
80 Robinson Road #02-00
Singapore 068898
Singapore
Email: subscriptions@benthamscience.net

CONTENTS

PREFACE

India is a mega biodiverse nation and the several self-generated traditions in food and agriculture are successful models for achieving the important first three SDG goals. Now it is time to build on from traditional local level measures to end poverty and malnutrition. A large number of field based programmes related to biodiversity, livelihoods and poverty reduction are being carried out by various agencies in different regions of the country. Most of the valuable experiences, successes and significant learning are cited, contributing to our understanding of linkages between the issues and remedy.

We intend to undertake an assessment of the actions related to biodiversity, livelihoods and poverty reduction using different case studies and approaches besides establishing a platform to provide space that could promote extensive outreach to facilitate mutual learning of experiences, knowledge, processes, results, impacts *etc*. from field based experiences.

The sustainable management of traditional and local level resources for livelihood is better depicted in this publication. We have several articles satisfying the merits of the envisaged topic that includes, Mainstreaming biodiversity for nutritional security and well-being with special reference to fisheries sector, traditional ecological knowledge, dilapidated Ethno-Conservation practices and impending impacts among Malayali Tribes of Kolli Hills, Eastern Ghats, India, perception on mushroom ecology among Kattunaikka tribes, biodiversity based benefit-sharing activities to improve the livelihood of the local/tribal communities of India, biodiversity and sustainable utilization of the genus Garcinia of the Western Ghats, diversity and utilizations of wild edible fruits in Agasthyamala biosphere, enumeration of successful livelihood models from biodiversity management committees of India and a case study of sustainable fishery resource management from Godavari mangrove wetlands.

Creating an economic stake in better living with biodiversity is enumerated in the following chapters, “Economic Thoughts in Mainstreaming Biodiversity”, “Concepts of robustness and its application in determining ecosystem health, a case study from Indian context, climate change, fisheries and coastal ecosystem in India”, integrated approach for developing biologically diversified urban landscapes @ TCS: A Success Story, interface between instruments of development planning and biodiversity planning and conservation,

Bioprospecting of marine sponges associated fungi for antioxidant and neuroprotective activity in raw 264.7 cells, USAB reactor coupled contact bed process for the clean extraction of banana pseudostemfibres, commercial viability and pest status of Musa cultivars identified in Kerala, also form part of the book.

Finally, the successful stories of biodiversity and livelihood and recognition processes currently in vogue in India are presented that can be replicated elsewhere.

Oommen V. Oommen
Department of Computational Biology and Bioinformatics,
University of Kerala, Kariyavattom,
Thiruvananthapuram-695581,
India

Laladhas K.P.
Department of Zoology,
St Stephen's College, Pathanapuram,
Kollam, Kerala-689 695,
India

&

Erach Bharucha
BharatiVidyapeeth Institute of Environment
Education and Research,
BharatiVidyapeeth University, Pune
India

"*This book provides a glimmer of hope that reaffirms local and national actions abound and our need to consolidate such actions*".

- Balakrishna Pisupati, Chairperson, FLEDG

FOREWORD

Biodiversity, something beyond its importance as a conservation science and climate change implications, has a significant role in providing sustainable livelihood especially considering the rural and forest sectors. The second and the third objectives of the Biological Diversity (BD) Act of 2002 itself highlight the sustainable livelihood. Taking a glance of its international counterpart *i.e.*, the Convention on Biological Diversity (CBD), since its inception during the Rio Earth Summit in 1992, is committed to empower its parties, to achieve three major objectives (a) conserving species, (b) using biological diversity sustainably, and (c) promoting sustainable development. Sustainable management of bio-resources is much needed for countries like ours where biodiversity is directly linked with providing livelihoods to and improving socio-economic conditions of millions of our local people, thereby contributing to sustainable development and poverty alleviation. Its continuing depletion, largely because of human activities, including over consumptive lifestyles should therefore be a concern to us. The present publication is so relevant, as in this modern era, agriculture, fishery and forestry sectors mainly aim to increase production of only a few bio-resources. We must also look into the diverse aspects of bio-resources, as that only can provide livelihood security to the future generations. The chapters on mainstreaming of biodiversity, ethno-conservation practices, diversity of wild edible fruits, biodiversity and sustainable utilization of Garcinia, concepts of determining ecosystem health, bio-prospecting of marine sponge *etc*. will create awakening thoughts in the mind of readers.

It is my pleasure to give foreword to this publication on "Biodiversity for Livelihood" and my sincere congratulations to the entire team of authors, editors and technical staff for producing with such a piece of work and I wish more such publications are made on biodiversity related topics to mainstream biodiversity in various social sectors, and thus, creating a mass awareness among the public especially among the youth of this country.

Dr. B. Meenakumari
Former Chairperson,
National Biodiversity Authority (NBA),
Chennai, Tamil Nadu,
India

List of Contributors

Achuth Sankar S. Nair	Department of Computational Biology and Bioinformatics, University of Kerala, Kariyavattom, Thiruvananthapuram-695581, India
Ajitha T.	Department of Zoology, University College, Thiruvananthapuram, Kerala-695034, India
Arnab Banerjee	Department of Mathematics, Jadavpur University, Kolkata 700032, India
Athira Kakkara	CV Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management - Keral, Technopark Campus, Thiruvananthapuram, India
Biju Kumar A.	Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram- 695581, Kerala, India
D.A. Evans	Department of Zoology, University College, Thiruvananthapuram, Kerala-695034, India
Dinesan Cheruvat	Kerala State Biodiversity Board, Thiruvananthapuram, India
Erach Bharucha	BharatiVidyapeeth Institute of Environment Education and Research, BharatiVidyapeeth University, Pune, India
Fr. Roy John	Department of Zoology, St Stephen's College, Pathanapuram, Kollam, Kerala-689 695, India
Indu I.	CV Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management - Keral, Technopark Campus, Thiruvananthapuram, India
J.S. Jayaprabha	National Institute for Interdisciplinary Science and Technology (CSIR) , Thiruvananthapuram-695019, India
Jaishanker R.	CV Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management - Keral, Technopark Campus, Thiruvananthapuram, India
Jayeeta Sen	Department of Environmental Planning, School of Planning and Architecture, New Delhi – 110002, India
K.P. Laladhas	Department of Zoology, St Stephen's College, Pathanapuram, Kollam, Kerala-689 695, India
K. Madhusudhanan	Department of Botany and Research Centre, St.Albert's College, Ernakulam, Kerala, 682018, India
K. B. Rameshkumar	Phytochemistry and Phytopharmacology, Jawaharlal Nehru Tropical Botanic Garden and Research Institute Palode, Thiruvananthapuram, India
Kavitha K. J.	Department of Zoology, University College, Thiruvananthapuram, Kerala-695034, India
Lekshmi N. Menon	Phytochemistry and Phytopharmacology, Jawaharlal Nehru Tropical Botanic Garden and Research Institute Palode, Thiruvananthapuram, India
M. Reginald Appavoo	Department of Botany & Research Centre, Scott Christian College (Autonomous), Tamil Nadu-629 003, India

Meenakshi Dhote	Department of Environmental Planning, School of Planning and Architecture, New Delhi – 110002, India
N. Anilkumar	M. S. Swaminathan Research Foundation, Chennai, India
N. Preetha	Kerala State Biodiversity Board, Thiruvananthapuram, India
N. Lekshmi	National Centre for Aquatic Animal Health, Cochin University of Science and Technology, Kochi-682016, Kerala, India
N. Mohanan	Garden Management, Education, Information Training Division, Jawaharlal Nehru Tropical Botanic Garden and Research Institute Palode, Thiruvananthapuram, Kerala, 695562, India
N.B. Mithrambika	Kerala State Biodiversity Board, Thiruvananthapuram, India
Naik Laxmikant	Environmental Sustainability, Health & Safety, Tata Consultancy Services, Subash Nagar Thane - 400601, Maharashtra, India
Nidheesh K.S.	School of Biosciences, Mahatma Gandhi University, Kottayam, Kerala, India
Oommen V. Oommen	Department of Computational Biology and Bioinformatics, University of Kerala, Kariyavattom, Thiruvananthapuram-695581, India
Oliver King E.D. Israel	M.S. Swaminathan Research Foundation, Chennai, India
P. S. Shameer	Garden Management, Education, Information Training Division, Jawaharlal Nehru Tropical Botanic Garden and Research Institute Palode, Thiruvananthapuram, Kerala, 695562, India
Prakash Nelliyat	Fellow (ABS), Centre for Biodiversity Policy and Law, India
Priti Kumar Roy	Department of Mathematics, Jadavpur University, Kolkata 700032, India
R. Ravinesh	Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram - 695581, Kerala, India
R. Ramasubramanian	M. S. Swaminathan Research Foundation, Chennai, India
R. D. Anpin Raja	Department of Botany & Research Centre, Scott Christian College (Autonomous), Tamil Nadu-629 003, India
R. D. Arun Raj	Department of Botany and Research Centre, Scott Christian College (Autonomous), Tamil Nadu-629 003, India
Ray J. G.	School of Biosciences, Mahatma Gandhi University, Kottayam, Kerala, India
S. Rajasekharan	Kerala State Biodiversity Board, Thiruvananthapuram, India
Sajeev C. Rajan	CV Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management - Keral, Technopark Campus, Thiruvananthapuram, India
Santanu Ray	Department of Zoology, Visva-Bharati University, Santiniketan 731235, India
Shabith Raj K.	Department of Zoology, University College, Thiruvananthapuram, Kerala-695034, India
Shahina N. K.	Department of Botany and Research Centre, St.Albert's College, Ernakulam, Kerala, 682018, India
Sooraj N.P	CV Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management - Keral, Technopark Campus, Thiruvananthapuram, India

Sooraj Kumar. V	CV Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management - Keral, Technopark Campus, Thiruvananthapuram, India
Suvarna Devi S.	Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram- 695581, Kerala, India
Suresh Babu	Kerala State Biodiversity Board, Thiruvananthapuram, India
T.P. Sajeevan	National Centre for Aquatic Animal Health, Cochin University of Science and Technology, Kochi-682016, Kerala, India
V. Selvam	M. S. Swaminathan Research Foundation, Chennai, India
V. Saraswathy	Department of Computational Biology and Bioinformatics, University of Kerala, Kariyavattom, Thiruvananthapuram-695581, India
V. B. Manilal	National Institute for Interdisciplinary Science and Technology (CSIR) , Thiruvananthapuram-695019, India

CHAPTER 1

Traditional Ecological Knowledge, Dilapidated Ethno-Conservation Practices and Impending Impacts among Malayali Tribes of Kolli Hills, Eastern Ghats, India

Oliver King E.D. Israel*

M.S.Swaminathan Research Foundation, 42 B2, President Venkat Rao Street, Gandhi Nagar, Mohanur Road, Namakkal – 637 001, India

Abstract: Local communities are the custodians of biodiversity and traditional knowledge and they are not only losing their rich crop genetic diversity, but also rural livelihoods. These changes have brought negative effects into their domains of knowledge, culture and management of natural resources and have affected their livelihoods significantly. This paper attempts to focus on the lives and livelihoods of the Malayalis of Kolli Hills, especially on three key areas of natural resources and associated traditional knowledge: neglected and underutilized crop species (NUS), sacred forest landscapes and local art forms that highlight ecological relationships. The experiences of several field based projects implemented by the M.S.Swaminathan Research Foundation since 1994 highlights the need for a participatory natural resource management strategy (PNRMS). People friendly pathways is required to be put in place to ensure long-term sustainability of resources in such a landscape so that livelihoods are sustained.

Keywords: Kolli Hills, Malayali Tribes, NUS, PPPPP Model, PNRMS, SACRED, TEK.

INTRODUCTION

Natural resources have a crucial role to play in the course of human evolution. Human societies devised different strategies for the management of natural resources to create stability and sustainability of their societies. Such strategies, knowledge and innovations of communities now constitute what is recognized as Traditional or Indigenous Ecological Knowledge. Experiences in the recent past indicate that such knowledge is subjected to major changes due to numerous internal and external driving forces.

* **Corresponding author Oliver King E.D. Israel**: M.S.Swaminathan Research Foundation, 42 B2, President Venkat Rao Street, Gandhi Nagar, Mohanur Road, Namakkal – 637 001; E-mail:ediok151173@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

Exposure of local communities to global forces results in the rapid erosion and dilution of centuries of traditional knowledge of communities. Local communities who were custodians of biodiversity and traditional knowledge are not only losing their rich crop genetic diversity andcommunity forests, but also rural livelihoods. These changes have brought negative effects into their domains of knowledge, culture and management of natural resources and have affected their livelihoods significantly. Hence, a participatory strategy for the management of nature and knowledge is essential.

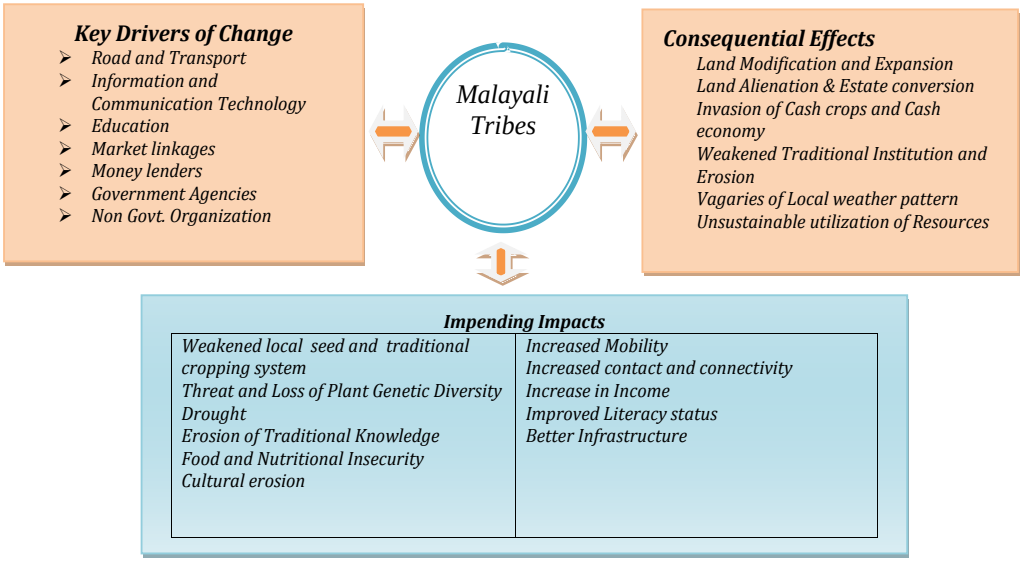


Fig. (1). Cultural Transitions, Agro biodiversity Impacts in Kolli Hills.

Malayalis are one among the major agrarian tribal groups dwelling in the Eastern Ghats of Tamil Nadu. The paper attempts to focus on lives and livelihoods of Malayalis of Kolli Hills, especially on three key areas of natural resources and associated traditional knowledge: neglected and underutilized crop species (NUS), sacred forest landscapes and local art forms that highlight ecological relationships. Traditional Ecological Knowledge (TEK) is the common thread that links them. Several contemporary forces influence traditional knowledge of the community that results in the erosion of knowledge and associated resources. The experiences of several field based projects implemented by the M.S.Swaminathan Research Foundation since 1994 highlight the need for a participatory natural resource management strategy (PNRMS). New people friendly pathways is required to be put in place to ensure long term sustainability of resources in the landscapes so that livelihoods are sustained. Promotion of ecotourism on a Public-Private–Panchayat–People– Partnership (PPPPP) model is suggested as one of the

viable pathways available.

The Kolli Hill site located in Tamil Nadu, South India in Namakkal district (78°17'05"E to 78°27'45"E and 11°55'05"N to 11°21'10"N) is a low range of hills spread over an area of 441.41[2] km. The altitude ranges from 180 m to 1415 m. It is inhabited by a homogenous group of tribal people known as the *Malayali Gounders*, who are believed to have migrated from the plains of Kanchipuram and settled in various hill ranges of the Eastern Ghats including Kolli Hills about five centuries ago [1]. Now their habitation is spread over 300 hamlets divided into 14 Revenue Villages.

TRADITIONAL AGRICULTURE, CROP GENETIC DIVERSITY AND ASSOCIATED KNOWLEDGE

Malayali tribes during their process of settlement, cleared forests and utilized land for cultivation of several food crops (Appendix **1**), notably minor millets. The Malayali tribal communities in Kolli Hills have maintained inter and intra specific minor millet diversity on farm through a set of practices based on local environmental and social conditions. Presently, twenty one landraces of little millet, Italian millet, common millet and kodo millet are being cultivated by these communities under different agroecological conditions (Table **1**).

Table 1. Intra-specific landraces of millets conserved by the Malayali Tribes in Kolli Hills.

S. No	Crop Name	Name of Landraces
1	Little Millet *(Panicum sumatrense)*	Perumsamai, Vellaperumsamai, Kattavettisamai, Thirigulasamai, Sadansamai, Malliasamai, Karumsamai
2	Italian Millet *(Setaria italica)*	Perunthinai, Palanthinai, Senthinai, Koranthinai, Mookkanthinai
3	Finger Millet *(Eleusine coracana)*	Perungelvaragu, Arisikelvaragu, Karakelvaragu, Karumuliankelvaragu, Suruttaikelvaragu, Sundangikelvaragu, Sattaikelvaragu
4	Kodo Millet *(Paspalum scrobiculatum)*	Thirivaragu
5	Proso Millet *(Panicum miliaceum)*	Panivaragu

The Malayali Tribal's seed system is characterized by local seed production, selection, storage, and exchange among local communities. A significant portion of harvested grain is normally stored as seed material by the farm family. Farm families used to maintain conventional implements such as Thombai (Grain Storage), Man Panai (Mud Pot used for Seed Storage) Kuthir (Larger Mud pot for Grain Storage). Rapti (Long Cloth bag for carrying Millet from Threshing yard to

CHAPTER 2

Perception on Mushroom Ecology among Kattunaikka Tribes

N.K. Shahina[*] and **K. Madhusudhanan**

Department of Botany and Research Centre, St.Albert's College, Ernakulam, Kerala, 682018, India

Abstract: The study documents the knowledge and usage of symbiotic mushrooms among Kattunaikka tribes from Wayanad and assesses its significance as a source of healthy food. The study was conducted during 2014-2016 through semi-structured and free listing interviews among selected Kattunaikka individuals. Total 15 species of wild mushrooms were collected which belong to 5 orders, 6 family and 6 genera. The usage of collective names to represent the mycorrhizal association revealed the good perception of Kattunaikka tribes on mushroom ecology. Termitomyces mushrooms were the most diverse and highly appreciated mushroom. Knowledge of distribution and ecology of ectomycorrhizal fungi signifies monitoring and retention of diversity and selection of species for forest nurseries.

Keywords: Cultural significance, Kattunaikka tribes, Symbiotic mushrooms, Traditional knowledge.

INTRODUCTION

Mushrooms are important forest resources which contribute to food diversity and security. They also function in nutrient recycling and act as a niche for several animal resources [1]. The ectomycorhizal mushrooms, especially play a vital role in nutrient transport as well as in maintaining the health and vitality of forest trees. They helps forest ecosystem to stand stable during changing environmental factors [2]. Many symbiotic fungi are functional foods with high nutritional and medicinal properties. The symbiotic mushrooms are difficult to domesticate, and one needs thorough understanding of the relation between the partners and the environment under which this relation can be optimized. These multivalued resources are threatened by several anthropogenic and natural causes such as land use change, habitat destruction, over-harvesting, over-grazing, and invasive species [3].

[*] **Corresponding author N.K. Shahina**: Department of Botany and Research Centre, St.Albert's College, Ernakulam, Kerala, 682018, India; E-mail:shahinaferose@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

Mushrooms generate strong and contrasting feeling in people like profound liking to extreme aversions. These feelings are generally part of culture and tradition. Through ethnomycological studies around the world that explored the diversity of useful mushroom species over the poisonous ones and it enhanced awareness into their indigenous uses in different cultures.The cultural significance (CS) of an organism is used to determined by its value to specific group of individuals [4]. The knowledge and perception may vary based on gender and age group. Turner [5] observed that cultural significance is useful for decision-makers who want to identify which species to protect at sites threatened by human activity.

Wayanad region of Kerala has good microclimatic conditions for mushrooms. Preliminary ethnobotanical works in Kerala showed that ethnic tribes in Kerala are food gatherers and few gath-er mushrooms from the wild [6]. Kattunaikka tribes maintains traditional knowledge, they known to be consumed around 20-25 species of mushrooms for food [7]. The present work focuses on the usage and knowledge of symbiotic mushrooms among Kattunaikka individuals from Wayanad.

STUDY AREA, TRIBAL COMMUNITY AND SURVEY METHODS

Wayanad district is a hilly terrain on the southern Western Ghats and located in the North east part of Kerala State. The area lies between North latitudes 11°26′ to 12° 00′ and East longitudes 75° 75’ to 76° 56′. The altitude varies from 700 to 2100 metres above Mean Sea Level (MSL). The moist deciduous forest is the dominant vegetation type. Southern moist-mixed deciduous forests consists the ‘evergreen families’ of Western Ghats namely, Clusiaceae, Dipterocarpaceae and Myristicaceae. During wet season, because of the thick foliage, the canopy of West-coast tropical evergreen forests of Wayanad looks similar to that of semi-evergreen forests. During January-April, the trees become more or less deciduous but the forests never become deciduous in toto. The leafless period varies from a few weeks to five months depending on the species.

Kattunaikka is one of the primitive tribes in Kerala and are prefer to live in and around the forest. They speak Dravidian language mixed with Kannada. Food gathering, hunting, fishing, trapping of birds and animals are the traditional occupations of the Kattunaikka. Most of them do not possess land.

The informations about mushroom were collected through semi-structured and free listing interviews [8, 9] during monsoon seasons of 2014-2016 among 35 selected individuals from Kattunaikka, including 19 women and 16 men (ages 10 to >58 years) at class interval 15 to assess the traditional knowledge on mushroom. The other activities included transect walk with key knowledge

holders, collection trials and taxonomic identification. The cultural significance of each mushroom was calculated by using different sub indexes [10]. Perceived Abundance Index (PAI), Taste Score Food Appreciation Index (TSFAI), Health Index (HI), Knowledge Transmission Index (KTI) and Conservation Effort Index (CEI). Categorisation and values were assigned to the answers for each Sub index. All values were given equal weightage and each sub-index was averaged across all persons interviewed (Table **1**).

Table 1. Categorisation and values assigned to the answers for each cultural significance sub index.

Sub Index*	Answer	Value
PAI	None Rare Medium Abundant	0 3.33 6.67 10
TSAI	Not good Average Good Excellent	0 3.33 6.67 10
KTI	Newly discovered use, cooked alone From some other people belong to other tribe Three generations involved (he, father/mother not teach to his children) Three/four generations involved (parents,he/she, sons and grandparents)	0 3.33 6.67 10
HI	The person does not eat because of confusion with poisonous species Eaten but hurts the stomach Eaten with confidence and considered healthy Eaten because of the perceived health benefits (provides strength and is nutritious)	0 3.33 6.67 10
CEI	God gives/nature provides Clear the bushes or burn the area Leave some part of mushroom there itself/take only matured pieces/water the area Protect the place/tree/habitat	0 3.33 6.67 10

*PAI=Perceived Abundance Index, TSFAI = Taste Score Food Appreciation Index, HI = Health Index, KTI = Knowledge transmission Index.

RESULT AND DISCUSSION

Total 15 species of symbiotic mushrooms were collected and identified which belongs to 5 orders, 6 family, 6 genera. The Scientific name, local name and ecology of these mushrooms are detailed in Table **2**.

Kattunaikka people have well-developed knowledge on native edible symbiotic mushrooms and the vernacular naming of these mushrooms indicates their perception on mushroom ecology. Termitomyces species were generally called as huthanave (huthu= termite). The characters which were found to be used for

CHAPTER 3

Biodiversity Based Benefit-Sharing Activities to Improve the Livelihood of the Local/Tribal Communities of India

S. Rajasekharan[*], N.B. Mithrambika, Suresh Babu and **Dinesan Cheruvat**

Kerala State Biodiversity Board, L-14- Jai Nagar, Medical College P.O., Thiruvananthapuram – 695011, India

Abstract: India, one among the mega biodiversity countries is considered as the homeland of most diverse and rich traditional/tribal knowledge systems because of its unique cultural expressions which are directly or indirectly associated with biodiversity. The available information shows that there are 350-400 million tribal people residing in 1.73 lakh villages located in and around the forest areas of India. In spite of implementing various local/national/international programmes, the socio economic conditions of these communities are still not much improved due to various reasons like poor implementation of different welfare programmes, increased rate of exploitation, non-scientific collection of natural bio resources, lack of scientific approach on the part of the planners, policy makers, and administrators in understanding the real problems and aspirations of local/tribal communities. Therefore, we have adopted a new multi-disciplinary integrated approach with a view to upgrade their skills, technologies and to make them capable of meeting the changing needs of the communities. In this communication, the authors envisioned some of the activities like creating mass awareness by capacity building programmes among the target group through biodiversity management committees, developing user friendly data base on Peoples Biodiversity Register (PBR), implementation of various biodiversity conservation strategies, development of best practises, training on systematic and sustainable collection of Non Wood Forest Produce (NWFP), semi processing, value addition and marketing of medicinal/edible/aromatic plants. Further, introducing entrepreneurial capacity building programme and establishment of a 'Trust' under the patronship of BMC to implement various activities related to biodiversity conservation and sustainable utilization are also envisaged. Apart from this; the authors highlighted the functioning and connectivity of BMC for providing better livelihood opportunities to tribal/local communities through implementing Access and Benefit Sharing (ABS), programme.

[*] **Corresponding author Rajasekharan S.**: Kerala State Biodiversity Board, L-14- Jai Nagar, Medical College P.O., Thiruvananthapuram – 695011, India; E-mail:drrajsek@yahoo.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

Keywords: Access and benefit sharing, Medicinal and aromatic plants, People's biodiversity register, Sustainable utilization, Traditional knowledge.

INTRODUCTION

Biodiversity is the lifeline of the planet Earth and forms the foundation for all living beings. It is the base for a wide range of ecosystem services necessary for people's livelihood and well-being. According to Convention on Biological Diversity (CBD), biodiversity is defined as 'the variability among all living organisms from all sources, including, inter alia, terrestrial, marine and other aquatic ecosystems and ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems'. In India, the process of market-driven commercialisation and trading of biotic and abiotic resources started about 350 years ago when the Europeans started exploitation of biodiversity rich nations especially the tropical countries. The industrial scale of production of value added products based on the raw materials and the associated knowledge of the traditional societies led to a destructive extraction of the bio-resources, which undermined the ecological security and stability of biodiversity rich third world nations as well as the livelihood security of the traditional communities.

India has a long history of Traditional Knowledge (TK) associated with biodiversity which is directly linked with diverse sectors such as agriculture, animal husbandry, architecture, biodiversity conservation and sustainable utilization, ecofriendly practices, forest and wild life management, traditional health care, medicinal and food plants, rural technology *etc*. The subsectors of each of these components are enlisted in Appendix **1**.

India is considered as the homeland of most diverse and rich traditional folks/tribal knowledge systems because of its unique cultural expressions, which are directly or indirectly connected with environment, ecology, biodiversity *etc*., ranging from coastal, desert and plains to mountainous regions. This varied and diverse topography is the result of the typical climate, edaphic factors, physio-geographic conditions, which in turn resulted in a very rich variety and variability of flora and fauna especially the plants used for food and medicine. Medicinal and aromatic plant wealth of India is immensely rich and diverse and has attracted the attention of traders from all over the world. The diversity that occurs in the flora and fauna has played a major role for evolving a unique classical health tradition and local/oral health tradition in India including the tribal healing art [1].

The available information from the Ministry of Environment from Forest Govt. of India [2] shows that there are 350-400 million tribal people residing in 1.73 lakh villages located in and around the forest areas of India. The subsistence of these

communities is mainly dependent on various components of bio-resources available within the forest areas. It also provides basic livelihood needs like fodder, fire wood, edible fruits, edible tubers, medicinal and food plants, *etc*. Collection, processing and selling of non-wood forest produces (NWFP) is also a source of income generation to meet their immediate requirements like food, medicine, education, housing *etc*. In spite of implementing various local/national/international project/programmes, the socio economic conditions of these communities are still not much improved due to various reasons like unscientific implementation of programmes, the increased rate of exploitation, improper extraction of natural resources, lack of value addition, inability to introduce good collection, processing, storage and selling practice and lack of biodiversity conservation practices, both at *in-situ* and *ex-situ* level. It may be due to illiteracy and ignorance, lack of participation, involvement and scientific approach on the part of the planners, policy makers and administrators in understanding the real problems and aspirations of local/tribal communities. There is a lack of effective and efficient management framework for dispensing the welfare programmes to the communities. Therefore it is highly essential to evolve new pragmatic approaches in understanding the needs, aspirations and problems of the tribal/local communities with a view to formulate scientific methods to resolve their issues more effectively by implementing unique project/programmes in a sustainable manner.

In this context, the tribal/local communities must be brought under various awareness and capacity building programmes with a view to educate them about their rights and the necessity of self-help, by empowering them in acquiring the skills, knowledge and experience to take greater responsibility for the development, through implementing various activities with an ultimate objective to alleviate poverty by improving the access to and control of resources, which they need to sustain. Therefore, instead of providing monitory assistance, they must be trained for some gainful employment by using their own skills and aptitude to upgrade their skills, technologies and make them capable of meeting the changing needs of the communities. Past experience showed that assistance in the form of money and material have done more harm than good to tribal/local communities because most of the assistance thus received is being fretted away by others. Standards of material goods they produce make them capable of organizing small scale industries based on locally available bio resources. Location-oriented production technology will provide them with respectful, gainful employment which in turn help will them to lead a socially, economically and healthy productive life.

To achieve these goals, a multi-disciplinary, multi sector participatory programme on biodiversity conservation and sustainable utilisation specifically focusing on

CHAPTER 4

Biodiversity and Sustainable Utilization of the Genus *Garcinia* L. (Clusiaceae) of The Western Ghats

P. S. Shameer[1], Lekshmi N. Menon[2], K. B. Rameshkumar[2,*] and **N. Mohanan[1]**

[1] *Garden Management, Education, Information and Training Division, India*

[2] *Phytochemistry and Phytopharmacology Division, Jawaharlal Nehru Tropical Botanic Garden and Research Institute Palode, Thiruvananthapuram, Kerala, 695562, India*

Abstract: The Western Ghats, one of the biodiversity hot spots in India, is a major diversity centre of *Garcinia* species. The region harbors 11 *Garcinia* species, of which 9 are endemic. Most of the *Garcinia* species are economically important with wide utility in both traditional and industrial sectors. The present chapter assesses the distribution, taxonomy and conservation aspects of the Genus *Garcinia* of the Western Ghats. Sustainable utilization of *Garcinia* species through plant products such as condiments, gamboges, resins, essential oils and high value secondary metabolites has also been discussed in detail. The chapter highlights the importance of utility and conservation of plant wealth in the Western Ghats.

Keywords: *Garcinia* species, Western Ghats.

INTRODUCTION

Biodiversity encompasses the diversity of species of plants, animals, microorganisms, genes in the organisms and the ecosystems that host the organisms [1]. Over 3.5 billion years of evolution, speciation, migration and more recently, human influence has resulted in the distribution and degree of the biodiversity that exists today. Biodiversity has an important role in the economic sectors that drive development. In recent years, there has been a growing concern about sustainable development of human race, and the utilization of natural resources wisely has become a global trend and necessity [2].

* **Corresponding author K. B. Rameshkumar**: Phytochemistry and Phytopharmacology Division, Jawaharlal Nehru Tropical Botanic Garden and Research Institute Palode, Thiruvananthapuram, Kerala, 695562, India;
E-mail: kbrtbgri@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

The first step towards conservation of biodiversity and sustainable utilization of natural resources is enumeration of the existing diversity that may help in developing strategies for conservation and sustainable utilization [3].

Although much effort has been made to conserve the richness of species and biodiversity, the state of knowledge regarding the earth's biodiversity is still poor. Many species on the earth became extinct even before we could access or study their potential benefits. Biodiversity is under considerable threat due to various factors, both natural and man-made. Globally it is estimated that 27,514 plant species are threatened as per IUCN data [4].

India is one among the 12 mega biodiversity centers of the world with about 12% of the global plant wealth, and ranks 6th in biodiversity with over 17,926 higher plant species under 2991 genera and 251 families [5]. However, most part of the Western Ghats, Andaman and Nicobar Islands, and the Himalayas, that account for over 30% of the geographical area of India still remain to be floristically explored and documented. The angiosperm flora of India is characterized by high endemism, with nearly one third of the total plant species endemic to the country [6, 7]. Within the Indian subcontinent three mega centers and 25 microcenters have been described, based on the diversity and distribution of endemic species [8]. India is also recognized as one of the world's 12 Vavilovian Centers of Origin and Diversification of Cultivated Plants, known as the 'Hindustan centre of origin of crop plants' [9]. At least 167 species of important agri-horticultural crops and 320 species of their wild relatives, belonging to 116 genera and 48 families, are known to have originated here [10]. Other economically important food and spice crops such as wheat, legumes, sugarcane, sesame, citrus, eggplant, banana, mango, ginger, jute, turmeric, cinnamon, pepper and cardamom also have high level of diversity in the Country. In India it is estimated that about 3000 species of angiosperms are with potential medicinal values, of which around 1300 species are widely used in different traditional systems of medicine such as Ayurveda, Siddha and Unani and also in Allopathy [11].

The Western Ghats of India is one of the mega biodiversity regions in the world, with wide ranging flora, fauna and landscapes. It is the mountain range that runs parallel to the western coast of the Indian peninsula. The region is a UNESCO World Heritage Site and is one of the eight "hottest hot-spots" of biological diversity in the world [12, 13]. A recent enumeration has identified 7402 flowering plants in the Western Ghats, of which 1270 endemic species and the region is the centre of origin and diversity of several important spice and food crops [14]. Literature review revealed that more than 80% of the endemic flowering plants of the region are hitherto uninvestigated for their chemical

constituents, bioactivities or potential utilities [15]. In the Western Ghats *Garcinia* species are among such least explored group of plants.

DISTRIBUTION AND DIVERSITY OF *GARCINIA* SPECIES IN THE WESTERN GHATS

The genus *Garcinia*, the largest genus in the family Clusiaceae, has pantropical distribution with about 250 species, mainly in the Indo-Malayan region and in Africa. The genus has reached its greatest diversity in the Madagascar and South East Asia. *Garcinia* species prefers semi-evergreen to evergreen habitats. In India, the genus is represented by 44 species, of which 38 species occur in wild, whereas the rest were domesticated for cultivation [16 - 22]. In India, *Garcinia* species are distributed mainly in three phytogeographical zones *viz*., the Western Ghats, the North East India and Andaman and Nicobar Islands. Maximum diversity is in the North East India with 17 species including 3 endemic species, followed by the Western Ghats with 11 species including 9 endemic species (Fig. **1**).

Fig.(1). Fruit: **A**. *G. gamblei*, **B.***G. gummi-gutta*, **C**. *G. gummi-gutta* var. *conicarpa*, **D**. *G. gummi-gutta* var. *papilla*, **E.***G. imberti*, **F.***G. indica*, **G**. *G. morella*, **H.***G. rubroechinata*, **I.***G. pushpangadaniana*, **J.***G. talbotii*, **K.***G.travancorica*, **L.***G. wightii.*

CHAPTER 5

Diversity and Utilisation of Wild Edible Fruits in Agasthyamala Biosphere Reserve

R. D. Arun Raj[*], **M. Reginald Appavoo** and **R. D. Anpin Raja**

Scott Christian College (Autonomous), Department of Botany & Research Centre, Nagercoil, Tamil Nadu-629 003, India

Abstract: Agasthyamala Biosphere Reserve (ABR) in Southern Western Ghats has been identified as one of the three centers of plant diversity in India. The *Kanis (kānis)* or *Kanikkar,* an indigenous population residing in the ABR holds rich traditional knowledge on wild edible plants in this region. A total of 49 Wild edible fruits (WEF) classified among 36 genera and 26 families are consumed raw by the *Kani*s in ABR. Maximum number of the fruit species belong to the family *Myrtaceae* with eight species. The present chapter describes these underutilized fruits in the context of their diversity, multiple utility and economic potential.Nutritional composition with special regard to ascorbic acid and anthocyanin has also been emphasized. It highlights the significance of these fruits as a cheap source of nutrients, the need for sustainable processes and suitable conservation approaches to be formulated.

Keywords: Agasthyamala Biosphere Reserve, Biodiversity, Ethnobotany, *Kani*s, Wild edible fruits, Western Ghats.

INTRODUCTION

Biodiversity plays a crucial role in procuring different fundamental human needs [1]. The immense diversity of botanical resources with statistics worldwide shows that only a very small fraction of plant resources has yet been utilized by the human race. Indigenous people inhabiting forests have predominantly depended on the rich flora around them for livelihood since ancient times. These plants provide staple food for them, act as medicines for various ailments and offer an alternative source of income.

Wild edible flora, especially of fruits often form the essential part of nutrient and

[*] **Corresponding author R. D. Arun Raj**: Scott Christian College (Autonomous), Department of Botany & Research Centre, Nagercoil, Tamil Nadu-629 003, India; E-mail:arunrajrd@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

vitamin supplements for indigenous people. They contribute significantly to the food security of rural and tribal people and address the food shortage. Furthermore, these plant resources have considerable agronomic potential for the development of new crops through domestication and provide a genetic resource pool for hybridization and selection. Being a good source of macro and micronutrients, fruits can form an essential part of a healthy and balanced lifestyle. Mostly they are rich in rapidly absorbed sugars which are very sweet and have relatively high calorific values. The nutritional value of fruits lies mostly in their micro nutrient content and dietary fibers. Fruits, especially of tropical origin are among the best sources of ascorbic acid. They supply several minerals including potassium, iron, calcium, manganese, phosphorous and magnesium. They can also act as an optimal mix of antioxidants as they contain the phenolic compounds, anthocyanins, carotenoids and other flavonoids along with antioxidant vitamins which can modify the metabolic activation of carcinogens [2] and act as anti-aging compounds [3]. Scientific evidences indicate that intake of fruits has been associated with a reduced risk of cardiovascular diseases and cancer at several sites [4, 5].

Historically, fruits were selected based upon factors such as agreeable taste, size, shape, and crop's adaptability to different environments, seed storage life, ease of plant propagation and multiplicity of uses other than as a fresh fruit [6]. Fruits selected in such a way are the major ones which are frequently introduced from one region to another. Mean while, many minor fruits consumed by various aboriginal communities all over the world are not widely domesticated. Despite growing wild and showing little potential for cultivation, many of them have enough nutritional quality to be developed into a major fruit and to help the socio-economic change of indigenous communities [7 - 9]. It is not easy to distinguish certain wild edible plants, including fruits from the cultivated ones as they are occasionally cultivated also [10], defined wild edible plants as 'plants those are neither managed nor cultivated, but available from their natural habitat and used as sources of food. Wild edible fruits (WEF) are a major component of the 'Non Wood Forest Products' (NWFP), a broad 'group' of products that include all plant and animal forest resources excluding timber, proposed by forestry department of Food and Agriculture Organization (FAO) of the United Nations [11]. The tropical continents have good knowledge of minor fruits . Approximately 2,800 minor fruits, 800 in America; 1,200 in Africa and 500 in Southeast Asia have been enlisted so far [12]. A total of 344 species has been described [13] from the Indian subcontinent alone. The small WEFs are often referred to as "natural functional products" and recommended today as a supplement for healthy diets in even the most developed regions of the world [14]. Analytical studies from various parts of the world prove that many of these fruits are nutritionally superior to some of the cultivated ones in several constituents [15 - 20]. Nevertheless, the

coverage of wild fruits consumed by tribal communities in all existing nutrient databases is sporadic, compared with the number of fruits consumed.

The major portion of Indian flora is encompassed by the 37% of the nation's forest cover [21], which mainly occupies the two high biodiversity hubs, the Eastern and Western Ghats. Of which, the Western Ghats is one of the 25 hotspots of the world [22] which harbours over 7000 species of flowering plants and is also home to many primitive and advanced ethnic communities who account for 5% of the area's population. The ethno botanicalstudies in Western Ghats have mainly focused on the medicinal plants, but those which stress the importance of WEFs are limited in number [23 - 29]. The indigenous communities of this area depend on the edible plants in the dense and unbroken forest ranges which are comprised of the two biosphere reserves *i.e.* The Nilgiri and Agasthyamala, and many other protected forests. Agasthyamala Biosphere Reserve (ABR) falls within the Indo-Malayan realm and lies between 8°5' to 13°00' N latitudes and 77°52' to 77°34' E longitudes (Fig. **1**).

It is located in the southern end of the Western Ghats, and includes a towering peak, 'The Agasthyarkoodam' at 1868 m, and the adjoining forests in Tirunelveli and Kanyakumari districts of Tamil Nadu and Thiruvananthapuram and Kollam districts of Kerala, covering an area of over 3500 km^2 including a core area of 1135 km^2, a buffer zone of 1445 km^2 and a transition zone of 920.36 km^2. IUCN has identified ABR as one of the three centers of plant diversity in India. It has also been identified as one of the three endemic centers in Kerala [30]. The ABR harbours vast plant diversity of about 2254 species of flowering plants, belonging to 75 families of which 475 species are endemic to Western Ghats. There is a tremendous diversity of wild edibles including many fruit bearing species found in these forests.The vegetation of this zone mainly consists of southern secondary moist mixed deciduous forests, west coast semi evergreen forests, riparian fringe forest *etc*. It comprises of a Tiger Reserve, Kalakad-Mundanthura and three wildlife sanctuaries, Shendurney, Peppara and Neyyar.

The *Kanis (kānis)* or *Kanikkar*is the only one indigenous community who live and practice their customs over centuries in the ABR and most of their settlements are located on its western portion. There are 159 tribal settlements located in this Biosphere Reserve, distributed in Kerala and Tamil Nadu [31]. *Kani*'s population of ABRis estimated to be approximately 25,000. The current main source of their income is from the mixed agriculture, wage labour and Non Wood Forest Products (NWFP) collection. *Kani*s are often known for their rich tradition in herbal medicinal practices. A restorative, immune enhancing, anti-stress and anti-fatigue drug, '*Jeevani*' has been developed based on the herbal medicinal plant '*Arogyapaacha*' (*Trichopus zeylanicus* L.) used in their traditional medicine [32].

CHAPTER 6

Creating an Economic Stake in Conservation: A Case of Sustainable Fishery Resource Management from Godavari Mangrove Wetlands of Andhra Pradesh

R. Ramasubramanian[*], **V. Selvam** and **N. Anil Kumar**

M. S. Swaminathan Research Foundation, III Cross Road, Taramani, Chennai, 600 113, India

Abstract: Mangrove ecosystem is one of the most productive coastal ecosystems providing multiple benefits to the coastal community. Mangrove forests provide more than 70 direct benefits ranging from fuel wood to fisheries resources to the coastal community. Mangrove wetlands act as spawning and nursery ground for various marine fishes, shellfishes and crustaceans with due presence of detritus. The high organic matter in the mangrove ecosystem enhances the fishery production. Since, mangrove wetlands provide livelihood to the coastal fishermen living near the mangrove wetland, the study was carried out in the Godavari mangrove wetland. The total landing from the five fish landing centres in the Godavari mangrove wetland showed that about 1,550.8 tonnes of total fishery resources were caught by 45,075 motorized and 16,572 non-motorized boats during the study period between February and December 2012. The average catch by the motorized and non-motorized boat catch per day was 23.84 kg and 20.61 kg respectively. In the group wise fishes, the fin fish catch was high while in the species wise catch, shrimps dominated the catch with a total of 195 tonnes, accounting for 13% of the total catch, followed by Mullets (11%), Crabs (10%) and molluscan shells (9%). The fish catch during summer was generally low and higher in pre-monsoon season (June).

Keywords: Finfish, Fishery resources, Livelihood, Mangrove ecosystem, Motorised boats, Non-motorised boats, Shrimp.

INTRODUCTION

Mangrove ecosystem occurring in the inter-tidal areas of tropical and sub-tropical coastal regions is one of the most productive coastal ecosystems providing multiple benefits to the local community.

[*] **Corresponding author Ramasubramanian R**: M. S. Swaminathan Research Foundation, III Cross Road, Taramani, Chennai, 600 113, India; E-mail:ramasubramanian@mssrf.res.in

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

It acts as a barrier against cyclonic storms and tsunami-induced storm surges and protects the agriculture lands, shrimp farms, livestock and the habitations.

Studies carried out after the 1999 super cyclone in Odisha and the 2004 Indian Ocean tsunami proved that mangroves are effective bio-shields. The loss of lives and the property was minimal in the villages covered with dense mangroves when compared to the loss in the villages without mangroves [1, 2]. The root system of the mangrove plants helps in trapping of the sediments brought by the rivers and also reducing the coastal erosion and to build the estuary.

In addition, the mangrove wetlands act as spawning and nursery grounds for various marine fishes, shellfishes and crustaceans [3 - 6]. The litter fall from one acre of mangrove wetland per year is about seven and a half tons. Litter fall is one of the indices of mangrove productivity. The detritus from the mangrove litter supports fishery [7]. High organic matter in the mangrove areas enhances the fishery production as they mainly feed on small benthic organisms [8].

Mangrove ecosystem is rich in biodiversity with diverse groups of aquatic and terrestrial organisms. The total diversity of the Indian mangroves is the highest in the world. The total species diversity of Indian mangrove is about 4,011, in which 920 are plant species and the remaining 3,091 are animal species [9]. Indian mangrove ecosystem covers 8% of the world's coast and 25% of the tropical coastline [10]. Mangrove forest is an important coastal resource for the economic development of coastal community, particularly the fishers. Mangrove forests provide more than 70 direct benefits ranging from fuel wood to fisheries [11, 12].

About 150 million people in Asia depend on fishing and allied activities. The fisheries sector provides animal protein for the human beings apart from providing livelihood and employment to thousands of fishermen. It also helps in earning foreign exchange. Rapid increase in population, degradation of marine ecosystems and increase in demand for fish result in dwindling fish stocks [13]. In Bangladesh, India, Indonesia and Vietnam large coastal population depend on the mangrove resources for their livelihood and other requirements [14]. However, the extent of mangroves has declined globally by about 50%, and in Asia, it has lost to 61% during the last three decades [14]. The degradation of the mangrove wetland has a direct impact on the livelihood of the coastal community particularly in the South Asian countries. The mangrove-dependent community catches fishes throughout the year in the mangrove wetland, unlike the marine fishing which is seasonal.

In this paper, we present the results of a study on capture fish assessment of Godavari mangrove ecosystem of Andhra Pradesh in India carried out as part of an initiative on conservation and management of coastal resources. Under this

initiative, the utilization of fish genetic resources of Godavari wetland was assessed between February and December 2012, and promoted integrated fishery development as a sustainable livelihood opportunity for the local community.

THE GODAVARI MANGROVE WETLAND

The flora and fauna of the Godavari mangrove wetland have been extensively studied [15 - 23]. There is no exclusive study on the fish landing from the Godavari mangrove wetland. This study reflects the economic importance of the mangrove wetland particularly for the artisanal fishermen living near by the mangrove wetland. The floral and fishery diversity of the mangrove wetland is in given (Table **1**).

Table 1. Diversity of mangrove flora and fishery resources including fin fishes and shell fishes.

S.No.	Mangrove and Associated Flora	S.No.	Name of the Species
			Crabs
1	*Avicennia alba*	1	*Scylla serrata*
2	*Avicennia marina*	2	*Pseudograpsus intermedius Chhapgar*
3	*Avicennia officinalis*	3	*Uca* sp
4	*Acanthus illicifolius*	4	*Macropthalmus crinitus*
5	*Aegiceras corniculatum*	5	*Pachygrapsus sp*
6	*Bruguiera cylindrica*	6	*Sesarma quadrata*
7	*Bruguiera gymnorrhiza*		**Finfish**
8	*Ceriops decandra*	7	*Stolephorus indicus*
9	*Excoecaria agallocha*	8	*Cynoglossus puncticeps*
10	*Rhizophora apiculata*	9	*Dendrophysa russelli*
11	*Rhizophora mucronata*	10	*Mugil cephalus*
12	*Sonneratia apetala*	11	Sardinella *fimbriata*
13	*Sonneratia alba*	12	*Elutheronema tetradactylum*
14	*Scyphiphora hydrophyllacea*	13	*Pisodonophis boro*
15	*Xylocarpus moluccensis*	14	*Terapon jarbua*
	Mangrove Associates	15	*Hilsa ilisha*
16	*Clerodendrum inerme*	16	*Arius caelatus*
17	*Hibiscus tiliaceus*	17	*Pomadasya hasta*
18	*Lumnitzera racemosa*	18	*Lates calcarifer*
19	*Thespesia populneoides*		**Molluscs**

CHAPTER 7

Economic Thoughts in Mainstreaming Biodiversity

Prakash Nelliyat*

Fellow (ABS), Centre for Biodiversity Policy and Law National Biodiversity Authority, 5th Floor, TICEL Biopark, Taramani, Chennai- 600113, India

Abstract: The composition between the global ecosystem/biodiversity and the economic system has been changing drastically with respect to population and economic growth. Unscientific economic growth without adequate precautions for safeguarding biodiversity has far-reaching consequences. Biodiversity loss is an external/social cost, since it hampers economy and the livelihood of people. The external issues and the need for their internalization have been widely discussed by environmental economists, which is the base for mainstreaming them. Rapid economic growth is imperative for a developing country like India. However, the preservation of natural resources like biodiversity, on which millions of people depend, is equally important to ensure that growth is more inclusive and sustainable. It is vital that every nation should preserve its biodiversity and the health of diverse ecosystems for global harmony, where mainstreaming the biodiversity concerns in various developmental programs is inevitable. Even if mainstreaming is an ideal approach for sustainable development, its practicability and success are dependent factors and a huge challenge, particularly for developing countries. More awareness generation, scientific information which establishes the linkages of biodiversity with developmental sectors, multi-stakeholders' co-operation, financial support, and incentive measures can facilitate biodiversity mainstreaming. Valuation of the biodiversity goods and services and damage costs is significant. Through valuation, one can easily convey the overall importance of biodiversity as well as the damage costs, due to haphazard economic growth, to the public and the policy makers, who are the key actors in mainstreaming biodiversity.

Keywords: Cost of Inaction, Economic Valuation, Internalization of Externalities, Mainstreaming Biodiversity, Sustainable Development.

INTRODUCTION

Over the last few decades human beings have changed their surrounding environment to meet the increasing demands for food, water, timber, textiles and fuel through unsustainable practices.

* **Corresponding author Prakash Nelliyat**: National Biodiversity Authority, 5th Floor, TICEL Biopark, Taramani, Chennai- 60011, India; E-mail:prakashnelliyat@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

This has compromised the long term resources and services that these ecosystems provide (ecosystem services), like clean air, water, or shelter from adverse weather. As a result many people, especially the poor in the developing world, have difficulties meeting their basic subsistence needs [1]. The world has recognised this fact and has come up with various remedial measures for reducing the damage to biodiversity under the umbrella of the Convention of Biological Diversity (CBD). However, its practicability and successful implementation are a challenge particularly to developing countries, where more developmental pressure exists.

According to IUCN [1], if sustainable development needs to be achieved and the services that biodiversity and healthy ecosystems provide to humans maintained, it is clear that biodiversity at all levels (species, ecosystems and genes) needs to be conserved and used sustainably. However, this cannot be achieved through isolated work in the ecosystem/biodiversity domain by the environmental community, but needs the collective endeavour of all parts of society, governmental agencies, non-governmental organisations and the private sector alike.

In this regard, mainstreaming biodiversity or the integration of biodiversity concerns in every developmental project and program is required. The paradox here is that traditionally biodiversity conservation has been the responsibility of the environment sector, and undertaken through tools such as enforcement of legal decisions, 'polluters pay principles' as well as the incorporation of protected areas. The developmental sector generally ignores its responsibility for biodiversity conservation.

However, developmental sectors should understand the fact that many economic sectors including agriculture, fisheries, forestry, health, nutrition, water supply, energy, trade, industry, transport and tourism depend on biodiversity. They also impact biodiversity in some way and at some level, and that can have far-reaching effects both on time and space. Presently, the biodiversity in most parts of the world is under threat and its consequences on economy and the business sector, and the livelihood of people may be innumerable. Hence, a more responsible approach from various developmental sectors towards biodiversity management is the need of the hour.

As mainstreaming is a complex phenomenon, a thorough understanding of the concept and its implementation mechanism, with the required information base includes the value of biodiversity, that needs to be explored, which is the focus of this paper/chapter. The first part of the paper emphasises on the background and the need for mainstreaming biodiversity. In this regard: (a) the socio-economic

significance and emerging challenges on biodiversity, (b) India's biodiversity scenario: daunting challenges and the need for its conservation and sustainable use, (c) the linkages between the global ecosystem/biodiversity system with the economic system and the metamorphosis of this linkage with respect to population and economic growth, and (d) the internalization of externalities or the social costs principle and its association with mainstreaming, have been discussed in detail. The second part is focussed on: (a) mainstreaming biodiversity: definition and scope, (b) mainstreaming biodiversity: a strategy with global significance for biodiversity management and (c) information base required for mainstreaming.The third part emphasised on the valuation of biodiversity for mainstreaming. The forth section is a case study on a South Indian textile industrial cluster on the ground of negligence of mainstreaming. The last (fifth) part gives the conclusion and the way forward.

BIODIVERSITY: SOCIO-ECONOMIC SIGNIFICANCE AND EMERGING CHALLENGES

Biodiversity means the variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems. The diversity includes variability within species (genetic diversity), between species (species diversity) and ecosystems (ecosystem diversity). It underpins the ecosystem functions and provides services such as: water purification and supply, waste assimilation and cleaning the air and water, regulation of pests and diseases, and soil nutrient cycling and fertility. Biodiversity influences the ecosystem's resilience. It plays a critical role in risk reduction, and helps to mitigate unpredictable global changes and natural disasters.

The rich biodiversity is the basis for good health, food security, economic growth, livelihood security and moderation of climatic conditions. The annual contribution of biodiversity to the world is estimated as USD 33 trillion. Many ecosystem/biodiversity goods and services are direct benefits and act as a safety net to indigenous peoples, poor and vulnerable groups, women, and children. Globally more than 1.3 billion people depend on biodiversity and on basic ecosystem goods and services for their livelihoods [2].

Biological resources and genetic materials are significant for manufacturing a wide range of consumer products having huge market potential at domestic and international level. Bio-resources and biodiversity are highly interlinked. Bio-resources are renewable and can be considered as a subset of biodiversity. One can interpret biodiversity as a stock and bio-resources as the flow from it; they are mutually interrelated in their existence and function [3]. Hence, the earth's biodiversity stock should be maintained intact through its sustainable utilization

CHAPTER 8

Concepts of Robustness and Ecosystem Health – with Case Studies from The Indian Context

Arnab Banerjee[1,*], **Santanu Ray**[2,*] and **Priti Kumar Roy**[1]

[1] *Centre for Mathematical Biology and Ecology, Department of Mathematics, Jadavpur University, Kolkata 700032, West Bengal, India*

[2] *Systems Ecology and Ecological Modeling Laboratory, Department of Zoology, Visva-Bharati University, Santiniketan 731235, West Bengal, India*

Abstract: Reservoirs and estuaries are two diverse types of aquatic ecosystems that have their own uniqueness. While artificial aquatic systems like reservoirs encompass hybrid characters of both lakes and streams, estuaries are considered as the most productive of all ecosystems. A detailed study of these ecosystems becomes essential to comprehend the health of such systems. Universal to any ecosystem is its ability to counter conditions of stress and this ability termed as robustness signifies the systems' sustainability. Robustness is a good indicator of ecosystem health and is also dependent on the magnitude and type of inflicted stress. A comparative analysis of ecosystem health and robustness indicators of Bakreswar reservoir and Hooghly Matla Estuarine system is presented as case studies. Descriptive ecosystem indices are discussed in the current study including different network indicators. As a conclusion of this study, it has been observed that while the Bakreswar reservoir is moderately stable with a fairly robust and mature system, the Hooghly ecosystem is facing degradation. Ecological network indices revealed that variation in robustness values for both the systems is related more with the fish biomass perturbation scenario rather than the producer perturbation. This is confirmed by the various network indices used for analysis.

Keywords: Ecological Network Analysis, Ecopath with Ecosim, Food Web, Reservoir, Trophic Structure.

INTRODUCTION

American conservationist Aldo Leopold (1887 – 1948) metaphorically spoke of the concepts of land health, sickness, mutilation, and violence while referring to land usage practices. The expression 'Ecosystem Health' is now widespread in ecological literature and is used as a general metaphor signifying something good

* **Corresponding authors Arnab Banerjee**: Centre for Mathematical Biology and Ecology, Department of Mathematics, Jadavpur University, Kolkata 700032, West Bengal, India; E-mail: arnab.banerjee@visva-bharati.ac.in **& Santanu Ray**: Systems Ecology & Ecological Modeling Laboratory, Department of Zoology, Visva-Bharati University, Santiniketan 731235, West Bengal, India; E-mail: sray@visva-bharati.ac.in

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

with the goal of finding the quality of both terrestrial and aquatic ecosystems like forests, rivers, lakes, and seas [1 - 4]. Environmental goals like conservation of viable population of native species and ecosystem diversity, maintenance of evolutionary and ecological processes, longtime management of evolutionary potential while accommodating for anthropogenic intervention and occupancy, have led to surveys related to ecosystem management and ecosystem health [5].

Over time, authors have tried to define 'ecosystem health' by standardizing the state of an ecosystem before the involvement of human and successive anthropogenic stress [6]. Lack of historical data for such man-reformed places and the reshuffling of species composition as evidenced by fossil records make it difficult to identify the time frame at which a particular ecosystem can be termed as healthy [7]. Though there is no direct method for assessment of any ecosystem possessing the following three attributes are considered 'healthy'; these include 1) productivity, 2) resilience, and 3) organization of biodiversity. These systems can endure stress and persist normal functioning [8 - 10].

In most cases, there are few reliable health indicators; for example, in forest ecosystems, the richness and abundance ensure that the invertebrates have a significant role in maintaining the system, but no single species, can be identified as reflectors of the system health [11]. Thus the need for other indicators for system health arises and many ecosystem indices can provide acceptable results for achieving this goal. These indicators are ecological network analysis (ENA) indices including Total System Throughflow (*TST*), Development Capacity (*DC*), Ascendancy (*A*), Redundancy or Overhead on Internal Flows (*O*), Finn Cycling Index (*FCI*), Robustness, and also eco-Energy content of a system [12 - 15].

The recovery of a perturbed ecosystem depends on the amount of resilience and robustness that the system possesses, which ensures continued functioning compared to its previous state [16] or sustaining some components regardless of the hostile conditions [17]. The recovery of the system also depends on the condition that it has not passed the point of irreversible change [18]. The last condition refers to an ecosystem property of resilience which is generally an ideal balance between the ecosystem and its efficiency to function optimally [15, 19 - 22].

As an ecosystem approaches maturity, its efficiency increases, and this in turn reduces the resilience. Too much resilience in the system has lots of diversity in-flows that prevent optimal functioning. A huge system usually presents a well-formatted multiplicity of connections among the constituent components and thus increase resiliency [23, 24] while sacrificing efficiency [19, 22]. It has been observed that an ecosystem functions optimally within a narrow range of this

balance between resilience and efficiency which is termed as the 'window of vitality' [19, 22]. Costanza (1992, b) [25] described ecosystem health as the cumulative function of three properties as *Health = System Vigor* x *System Organization* x *System Resilience*. Therefore it is necessary to study ecosystems from this point of view, in order to ascertain their robustness or health [10, 26].

The recovery of an ecosystem is directly related to the level of robustness of it. If a system can endure stress and continue functioning, it can be considered as robust [16 - 18]. The calculation of the robustness of an ecosystem depends on the analysis of the food web of that region [10, 27].

Artificially created ecosystems like reservoirs and estuaries are no exception from this situation. These water bodies have transitional properties of both lotic and lentic systems [28, 29]. Bakreswar reservoir, the current area of focus, fulfills most of the properties of a typical reservoir system, like the supply of freshwater, providing economic support to the villages of neighboring areas, and also offer some elements of recreational value [30].

Robustness studies have been conducted in different types of ecosystems *viz.* reservoirs, estuaries, *etc*. [31]. The case study presented here deals with health indicators for the Bakreswar reservoir ecosystem with a particular focus on robustness which is used as an ecosystem indicator for ENA.

CASE STUDY – BAKRESWAR RESERVOIR

Methodology

Study Site

Bakreswar reservoir, built on the Bakreswar River in 1999 initially proposed as a backup water supply for the Bakreswar Thermal Power Plant, is the current case study site. This artificial water body is located between lat. 23^{O} 50.519’ N; long. 87^{O} 24.612’ E (Fig. **1**) also serves as a source of drinking water supply for the neighboring villages and also as an abode for migratory birds [32]. According to [33], this reservoir has a storage capacity of 2.29 million m^3 and is spread over an area of 6.38 sq. km. A detailed study of trophic structure [30] and environmental factors and spatial pattern of zooplankton [34, 35] have been done previously showing that this reservoir is a moderately mature ecosystem with fair chances of facing stress due to anthropogenic impacts.

CHAPTER 9

Climate Change and Its Impacts on Marine Fisheries and Livelihood: An Indian Perspective

Biju Kumar A.[*] and **Suvarna Devi S.**

Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram-695581, Kerala, India

Abstract: Fisheries and related activities, including aquaculture in inland and marine sectors, offer livelihoods to thousands of people in developing countries like India, besides contributing significantly to economic and nutritional security of the nation. One of the major challenges in the world, especially in developing countries like India, is to address the issue of sustaining the dwindling fisheries resources, while meeting the challenges posed by emerging external threats on resources, such as climate change. In the marine sector, climate change is projected to affect individual organisms, populations, species distributions, and ecosystem composition and function both directly (*e.g.*, through vagaries in precipitation, temperature, sea level changes, ocean acidification, *etc*.) and indirectly (*e.g.*, through the intensity and frequency of extreme climate events such as storms). Evidence of climate-change impacts is the strongest and most comprehensive for natural systems and it impacts lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific period and the vulnerability of an exposed society or system. The major adaptive strategies evolved centers around providing awareness to the coastal population, training on alternate livelihoods in order to negate the risks and ill effects of climate change, and vulnerability assessment at micro levels. There is also a need for flood mapping, flood forecasting, development of a hydrological framework and downscaled climate change projection modelling coupled with strengthening coastal protection methods with the participation of local communities. These adaptation methods would become effective only through mainstreaming biodiversity into climate change strategies and by integrating climate change risk in the disaster management policies.

Keywords: Adaptation, Blue growth, Climate change, Livelihood, Management, Ocean acidification.

[*] **Corresponding author Biju Kumar A**: Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram- 695581, Kerala, India; E-mail: bijupuzhayoram@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

INTRODUCTION

Fisheries and aquaculture, especially in the marine environment, besides satisfying the protein requirement for millions of people around the world, support the livelihood of several millions directly or indirectly from activities in the fisheries sector. In the recent past, oceans are seen as the primary ecosystem to augment the economy and 'Blue Growth' is a strategic, innovative approach to improve the use of aquatic resources while simultaneously increasing social, economic and environmental benefits for communities dependent on fisheries and aquaculture [1]. The aim of the concept is to "secure or restore the potential of the oceans, lagoons and inland waters by introducing responsible and sustainable approaches to reconcile economic growth and food security with the conservation of aquatic resources" [2]. At the same time, one of the major challenges before human societies is to provide food and livelihoods to a population of above 9 billion people by the middle of the twenty-first century, while addressing a series of environmental issues of the modern time, including climate change on the depleting resource base [3].

The global commitments aim to end poverty and hunger and ensure that economic, social and technological progress occurs in harmony with nature, through the sustainable management of natural resources, as envisaged in the United Nations Agenda 2030 for Sustainable Development Goals [4]. Climate change is one of the major challenges facing mankind today, in order to achieve the sustainability of dwindling natural resources that form part of fisheries. The Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), which came into force on 4th November 2016, is one of the important steps towards addressing the issues of climate change on aquatic resources. The agreement, which aims at keeping the global temperature rise in this century well below 2°C above pre-industrial levels, recognizes the fundamental priority of safeguarding food security and ending hunger [3].

Surrounded by the Indian Ocean, the Arabian Sea and the Bay of Bengal, India has a coastline of above 7,500 km, spanning nine maritime mainland States and two Union Territories (UTs). The Exclusive Economic Zone (EEZ) extends to 2.02 million sq km and the continental shelf area to 0.18 million sq km. The Indian coasts support about 20 per cent of the total 1.2 billion human population. The coastal and marine ecosystems are highly productive and provide significant contributions to food and nutritional security, economic and social development from fisheries and aquaculture, marine and coastal tourism, shipping, mining, energy, and ecosystem services such as carbon sequestration, water filtration, atmospheric and temperature regulation, protection from erosion and extreme weather events. However, these systems are increasingly under pressure due to

unsustainable development practices, destruction of habitats, pollution, over exploitation of resources, presence of invasive alien species and climate change.

Global capture fisheries production was 90.9 million tonnes in 2016, with the marine sector contributing to about 87.2 million tones [3]. In India the estimated marine fishery landing recorded 3.56 million in the year 2019, registering the seventh position in global marine fish production [5]. Further, this sector provides employment to about one million fishers and contributes to over 30,000 crores of Indian rupees towards export earnings of the country annually [5]. While the promise of fisheries sector towards strengthening economy, poverty alleviation and nutritional security are brighter, the issues of over exploitation, habitat degradation and fragmentation, invasive alien species, pollution and climate change have contributed to the decline in productivity in the sector. The contribution from capture fisheries (fisheries from natural water bodies) is reaching its limits; there is ample scope for expanding aquaculture, especially in the lesser attended coastal waters. One of the major challenges in the world, especially in developing countries like India, is to address the issue of sustaining the dwindling fisheries resources, while meeting the challenges posed by emerging external threats on resources such as climate change. Therefore, there is an urgent need to assess, to the extent possible, the potential impacts of climate change on fisheries and aquaculture and related well-being of the people who depend on these resources, not to speak of filling the knowledge gap available in the field through intensifying research and strengthening the database.

IMPACTS ON FISHERIES

Climate change is projected to affect individual organisms, populations, species distributions, and ecosystem composition and function both directly (*e.g.* through vagaries in precipitation, temperature, sea level changes, ocean acidification, *etc*.) and indirectly (*e.g.* through changing the intensity and frequency of extreme climate events such as storms). Evidence of climate-change impacts is strongest and most comprehensive for natural systems and it impacts lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climatic events occurring within a specific period and the vulnerability of an exposed society or system [6].

Studies around the world have proved unequivocally that aquatic systems that sustain fisheries and aquaculture are undergoing significant changes as a result of global warming and projections indicate that these changes will be accentuated in the future [7]. A number of marine species, depending on their mobility and habitat connection, are responding to climate impacts by shifting their distributions poleward and to deeper waters [3]. Further, increased uptake of

CHAPTER 10

Integrated Approach for Developing Biologically Diversified Urban Landscapes @ TCS: A Success Story

Naik Laxmikant*

Environmental Sustainability, Health & Safety, Tata Consultancy Services,Yantra Park -(STPI), 2nd Pokharan Road, Opp HRD Voltas Center, Subash Nagar Thane - 400601, Maharashtra, India

Abstract: TCS has given a new dimension to sustainability by implementing site specific biodiversity mapping & action plans, biotechnology solutions for waste management and community bio-conservation programs. This integrated approach turns TCS campuses into the biologically diversified urban landscapes.

Keywords: Bio-conservation, Biodiversity mapping, Integrated sustainability, Urban landscapes.

INTRODUCTION

Biodiversity is the foundation of life on earth and one of the pillars of sustainable development. Biodiversity, in general, and urban biodiversity, in particular, are under severe threat and is decreasing at an alarming rate due to various processes of urbanization, industrialization, environmental pollution *etc*. There is an urgent need to take necessary steps for conservation and enhancement of various elements of urban biodiversity. Large landscapes in urban areas play significant roles in protecting and conserving biodiversity.

Tata Consulting Services Ltd, a leading and the largest IT Company in India, has given a new dimension to sustainability by linking biodiversity conservation to business process.

* **Corresponding author Naik Laxmikant**: Environmental Sustainability, Health & Safety, Tata Consultancy Services,Yantra Park -(STPI), 2nd Pokharan Road, Opp HRD Voltas Center, Subash Nagar Thane - 400601, Maharashtra, India; E-mail:laxmikant.pnaik@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

An integrated approach is followed to developing biologically diversified landscapes through effective implementation of site specific Biodiversity Action Plans for conservation and enhancement of native urban biodiversity.

MATERIAL AND METHODS

Biodiversity conservation is an integral part of TCS environment philosophy and planning for sustainable development. Biodiversity considerations are integrated into Environmental Management System of ISO14001. The present discussion deals with biodiversity within the 14 owned/leased TCS campuses (Table **1**) throughout India which varies from 2.5 acres to 70.0 acres in major cities.

Biodiversity mapping has been carried out and species recorded were enlisted. The survey for floral species was carried out based [1] while for fauna methodology [2] adopted includes the direct sighting of animals [3 - 5], and indirect methods through calls, dropping, habitats and nests, burrows, discussion with the local staff *etc*.

Based on the biodiversity mapping site specific Biodiversity Action Plan was formulated and has been implemented for conservation and enhancement of flora and fauna for the protection of depleting urban biodiversity.

Table 1. List of TCS Facilities under consideration across India.

Sl. No.	Name of Facility	Location/Type (W/L) Owned/Leased	Area (Acres)
1	Kalinga Park	Bhubaneswar (W)	45.00
2	Siruseri	Chennai	70.00
3	Banyan Park	Mumbai (W)	22.50
4	Yantra Park	Thane (W)	13.70
5	Sahydri Park	Pune (W)	50.00
6	Garima Park	Gandhinagar(W)	25.50
7	Awadh Park	Lucknow (L)	03.50
8	Mihan	Nagpur (W)	54.00
9	Noida-2	Delhi (W)	02.50
10	Deccan Park	Hyderabad (W)	22.50
11	Synergy Park	Hyderabad (L)	69.23
12	Peepul Park	Trivandrum (W)	14.50
13	New Campus	Kochi (W)	15.60

(Table 1) cont.....

Sl. No.	Name of Facility	Location/Type (W/L) Owned/Leased	Area (Acres)
14	Think Campus	Bangalore (L)	10.00

RESULTS

Biodiversity of TCS urban landscapes across the India (Fig. **1**) is taxonomically represented by 380 species of flora represented by 256 genera and 100 families. Psygiognomically flora can be categorized as trees, shrubs, herbs, grasses, climber's ferns, epiphytes and bamboo.

Fig. (1). A view of ecofriendly TCS campuses in India (Kochi, Hyderabad, Bhubaneswar *etc*.) Biologically diversified green envelope.

The native plant species having ecological significance in terms of shade, fruit, ornamental and medicinal values are selected for landscaping. The campuses across the country boasts of a large number of well grown native trees with a few rare and endangered species (Fig. **2**) such as Baobab Tree (*Adansonia digitata*,Thane), Red Sandal Wood (*Pterocarpus santalinus* Kolkata & Bhubaneswar), Rudraksh Tree (*Elaeocarpus granites* Bhubaneswar and), Camphor Tree (*Cinnamomum camphora* Bhubaneswar).

Biodiversity action plan is a multifaceted strategic approach for implementation of various following programs for conservation of flora and fauna. The details of the conservation program are discussed below.

Flora Conservation Programs

It includes, creation of habitat, protection of traditional native plant species (Fig. **3**), transplantation of trees during construction phase, protection of endangered, rare, threatened plant species, implementation of various plantation drives under Greening the office Program, establishing medicinal garden within premises, providing nursery for propagation of plants *etc*.

CHAPTER 11

Interface Between Instruments of Development Planning and Biodiversity Planning and Conservation

Meenakshi Dhote[*] and **Jayeeta Sen**[*]

School of Planning and Architecture, Department of Environmental Planning, New Delhi – 110002, India

Abstract: Biodiversity sustains human civilisation as it is intricately related to the supply of all the ecosystem services that underscore human well-being. The connotation 'human well – being' denotes amongst other things 'security' that entails security to 'resource access' and 'adequate livelihoods'- as basic materials for a good life. However, the benefits of growth and development accruing from our natural resources need to be distributed equitably amongst the 'people' without damaging the 'ecological health of the planet' to achieve the goals of the sustainable development (2015) at the global level.

Though cities are proficient means of spatial organisation that provide shelter and livelihood to a large number of people and have developed into foci of innovations and economic growth they have been inept of taking care of nature due to their exhaustive and unsustainable consumption pattern. They are intense hubs of energy and material consumption that emanates massive wastes damaging environmental health and, in turn, biodiversity.

The answer to this dilemma lies in the Mainstreaming Biodiversity into the city planning and management which will balance biodiversity and development. Mainstreaming or including biodiversity into urban planning is imperative as cities draw numerous ecosystem services at local, regional and global scales. However, this expression 'mainstreaming' warrants a clear understanding of the jargon itself and the instruments that will enable integration of the same.

In this paper, an attempt has been made to explore the diverse instruments that are available at the global, national, subnational and local levels for biodiversity conservation and management and urban planning processes. The idea is to explore the interface that exists between the instruments of the two spheres and create a convergence between the processes of urban planning and biodiversity conservation.

[*] **Corresponding authors Meenakshi Dhote & Jayeeta Sen**: School of Planning and Architecture, Department of Environmental Planning, New Delhi – 110002, India; E-mails: jayeetaplanner@gmail.com and m.dhote@spa.ac.in

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

Keywords: Biodiversity planning, City planning, Development planning, Ecosystem service.

INTRODUCTION

The expression 'Biodiversity', defines 'LIFE -on planet Earth. It has sustained human civilisations through unremitted supply of goods and services from the very time they have set their foot on this planet and even today human beings continue to benefit from this ceaseless supply of 'goods and services' of nature.

The word 'biodiversity' was first believed to be compressed from the expression 'biological diversity'in 1985 and has been coined by W. G. Rosen. He developed the expression during the planning of the National Forum on Biological Diversity that was held in 1986 and was organised by the National Research Council (NRC). It first appeared in the publication in 1988 when sociologist E.O. Wilson used it in the title of the proceedings of the forum of NRC that was part of the National Academy of Sciences [1, 2]. This diversity of life thus have long captivated the interest of the scientific communities and their continued rigorous research and quest for knowledge have contributed to a wide gamut of vocabulary like 'Urban Biodiversity', 'Ecosystems and Ecosystem Services', 'Human well – being' and 'quality of life'. like. Currently, the global custodian of biodiversity is the Convention on Biological Diversity (CBD) that provides a regulatory framework for conservation of biodiversity. This global body was an outcome of the 1992 Conference on the Environment and Development "Earth or the Rio Summit". The CBD entered into force on 29 December 1993 and is the first comprehensive global and legally binding convention regarding the Earth's biological resources, making biodiversity the common concern of all humans and an integral part of the development process. The CBD binds nation states (*i.e.* national/central level of government) that are signatories to the Convention and India is a party to the Contract. The CBD was convened for the global protection, conservation and enhancement of biodiversity and has threefold objectives that is mentioned in Article 1 – 1) The preservation of Biological Diversity 2) the sustainable use of its components and 3) the fair and equitable sharing of its natural resources. The CBD for conservation and protection of biodiversity endorsed the environmental principles *viz* . – the precautionary principle and the application of Environmental Impact Assessment (EIA) [3, 4]. The CBD in its Article 2 defines Biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems. "Further, global experts observe that Biodiversity underpins ecosystem functioning and the provision of goods and

services that are essential to human health and well-being. This signifies that Biodiversity reinforces the availability of ecosystem services by being a source of production. It supports the supply of all services and is the ffoundation of ecosystem services upon which human well-being reposes [5].

Biodiversity do not occur in isolation and are much dependent upon the abiotic components and geographies of which they are part. This defined structural and functional unit when expressed on a spatial scale is known as – the ecosystem. The word is believed to be coined as early as in 1935 by Sir Arthur Tansley in his work "The use and abuse of Vegetational terms and concepts", Ecology 16, 284 - 307. He also introduced the concept of ecosystem and recognised the interactions between the living and non – living component of the ecosystem [6].

Ecosystems as defined by the CBD are dynamic complexes of plant, animal and microorganism communities and their non-living environment interacting as a functional unit. Humans are also fundamental part of the ecosystem. Ecosystems can be terrestrial, marine, inland or coastal, rural or urban in character [3, 7]. Whilst the abiotic component of the ecosystem are defined by the climate, geology, geomorphology, soil, slope, rivers, lakes, ponds, wetlands and the aquifers and the groundwater supply within the ecosystem, the other constituent of the ecosystem comprising the biotic components broadly comprise of the vegetation and the wildlife and more specifically the flora and the fauna that are archetypal of that ecosystem.

It is believed that the expression 'Ecosystem Services' was formally introduced to the scientific community in 1981 by Ehrilich and Ehrilich [8]. Ecosystem Services can be defined as the goods and services/benefits that we obtain from ecosystems for our survival and development. These services are usually made available to us through the interactions between the variety of plants and animals that make up biodiversity (biotic components) of the earth with the abiotic components (water, light, radiation, temperature, humidity, atmosphere, and soil). The range of environmental benefits that we derive from the ecosystems is ecosystem services that ensures human well- being. The four major components of the ecosystem services are:

- Provisioning services include (provision for food, firewater, raw material and medicinal resources)
- Regulating services encompass (local climate and air quality regulation, carbon sequestration and storage, moderation of extreme events, waste water treatment erosion, prevention and maintenance of soil quality, pollination and biological control)
- Habitat and supporting services include(habitat for species and maintenance of

CHAPTER 12

Bioprospecting of Marine Sponge Associated Fungi for Antioxidant and Neuroprotective Activity in Raw 264.7 Cells

N. Lekshmi[1], R. Ravinesh[2] and **T.P. Sajeevan[1,*]**

[1] *National Centre for Aquatic Animal Health, Cochin University of Science and Technology, Kochi-682016, Kerala, India*

[2] *Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram - 695581, Kerala, India*

Abstract: The chemical and biological diversity of the marine environment with a wide variety of marine organisms are proven to be a very rich source of natural products with biomedical applications. Bioprospecting of marine algae, fungi, sponges and their associated organisms diverse in taxonomy is largely productive and biologically active and thus offer a great scope for the discovery of new biologically active compounds. The present study aims to evaluate the antioxidant properties and neuroprotective activity of fungi isolated from the marine sponge *Callyspongia fibrosa*. The molecular identification of the fungi by DNA Sequencing and subsequent phylogenetic analysis showed 99% similarity to *Aspergillus tamarii*. The ethyl acetate crude extracts of *Aspergillus tamarii* exhibited significant antioxidant activity with an IC50 <200 µg/ml on 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay. In addition, the extracts exhibited Nitric Oxide (NO) inhibitory activity in Lipopolysaccharide (LPS) stimulated RAW 264.7 neuroblastoma cells in a dose dependent manner, indicating that *Aspergillus tamarii* produces potential antioxidant and neuroprotective compounds.

Keywords: Antioxidant activity, *Aspergillus tamarii*, *Callyspongia fibrosa*, Marine bio-prospecting, Neuroprotection.

INTRODUCTION

The oceans are a rich source of biological and chemical diversity, which cover more than 70% of the earth's surface and contain more than 200,000 described species [1]. The chemical and biological diversity of the marine environment thus offers enormous scope for the discovery of natural products, several of which are targets for biomedical development.

[*] **Corresponding author T.P.Sajeevan**: National Centre for Aquatic Animal Health, Cochin University of Science and Technology, Kochi-682016, Kerala, India; E-mail: sajeev@cusat.ac.in

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

As less than 10% of the world's biodiversity has been tested for biological activity, many more useful natural lead compounds are awaiting discovery [2]. Hence, it is crucial that new drug candidates from unexplored or underexploited habitats should be pursued as sources of novel therapeutic agents [3].

Marine sponges (Phylum: Porifera) constitute one of the most primitive multicellular organisms (>600 million years old) on earth. They have been ranked very high in the priority of natural product research with the discovery of a wide range of bioactive chemical components and secondary metabolites with potential pharmaceutical applications [4]. Due to their long evolutionary history, sponges and their associated organisms possess vast genetic diversity, producing several novel metabolites with antioxidant and neuroprotective properties. Thus, the isolation of sponge derived bioactive molecules heralded a new era in biomedical research. Marine derived fungi are one such group of microorganisms which occupy an important ecological niche in the environment possessing immense biotechnological potential *viz*. free radical scavenging activity, nitric oxide inhibition, phosphatase inhibition, kinase inhibition *etc*. The present study envisages to extend the search for antioxidants and neuroprotectants from the sponge associated fungi *Aspergillus tamarii*.

MATERIALS AND METHODS

Isolation of Sponge Associated Fungus

The sponge samples were collected from Vizhinjam Bay, Thiruvananthapuram and brought to laboratory in ice under sterile conditions. The sponge was identified as *Callyspongia fibrosa* by morphological characteristics. The sponge tissue was cut into small pieces of approximately 1cm x 1cm and rinsed 2-3 times with sterile sea water to eliminate adherent surface debris. The samples were then immersed in 70% ethanol for 60 -120 s for surface sterilization and further dried with sterile cotton cloth to stop the sterilization with ethanol [5, 6]. The small pieces of sponge tissues were placed on a petridish containing Sabouraud Dextrose Agar (SDA) (Himedia, India) prepared in 30 ppt seawater with sterilized tweezers so that the freshly cut edges are in direct contact with the agar surface. The plates were then incubated at 28° C for 5-7 days and observed for fungal growth. Fungal colonies were sub cultured and pure colonies were identified by taxonomic identification, by DNA amplification of Internal Transcribed Spacer (ITS) region of fungal genome.

Mass Production and Extraction of Extracellular Secondary Metabolites

For small scale fermentation, pure fungal strain was inoculated in a 1000 ml Erlenmeyer flask containing 500 ml of SDA medium prepared in 30 ppt water. Fermentation was performed at room temperature under static conditions [7]. After 4 weeks, the metabolites from the culture medium were extracted by adding 500 ml of ethyl acetate to the culture flask and kept closed for at least 24 hours [8]. The fungal mycelium was separated with Whatman No.1 filter paper from fermented broth and filtered broth was allowed to liquid – liquid separation (1:1 ratio) with ethyl acetate in a separating funnel. The organic solvent was evaporated under reduced vacuum in a rotary evaporator to yield an ethyl acetate extract. The dried ethyl acetate extract was stored in -20° C, and used for bioassay.

Assay for Antioxidant Activity of Marine Endophytic Fungi

The DPPH radical scavenging activity of the crude extract was assessed on 96-well culture plates [9]. The dried ethyl acetate extracts of fungi was dissolved in methanol and tested at 5 different concentrations (40, 80, 100, 200, 400 µg/ml). For this, 100 µL of extract and 100 µL of 0.2 mM methanolic DPPH (Sigma, USA) solution were incubated at 37 °C for 30 min under dark conditions. The absorbance was measured at 517 nm on a microplate reader against a blank solution that contained methanol instead of crude extract. DPPH scavenging rate (%) was calculated as (Absorbance $_{control}$ – Absorbance $_{test}$ /Absorbance $_{control}$) × 100. All experiments were done in triplicates.

Molecular Taxonomy of the Fungus

The taxonomic identification of the fungal strains were done by PCR amplification of Internal Transcribed Spacer (ITS) region of fungal genome, sequenced and the phylogenetic tree was constructed. Briefly, fungal genomic DNA was isolated using DNAzol reagent, and the PCR amplification of the ITS region was done using the universal primers ITS 1 (5′TCC GTA GGT GAA CCT GCGG 3′) and ITS 4 (5′-TCC TCC GCT TAT TGA TAT - 3′) [10]. The PCR product was sequenced by Sangars sequencing method. Nucleotide sequence data were analyzed using BLAST and aligned using Clustal W on MEGA 6 [11]. The ITS sequences of closely related fungi were retrieved from Gen Bank, and their similarity to the current isolate was assessed at the nucleotide level. A phylogenetic tree was constructed using the Neighbor-Joining (NJ) method with boot strap values based on 1000 replicates.

CHAPTER 13

UASB Reactor Coupled Contact Bed Process for the Clean Extraction of Banana Pseudostem Fibres

J. S. Jayaprabha and **V. B. Manilal***

National Institute for Interdisciplinary Science and Technology (CSIR), Thiruvananthapuram-695019, India

Abstract: A large quantity of biomass generated aspseudo stem after banana bunch harvesting is presently discarded as waste by farmers due to the lack of proper utilization. These wasted banana pseudo stem biomass are rich sources of natural fibres. Current extraction methods such as mechanical and manual have many problems and are unable to produce quality fibres in bulk. The present paper reports the anaerobic separation of fibres from banana pseudo stem using a UASB reactor coupled contact bed for the production of clean fibres. Fibre separation was achieved in 6-7 days at the optimum pH and temperature in UASB coupled contact bed. Parameters specific to the process such as COD, biogas and extracellular hydrolytic enzymes of the process water were monitored during the anaerobic separation of banana pseudo stem fibre in the contact bed. The UASB reactor coupled contact bed was advantageous for the extraction of banana pseudo stem fibre where biogas is generated from the anaerobic degradation of cementing molecules, mainly pectin, concomitantly at around 5 litre/Kg pseudo stem. The optimization of pH and temperature for the maximum pectinases activity were also studied separately. Optimum pH and temperature for pectinases activity were at pH 7.0 and 30^{o}C, respectively. There were no damages to fibres and yield was higher when compared to mechanical or physical extraction methods.

Keywords: Banana pseudo stem, Extracellular enzymes, Pectinases, Up flow anaerobic sludge bed (UASB) reactor.

INTRODUCTION

Banana is widely cultivated in almost all the states of India. Apart from fruit, it generates huge amount of biomass in the form of pseudo stem, leaves, and suckers. The banana pseudo stem is rich in natural fibres. The bast fibre of bananais an excellent source of cellulose and is widely accepted for its strength and quality.

* **Corresponding author Manilal V.B.**: National Institute for Interdisciplinary Science and Technology (CSIR), Thiruvananthapuram-695019, India; E-mail:manilalvb@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

Currently, they are dumped or discarded in the field creating serious environmental problems due to the lack of utilization. If properly exploited, about 1.5 million tonnes of fibre could be extracted from 30 million tonnes of pseudo stem annually [1]. It provides an uninterrupted supply of raw material to industries for producing paper, cardboards, tea bags and in textile and composite making industries. The banana pseudo stem fibre is currently extracted either by hand stripping or by mechanical method. The hand stripping is done by scrapping the pseudo stem with a blunt knife, and mechanical involves the use of machines, but both methods have the disadvantage of reduced fibre quality. Conventional retting process results in longer process duration and an uncontrollable growth of undesirable flora which also affect the fibre quality significantly [2]. The use of specific enzymes like pectinases is rarely used by farmers because of its high cost.

Manilal VB, [3] have used a high rate UASB reactor coupled anaerobic contact bed tank for the demonstration of anaerobic bio-extraction process.The fundamental principle behind the bio-extraction process is anaerobic decomposition,which is a four-step process that involves different classes of microbial consortium namely hydrolytic, acidogenic, acetogenic and methanogenic. Hydrolysis is the primary step in the process of fibre extraction where extracellular enzymes play a significant role. As a result, large biopolymers responsible for fixing the fibres are hydrolyzed into soluble oligomers and monomers through the actions of extracellular enzymes produced by microorganisms.

The present paper monitors different parameters such as COD, biogas, extracellular hydrolytic enzymes of the circulating liquid during the anaerobic separation of banana pseudo stem fibre in the UASB coupled contact bed. The study alsoevaluates the optimum pH and temperature for enhanced pectinases activity. Further, it comparedthe anaerobically extracted banana fiber withphysicallyextracted fiberby assessing its chemical and physical properties.

MATERIALS AND METHODS

Sample

Nendran (AAB) a variety of *Musa*, widely cultivated in the region was the source of sample material for the anaerobic extractionof fibres. Sheaths were dismantled from fresh banana pseudo stemof Nendrancollected from a local plantation at Thiruvananthapuram, Kerala, India.

UASB Reactor Coupled Contact Bed Anaerobic System

A laboratory set up having UASB reactor coupled anaerobic contact bed tank was used as a model system for the anaerobic treatment of banana fibre (Fig. **1**). The UASB reactor was fabricated with jacketed glass column of 1-meter length fitted with a gas-liquid-solid (GLS) separator on the top, and a stainless steel conical bottom was mounted for feeding the effluent from the anaerobic contact bed tank (ACBT).The reactor had a working volume of 13.5 Litre. The amount of biogas production was measured by a wet gas flow meter connected to the GLS. A contact bed glass tank of 5 Liters was fabricated and connected to UASB reactor for placing the banana pseudo stem in the liquid. Liquid from the anaerobic contact bed tank (ACBT) was pumped with a peristaltic pump (Watson & Marlow Ltd 505U) to the UASB reactor and effluent from the UASB reactor was circulated to the ACBT loaded with banana pseudo stem. Thiscirculation was continued till separation of the fibres was achieved. The reactor was seeded initially with 500 gmmicrobial sludge from a working UASB reactor. The inoculum (seed culture) used in the study was the microbial sludge taken from a laboratory UASB reactor, developed by the National Institute for Interdisciplinary Science and Technology (NIIST), Thiruvananthapuram, India.The experiments were continued for more than a year for obtaining stabilized performance by the growth of bacterial sludge in the UASB reactor.

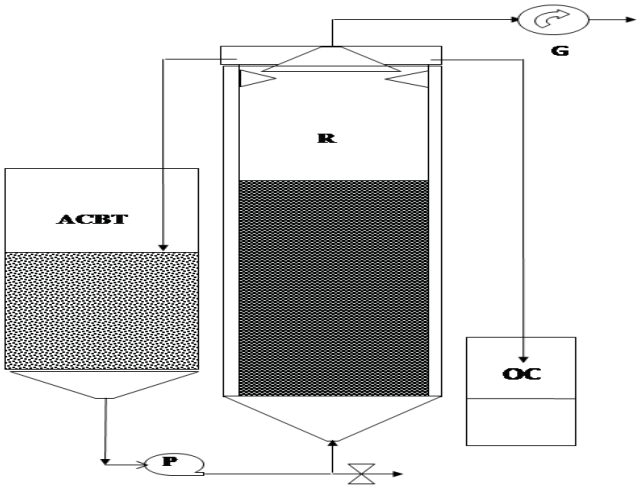


Fig. (1). Schematic diagram of laboratory UASB reactor coupled anaerobic contact bed tank. R: UASB reactor; ACBT: anaerobic contact bed tank; P: pump; G: gas flow meter; OC: overflow connector.

CHAPTER 14

Diversity, Genome Classification, Commercial Viability and Pest Status of *Musa* Cultivars Identified in Kerala

K.J. Kavitha, T. Ajitha, Shabith Raj K. and **D.A. Evans***

Department of Zoology, University College, Thiruvananthapuram, Kerala-695034, India

Abstract: Kerala is blessed with rich diversity of *Musa* cultivars and each of them is characterized by unique taste, flavor, aroma and nutritive values. Farmers doing commercial cultivation are highly selective and interested only in cultivating commercially viable cultivars such as *Nendran, Palayankodan, Kappa, Gnalipoovan* and *Robusta*. Intensive application of urea containing synthetic fertilizers has resulted in the lushness of plants leading to the low content of secondary metabolites, which made them highly susceptible to pest attack. Non-selective application of systemic insecticides in edible crops leads to the contamination of toxins in fruits and their entry into food chain. Among 80 *Musa* cultivars identified during field study in various sites of Kerala, 60 are indigenous and 20 are hybrids of exotic. Ten cultivars among the indigenous group are diploid with genome constitution AA, and all of them are resistant to pest attack. Farmers are reluctant to cultivate diploid and pest resistant *Musa* cultivars due to some characters such as small fruit bunch, low market value, and low glucose content leading to the lack of pleasant taste, long duration to set flower and long duration for the replanted suckers to sprout. Analysis of genome constitution of 80 indigenous cultivars revealed that 12% of them are diploid with AA, 10% are AB, 15% are AAA, 13% with ABB and other 50% are AAB. Some of the cultivars with AAB genome constitution also showed high degree of resistance against insect pests, due to very high content of flavanoids, total phenols, very high activity of Phenylalanine ammonialyase, Polyphenol oxidase and Peroxidase in the pseudostem and leaves. No tetraploid *Musa* cultivars were identified in Kerala during the course of study. Wide spread transformation of agriculture lands to rubber plantation has resulted in the depletion of diversity of *Musa* cultivars. Many exotic *Musa* cultivars, introduced in Kerala, did not have wide acceptance from the public and among farmers, due to the lack of pleasant taste compared to indigenous types. RAPD analysis of the indigenous *Musa* cultivars revealed that they exhibited high degree of genetic variability and genetic polymorphism. In Kerala, 90% of the *Musa* cultivation is done by small scale farmers and most of them do not have their own land for cultivation and hence, they took land at lease for one year contract from owners. They are very particular to cultivate *Musa* which can give harvest within one year. Most of the cultivars identified during the course of study were unable to give harvest within one year.

* **Corresponding author Evans D. A.**: Department of Zoology, University College, Thiruvananthapuram, Kerala-695034, India; E-mail:drevansda@gmail.com

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

This is the reason for the abundance of only few commercially viable cultivars in the agroecosystems. Each Panchayath should take active conservation measures to conserve the diploid and indigenous cultivars which are resistant to pests. These cultivars can be used in future for breeding programmes to develop pest resistant and commercially viable *Musa* cultivars.

Keywords: Flavanoids, *Musa* diversity, Peroxidase, Pest resistance, Pest susceptibility, Phenols, Phenylalanine ammonia lyase, Polyphenol oxidase.

INTRODUCTION

Bananas and plantains are believed to be one of the earliest plant species to be domesticated [1] and play a pivotal role in human welfare, since time immemorial. Banana is the common name for herbaceous plants of Genus *Musa* and for the fruits they produce. *Musa* cultivars are the major fruit crops globally cultivated and consumed in more than 100 countries, throughout the tropics and subtropics. They provide a staple food for millions of people [2]. They also provide a well-balanced diet and contribute to the livelihood through crop production, processing and marketing. In developing countries, they are the most important food crop after rice, wheat and maize [3]. India is the largest producer of banana in the world. They are the cheapest, plentiful and most nourishing of all fruits and are consumed by the rich and poor alike. Bananas promise to meet the demand for vital needs such as fruit, fiber and fuel for growing population all over the world. Owing to the multifaceted uses, high economic returns and greater socio-economic significance, banana is often referred to as '*Kalpatharu*' or plant of virtues [4]. The plant is considered as a symbol of prosperity and fertility due to its place as a token of good will in various religious practices and ceremonial functions [5].

It is a perennial plant that reproduces by the suckering of plants emerging from the same corm. Each plant flowers only once, that finally develops as fruit bunch [6]. Banana plant is the largest herbaceous flowering plant. They are generally tall and fairly sturdy and often mistaken for trees, but their main up right stem is actually a pseudostem that grows 2 to 5 meter tall, growing from a rhizome. After fruiting the pseudostem dies but offshoots may develop from the base of the plant. Leaves are spirally arranged and may grow up to 270 cm and 60 cm width. Each pseudostem normally produces a single inflorescence, also known as banana heart. The banana fruit develops from the heart as a hanging cluster made of tiers, up to 20 fruits per tier. The hanging cluster is known as bunch, comprising 5 to 20 tiers [7].

Globally bananas are the fourth largest agriculture commodity in the world trade after cereals, sugar, coffee and cocoa with 97.5 million tons of production. It is

grown in about 120 countries; total annual world production is estimated to be 98 million tonnes of fruits. About 87% of all banana produced in the world are cultivated by small scale farmers [8]. India leads the world as number one in the production of banana with an annual output of about 14.2 million tones. Other leading producers are Brazil, Ecuador, China, Philippines, Indonesia, Costarica, Mexico, Thailand and Colombia. The advantage of this fruit is its availability round the year.

Banana is one of the oldest tropical fruits cultivated by human from prehistoric times in India with great socio economic significance, interwoven in the cultural heritage of the country. It is also an important food crop in terms of gross value, after paddy, wheat and milk products and forms an important crop for subsistence to farmers. It is also a dessert fruit for millions, apart from staple food owing to its rich and easily digestible carbohydrates with caloric value of 67 to 137/100g fruits [9]. Banana contributes 37% of the total fruit production in India. Availability of banana throughout the year, irrespective of season makes them a popular food fruit and subsidiary food of the masses in India [10]. In India most of the banana is produced on a small scale basis in different production system. The phenomenal increase in production has been due to adoption of high density planting; use of tissue cultured clones and drip irrigation which significantly improved productivity. Banana ranks first in the production and third in area among Indian fruit crops.

Major banana growing states in India are Maharashtra, Tamil Nadu, Gujarat, Assam, Karnataka, Kerala, Bihar, West Bengal, Andhra Pradesh, Orissa and Madhyapradesh. Production is highest in Maharashtra (3924.1 thousand tonnes/year) followed by Tamil Nadu (3543.8 thousand tonnes/year).Within India Maharashtra has the highest productivity of 65.70 metric tonnes/hectare, against the national average of 30.5 tonnes/hectre. India is believed to be one of the centers of origin of banana.

In Kerala, bananas are cultivated in an area of about 80,640 hectares with annual production of 7,93,339 tonnes [11]. Kollam, Thiruvananthapuram and Pathanamthitta are witnessing a revolution in banana cultivation in Kerala. Farmers are taking vast stretches of land on short and long term lease to farm bananas. An interesting aspect of banana market in Kerala is that there has been no price fall for the last couple of years. Even though price remains steady, only two cultivars such as *Nendran* and *Kappa* (*Red banana*) are economically viable throughout the year.

CHAPTER 15

Glomus Microcarpum: A Dominant Arbuscular Mycorrhizal Associate of Banana in South India

K.S. Nidheesh and **J.G. Ray***

School of Biosciences, Mahatma Gandhi University, Kottayam, Kerala, India

Abstract: An Arbuscular mycorrhizal fungus (AMF) is one of the biodiversity components of soil significant to soil fertility. The AMF is essential for the healthy growthof many plants. In our extensive investigation on the natural AM flora of diverse commercially cultivated banana fields in South India, the AM fungus G*lomus microcarpum* was one of the major root associates of banana. It is associated with all the 13 banana varieties in South India. The spore density of *G. microcarpum* in soil samples ranged from 10 to 510 per 100g soil. Mean spore density in summer season (139.51±9.58) was significantly higher (P<0.0001) than that of monsoon season (91.61±4.73). In relation to banana varieties, the average spore density of *G. microcarpum* in the summer ranged from 20 (*Kadali*) to 185 (*Rasthali)*, and that of monsoon ranged from 30 (*Attukannan)* to138.6 (*Chenkadali*) spores per 100g soil. The difference in spore density over banana varieties was not significant (P>0.05) in both the seasons.The average AM fungal root colonization in banana varieties ranged from 32% to 85%. The mean AM fungal colonization of monsoon season was significantly (P<0.0001) higher than the summer. In general, information on any aspect of natural AMF biodiversity in soils is highly beneficial to sustainable cultivation of any crop.

Keywords: Arbuscular Mycorrhizal Fungi, Banana, *Glomusmicrocarpum*, South India, Sustainable Cultivation.

INTRODUCTION

Arbuscular Mycorrhizal fungi (AMF) represent an important part of the natural soil microbial diversity of terrestrial ecosystems. The AM fungi are common symbiotic associates found in the roots of terrestrial plants, especially many cultivated crops. The beneficial plant-microbe interactions between AM fungi and higher plants determine plant health [1] and they also enrich soil fertility.In general, conservation of biodiversity of AM fungi is highly significant in the maintenance of sustainable agricultural practices.

* **Corresponding author Ray J. G.**: School of Biosciences, Mahatma Gandhi University, Kottayam, Kerala, India; E-mail:jgray@mgu.ac.in

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

The *in vitro* and greenhouse experimentations with banana have already revealed that mycorrhizal associations enhance productivity of the crop [2]. In general, mycorrhiza enhances plant uptake of macro and micronutrients [3, 4]. Mycorrhiza is also known to improve disease resistance [3] and resistance to root parasitic nematodes [5, 6] in many crops. Mycorrhiza alleviates various metal toxicities in soils [7]. In majority of previous experimentations on suitability of AMF applications in banana, different species of Glomus such as *G. mosseae* [3, 6], *G. monosporum* and *G. Intraradices* [6] are used.

Although Glomus dominates in Indian soils [8, 9], no evidence on the presence of *Glomus microcarpum* in banana is available except a rare report of its presence in just one site in Tamil Nadu [10]. Experimental trials on the beneficial role of this AM species in banana are also absent. South India is well known as a traditional area of cultivation of banana in the world. Therefore, new information on the presence of AMF associates in banana in the region, especially the pesticide tolerant species such as *G. microcarpum* [10] is highly relevant. Moreover, the detailed information of AMF associates of banana in the region becomes highly useful for understanding its role as a biofertilizer for the crop. It was in this context, a specific survey on the association of *G. microcarpum* in various banana cultivated fields of Kerala, Tamil Nadu and Karnataka was carried out. This study mainly explores the distribution of the species in diverse banana varieties and soil fertility parameters, in relation to different seasons.

SOIL SAMPLE COLLECTION FROM THE STUDY AREA

Soil samples of large fields are collected from the three South Indian States such as Kerala, Tamilnadu and Karnataka (08°13'29" to 13°08'20" N and 75°07'19" to 78°37'16" E). Fields, where the crop is cultivated for commercial purposes are selected for sampling purposes. The sampling was made in the summer and the monsoon seasons of July 2012 to July 2015. In the three-year period, composite soil samples of 286 locations from 143 fields representing two seasons (Fig. **1**) were collected.The samples were collected at random from three separate locations (minimum 50 meters apart) of each field. From each location, about 500 g of soil was taken from the rhizosphere region. Three soil samples taken from the location at a depth of 0 to 40 cm (10 cm x 10 cm pits made around a minimum of 3 plants) were mixed together to make a composite sample of each location. Afterwards, the composite soil samples from the three locations of a field were thoroughly mixed together to make the next level composite sample. Approximately one kilogram of such a composite sample was collected for laboratory studies and kept in labelled plastic bags. The fine, healthy lateral roots collected from the three locations of a field were also put together in a labelled

bottle as a composite root sample. The root samples collected for assessment of percentage colonization were fixed in 50 ml of 10% potassium hydroxide (KOH).

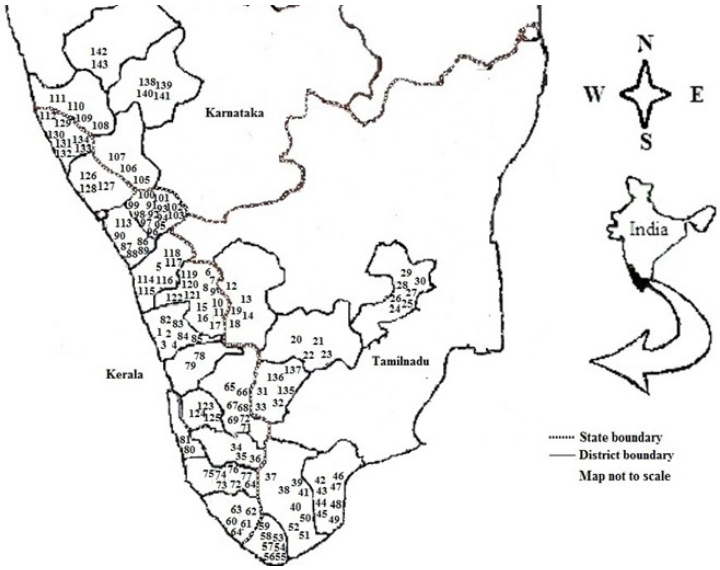


Fig. (1). Study area showing the 143 fields of sample collection.

SPORE ISOLATION AND IDENTIFICATION OF THE AM FUNGI

Wet sieving and decanting procedures of [11] were used for the isolation of AM fungal spores from soils. The spore count was carried out by the plate method of [12]. Intact and crushed spores were mounted on slides in polyvinyl-lactoglycerol (PVLG) and PVLG mixed with Melzer's reagent. The spores then examined under the microscope (Motic BA 310) were identified up to the species level on the basis of the classification systems of [13, 14]. The original species descriptions of [15], as well as new online classification available at [16], were also utilized in the classification.

ASSESSMENT OF MYCORRHIZALROOT COLONIZATION AND ITS ESTIMATION

The percentage colonization of the root system was estimated after clearing and staining the roots [17]. The clean root segments were stained with 0.05% trypan blue in lactophenol. Exactly 100 root segments from each sample were examined for AM fungal structures (arbuscule or vesicle or mycelium) under a microscope.

CHAPTER 16

Biota - A Mobile Computing Platform for Biodiversity Research

R. Jaishanker[*], Athira Kakkara, Sajeev C. Rajan, Sooraj N.P., Sooraj Kumar V. and **Indu I.**

CV Raman Laboratory of Ecological Informatics Indian Institute of Information Technology and Management - Keral, Technopark Campus, Thiruvananthapuram, India

Abstract: Habitat degradation and invasive alien species are two principal forces that antagonistically interfere with native biological diversity of any region. Both the above are widely reported from India. Despite well-intended fiscal commitments towards biodiversity conservation at various levels, the ground reality is not always rosy. Lack of timely and *actionable information* threats to biological diversity strips practical utility from a majority of studies.

The advancement in information and communication technology that enables stand-alone, distributed client-server or cloud-based applications, which access information *via* web interface; opens hitherto unavailable options to conservation biologists. Mobile computing platforms provide a means to seamlessly integrate concurrent conservation campaigns while precluding duplication. With an in-built global positioning sensors, wireless connectivity, multi-media capabilities, browsers, *etc*., mobile platforms have the potential to transform biodiversity studies and boost conservation efforts. They provide an affordable means of scalable and rapid biodiversity field campaigns.

The authors present BIOTA – a BIOdiversiTy App that helps to identify and flag geographic coordinates of invasive plant species in India. The current release (Version 1.0) can identify 10 invasive plant species and record its location with time stamp on Google map. BIOTA is currently developed for Android operating system and can be downloaded from www.iiitmk.ac.in/cvrlei. Adoption of BIOTA by researchers, students and conservation enthusiasts will help to rapidly generate information on the presence of invasive species at various locations. This, in turn, will help to improve the prediction accuracy of invasive species distribution and to generate *actionable information*.

Keywords: Biodiversity, Field survey, Invasive species, Mobile computing platform.

[*] **Corresponding author R. Jaishanker**: CV Raman Laboratory of Ecological Informatics Indian Institute of Information Technology and Management-Keral, Technopark Campus, Thiruvananthapuram, India; E-mail:jrnair@iiitmk.ac.in

Oommen V. Oommen, Laladhas K.P. and Erach Bharucha (Eds.)

INTRODUCTION

Unprecedented expansion and escalation of human activities in the biosphere over the last five decades have established neo-normals for bio-physical parameters. In turn, they erode our ability to predict global fluxes. We are now in a transition phase, learning to adjust from reliable long-term bio-physical predictions to loaded short-term ones to adapt to climate induced challenges. Emerging challenges sprout from neo-normals that strive to reorganize prevailing biological network structure by either preferentially favoring introduced species or stifling keystones and endemics. Cumulative changes at primary level of biological network structure within an ecosystem may crush guardrails and plunge to new irreversible states. The creeping nature of cumulative buildup renders it indiscernible till the ecosystem exceeds its resilience thresholds. By then, it would be too late to strive for conservation.

To be effective, conservation efforts should be continuous. Documentation of life forms, quantitative expression of bio-physical parameters at finer scales within habitats and perpetual alertness to identify presence of new species within ecosystems are three non-negotiable constituents that reinforce successful conservation campaigns. The former still remains as one of the primary scientific goals of this century [1]. Whilst successful pilot projects have demonstrated feasibility of automated sensor-based capture of weather (bio-physical) parameters [2], operational implementation stories are rare. A perusal of Global Biodiversity Information Facility (GBIF) reveals large voids in presence/absence data of invasive species.

Advances in communication and information technology have opened new vistas that can assist in plugging the gaps of non-negotiable constituents of conservation efforts. Among the many possibilities, virtual collaboration and shared databases that lead to actionable information; stands out as the most potent. The authors present BIOTA: A mobile biodiversity App that can capture presence-absence data of invasive species in India. The launch version (V 1.0) focuses on a select list of 10 most invasive plant species and the endemic *Gluta travancorica* in India.

Subsequent versions will include more species. Widespread adoption of BIOTA will transform the way invasive species distribution, spread modeling and management is handled.

MOBILE APPS IN BIODIVERSITY

The world is moving to a predominantly digital paradigm. The two-way

communication facilities offered by smart phones have provided an impetus for seamless correspondence for almost all sectors. It immediately opened pathway to collect data and store it to a central database. A web-accessible central database can provide the tools for the submission, visualization and analysis of data collected by varied users from many different locations. It is for the conservation biologist to leverage this opportunity.

Extensive data collected using conventional methods by different researchers end up as inaccessible formats. Repeated data collection consumes a good amount of resources of all conservation projects. This can be overcome by mobile applications, which empowers conservation biologists, students and enthusiasts to rapidly generate information on any of the environmental phenomena, presence/absence of species at various locations, *etc*. Published literature contains references to mobile apps developed to study nature [3]. However, our search for an Indian App for ecology/conservation biology was fruitless.

BIOTA

In its present form; BIOTA – The BIOdiversiTy App helps to identify and flag geographic coordinates of invasive plant species in India. The current release (Version 1.0) can identify 10 invasive plant species and record its location with time stamp on Google map. It presents a framework for data collection and communication between field scouts, modelers and conservation planners. BIOTA is currently developed for Android operating system and can be downloaded from www.iiitmk.ac.in/cvrlei. The unique feature of this approach is that it provides a platform to submit the data collected using smart phone to a database and viewed using Google Maps. The data can subsequently be used as input to predict species invasion.

USER INTERFACE

BIOTA (Version 1.0) is primarily designed to use in field for data collection and visualization of the presence/absence of 10 invasive species (high risk) [4] at different locations on Google Map (Figs. **1** and **2**).

It demonstrates the collection and submission of data from field experts and the potential to view data on Google maps *via* database server. Multiple workers can submit data from various locations to a central database. The BIOTA App is a framework designed to collect information on the Biodiversity: Phytodiversity and Zoodiversity (Fig. **2**).

CHAPTER 17

Successful Livelihood Models through BMCs in India

K. P. Laladhas[1,*], Fr. Roy John[1], V. Saraswathy[2], Erach Bharucha[3], Achuth Sankar S. Nair[2] and **Oommen V. Oommen[2]**

[1] *Department of Zoology, St Stephen's College, Pathanapuram, Kollam, Kerala-689 695, India*

[2] *Department of Computational Biology and Bioinformatics, University of Kerala, Kariyavattom, Thiruvananthapuram-695581, India*

[3] *Bharati Vidyapeeth Institute of Environment Education and Research, Bharati Vidyapeeth University, Pune, India*

Abstract: India is a mega-biodiverse country, home to nearly eight per cent of the world's total recorded species of plants and animals. The conservation of our heretic biodiversity, sustainable utilization of its resources and access and benefit sharing of its bioresources by the statutory biodiversity management committees (BMC) and self-help groups at local level is a remarkably replicable model. Participatory, local level traditionally linked, viable alternative methods are employed to conserve our precious bioresources and some of the successful models can be identified at local level which can be duplicated across the world for the management of biodiversity. Biodiversity can be aligned with the livelihood primarily in terms of their dependence for food, medicine and shelter and subsequently trade and economic needs. By our successful models, local people support rather than resist efforts to protect wildlife and biodiversity. Some of the models include Common man's Tuber conservancy from Wayanad, Kerala, conservation and trade of millets by poor Dalit women (The millet sisters) from Medak district of Telengana State, ABS from broom grass employed by BMC of Raipassa, a small tribal village of Tripura State. BMC of Pithorabad established organic wheat marketing linked to local livelihood, BMC, Eraviperoor employed best practise agriculture, and livelihood developments in Modi (Jheri) Village in Asifabad District of Telengana. Sustainable marketing practice established by BMC of Sikaribari from Tripura, sustainable trade and ABS for Medicinal plant resource trade by BMC of Kalmegh and neem leaf trade by Andhra SBB are some of the replicable models. People's artificial reefs for sustainable livelihood for fisher folks of Kerala, sustainable trading of snake venom by Irula tribal Cooperative society, trade and sustainable conservation of environmentally acclaimed Ongole breed's successfully to many countries, and ABS employed by Indian Institute of Oil Research accessed microbial bio resources for insect pest and plant disease management of crops, are noteworthy.

[*] **Corresponding author K. P. Laladhas**: Department of Zoology, St Stephen's College, Pathanapuram, Kollam, Kerala-689 695, India; E-mail:laladhas@gmail.com

Keywords: ABS, BMC, Livelihood model, Local level conservation.

INTRODUCTION

India is one amongst the 12 mega-diverse countries in the world and home to nearly 8% of the world's total recorded species of plants and animals. India represents eleven percentage of world flora and seven percentages of the world fauna. Across the nation, people, communities and regulatory arms of the Government have played an outstanding and innovative role in conserving India's rich biodiversity heritage. At the local level, we have exemplary and replicable models for the conservation of biodiversity, sustainable utilization of its resources and access and benefit sharing by self-help groups and the statutory biodiversity management committees (BMC).

Over-exploitation of bioresources, climate change-associated risks, deforestation, and menace of invasive alien species, environmental pollution and population explosion enormously exert pressure over the biodiversity. Immediate mitigatory responses and conservation measures are inevitable at national, sub national, regional and local level. Participatory, local level traditionally linked, viable alternative methods are essential to conserve our precious bioresources and some of the successful models can be identified at local level which can be duplicated across the world for the management of biodiversity.

Poverty alleviation and biodiversity conservation are the basic social goals [1] and the fundamental responsibility of modern governance [2, 3]. The continued legitimacy of the developmental state rests on its willingness to address the cardinal issue by interlinking biodiversity conservation, sustainable utilization of its bioresources with the real local level stake holders and local biodiversity governance machinery. We have multiple agencies to conserve the natural resource environments such as forests, national parks, and water bodies where only a part of the biodiversity exists. In Kerala the homestead biodiversity is enriched with the plurality of agro biodiversity, medicinal plants and heavy population of arthropod diversities. Indeed, the attempts to conserve biodiversity and alleviate poverty by establishing local level conservation measures, good practices in farming, regulated and sustainable utilization of bio-and natural resources are effectively monitored at local level by the Biodiversity Management Committee (BMC) as envisaged by the Biodiversity Act 2002 by the National Government in India [4]. From the BMC model in India [5], the involvement of communities at local level can potentially address all the obstacles and resistance against conservation and sustainable utilization of its resources.

Biodiversity can be aligned with the livelihood primarily in terms of their dependence for food, medicine and shelter and subsequently trade and economic

needs [6]. By our successful models local people support rather than resist efforts to protect wildlife and biodiversity. The chief principle underlying community-oriented wildlife management programs, thus is to share with community members some material and/or monetary benefits to secure their willing participation for conservation.

Analyses of such efforts and their effectiveness have multiplied in the past decade, and yet the extent to which community-based programs have effectively combined the goals of biodiversity conservation and poverty alleviation remains an open issue. Much of the examples and models displayed here are an approach to focus on specific cases rather than undertake a comparative assessment of different initiatives located in varying ecological and social contexts.

There have been efforts from the Government to support activities of local institutions or individuals to further conservation and sustainable use of bioresources. Incentivising such initiatives do not necessarily involve financial support. It however does require recognition.

There is also a need for public awareness through print media, the television and newer tools such as social media.Such efforts however are few and far between. The concept of an award is only as good as the publicity that goes with it. There is also the need to replicate good innovative conservation practices through an appreciation of best practices which are award winning.

The range of such initiatives is different in India's ten biogeographic zones. They address both wild and domesticated biodiversity. Celebrating these bold innovative initiatives thus can go a long way in creating an ethos and rekindle values for furthering conservation of species and natural or traditional cultural landscapes.

While this is important, maintaining a large database on these successful and diverse attempts at creating a platform for access and benefit sharing must become a part of our nation's biodiversity documentation. The awards process can help to put these together at BMC, SBB and NBA level. The traditional cultural knowledge and skills as well as religious sentiments are an essential part of stitching together the mosaic of information from multiple sources.

This chapter is a small attempt to bring together these concerns for the future of a liveable nation with food security, and the wellbeing that comes from a communion with nature.

CHAPTER 18

The Biodiversity for Livelihood; Recognition Processes in India

Erach Bharucha*

Bharati Vidyapeeth Institute of Environment Education and Research, Bharati Vidyapeeth University Pune, India

Abstract: Biodiversity conservation is inevitably a requisite in our dynamic world. In a highly populous country like India, conservation of biodiversity and a strong communication, education and public awareness initiative is most essential for its sustenance. A strategy is required to have a deep understanding of our diverse biogeographic regions and locale specific traditions that are closely linked to bioresources. This requires an appreciation of the persons associated with the conservation of both natural and cultural diversity. For conservation of biodiversity to become a part of a people's action program, there is a need for their efforts to be recognized and rewarded. This has led to creating awards for biodiversity conservation and/or sustainable use at the national level. To recognize and publicly acknowledge such contributions that have led to positive biodiversity conservation actions and societal equity of resource utilization, the Government of India has established the 'India Biodiversity Awards' which are informative and replicable at the international level.

Keywords: Awards, Awareness, Benefit sharing, Biodiversity, Conservation, Recognition.

INTRODUCTION

The growing need for biodiversity conservation in a rapidly emerging economy has now become increasingly urgent. In previous few years, around 50 percent of India's people will live in urban centers. The disconnect with nature will become increasingly apparent unless a strong conservation communication, education and public awareness (CEPA) initiative is created. The conservation of bioresources, however, requires a new pedagogic framework. The conservation ethos in society can be mainly brought about by action oriented-strategies.

* **Corresponding author Erach Bharucha**: Bharati Vidyapeeth Institute of Environment Education and Research, Bharati Vidyapeeth University Pune, India; E-mail:kapilabharucha@gmail.com

For reviving such an ethos that was a part of our ancient civilization, there is no better way than preserving small 'hot specks' of biological value across India. However, such a strategy requires a deep understanding of our diverse biogeographic regions and locale-specific traditions that are closely linked to bioresources.

This requires an appreciation that bioresources, both natural (wild flora and fauna) and cultural diversity (local cultivars and livestock breeds) should be conserved.

This thinking has emerged from appreciating that the conservation of resources can only become a reality if it can be used sustainably over a long period of time. Earth resources are dwindling and bioresources can go extinct forever unless people feel that they derive benefits by preserving them in the long, middle and short terms.

This is what emerged through the Brundtland Report 'Caring for the Earth' which was tabled in the UN after the Rio Conference in 1992. The debates on how all nations could together bring about such a worldwide strategy, took many years and many international conferences that finally led to Convention on Biodiversity being signed by a large majority of likeminded nations in 1992. India undoubtedly played a major role in the ideology that conservation and sustainable use of bioresources is the only workable strategy. A decade later, the Sustainable Development goals in (2015) suggested that economic issues – societal equitability and environmental conservation could strengthen the world's resource use structure.

A parallel thinking was from the biodiversity conservation lobby that realized that conservation of both natural and cultural diversity required a focused set of targets which led to developing the Aichi Targets.

Interestingly, these international debates strengthened our own ancient cultural ethos on preserving and even venerating all forms of life and our sacred places.

While preserving flora and fauna is linked to SDGs, the need for communication, education and public awareness (CEPA) for biodiversity conservation is strengthened by Aichi Target 1. India is a party to both these international obligations.

Hon. Supreme Court Judgement in the PIL by MC Mehta made the Government wake up to the need for a long term public awareness strategy for conserving bioresources (NBAP - 2009).

However, for this to become a part of a people's action program there is a need

for their efforts to be recognized and rewarded. This led to creating awards for biodiversity conservation and/or sustainable use at the national level.

AWARDS FOR BIODIVERSITY CONSERVATION AND SUSTAINABLE USE

The concept of providing awards for conservation and sustainable use was first developed in 2012 at CoP 11 in Hyderabad. This was aimed at energizing the Biodiversity Act 2002 and shifting the focus of conservation to the grass roots at Biodiversity Management Committees level.

Many of the conservation and sustainable use of bioresources that have been carried out by individuals, local communities, or civil society groups, had not been adequately recognized. Their contributions, however, towards supporting both wild and domesticated bioresources was varied and cumulatively of considerable value. Several of these strategies were great models which could be replicated.

To recognize and publicly acknowledge such contributions that have led to positive biodiversity conservation actions and societal equity of resource utilization, the GOI, MOEF and CC, the NBA and the UNDP, have established the 'India Biodiversity Awards' in 2014, 2016 and 2018. This was supported by UNDP and the NBA. The pattern of these awards has evolved over the last five or six years. The response of entries has been overwhelming. More than the recognition of their work both as prizes and certification, it is the variety and replicable models that have emerged which is of great significance.

Over this period the nature of the awards and awardees themselves has undergone changes. This shows that the awards process for conservation and sustainable use of resources is coming of age. It demonstrates that there is a dynamic change process in the thinking on biodiversity management (See Box **1**).

The trend shows that the awards have shifted from Government initiatives such as PAs, towards other forms of biodiversity governance. The terminologies used for the combination of conservation and sustainable use are also being progressively clarified.

Box 1. Classification of Awards.

	Category 1	Category 2	Category 3	Category 4
2014	Community Stewardship	Decentralized governance	Co- Management	Protected Areas

SUBJECT INDEX

D

E

F

G

H

I

J

K

L

M

N

P

R

S

T

U

W

Z

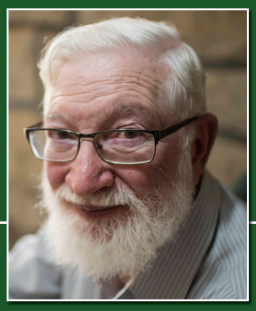
Oommen V. Oommen

Dr Oommen V. Oommen is an eminent biodiversity conservationist with several years of experience as a teacher, scientist and a policymaker. He has more than 40 years of teaching experience in endocrinology, animal physiology, biochemistry, genetics, ecology, developmental biology and biodiversity and is actively involved in science popularization programs. He is also a CSIR Emeritus scientist. He served as the chairman of Kerala State Biodiversity Board and during this period, he had been responsible for bringing about policy decisions to enable the conservation and sustainable use of biodiversity. Currently, he is an emeritus professor at the Department of Bioinformatics and Computational Biology of the University of Kerala, India. As recognition of his outstanding research contribution to caecilian biology and molecular taxonomy, scientists from Natural History Museum, London, named a caecilian amphibian, Uraeotyphlus oommeni, in his honour. He has published over 160 research papers, 15 book chapters, 20 GenBank submissions, a few edited four international books in the last seven years and several popular science articles.

Laladhas KP

Dr Laladhas K P is an academician and researcher from the area of Life Science, who specialised in biodiversity conservation and bio-prospecting. He has also worked in consultancy projects funded by the UNDP and National Medicinal Plant Board. Two of his International Books have been edited and published by Springer International and Bentham Publishers. He published more than fifty research publications in peer reviewed International and National Journals and authored seven Books from the area of Environment and Biodiversity.

He served the Kerala State Biodiversity Board as its Member Secretary for more than five years. He has also worked as an expert member of Kerala Coastal Zone management Authority, Ministry of Environment and Forest, Government of India and a Member of working group on Biodiversity, constituted by Kerala State Planning Board for 13th Five year plan. Presently, Dr Laladhas is the Principal and Professor of St Stephens College, Pathanapuram.



Erach Bharucha

Dr. Erach Bharucha is a well-known surgeon in Pune, India, for over 50 years. He has been active in wildlife conservation for four decades and has been a member of several central and state government committees. As an environmental educator at PG/UG/and school level, he has an interest in education for sustainable development. He has been a member of the Executive Committee of Bombay Natural History Society, and Governing Council of Salim Ali Centre for Ornithology and Natural History and Vice President of Wildlife Trust of India. Dr. Bharucha has been associated with the NCERT, SCERT and UGC to further the cause of formal environmental education. Dr. Bharucha has been the chairman of the Maharashtra State Biodiversity Board from 2012 to 2014.