Agrobiodiversity Hotspots in India Conservation and Benefit Sharing Volume-I

Agrobiodiversity Hotspots in India

Conservation and Benefit Sharing Volume I

M.P. Nayar • A.K. Singh • K. Narayanan Nair

Protection of **P**lant **V**arieties & **F**armers' **R**ights **A**uthority
Department of Agriculture & Cooperation
Ministry of Agriculture
GOVERNMENT OF INDIA

Agrobiodiversity Hotspots in India:

Conservation and Benefit Sharing

Volume 1

M.P. Nayar, A.K. Singh, K.Narayanan Nair

Protection of Plant Varieties and Farmers' Rights Authority
Government of India
New Delhi

Agrobiodiversity Hotspots in India:
Conservation and Benefit Sharing
Volume I

Final Report of the Task Force 06/2007 constituted by the PPV & FRA, vide OM No. PPV & FRA/6-22/07/1312, dated October, 08, 2007 to identify the Agrobiodiversity hotspots in India for purposes of the 'National Gene Fund' usage.

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Cover page photographs (clockwise from top left) :
• Wild relative of turmeric (*Curcuma raktakanta* Mangaly & Sabu)-endemic to Malabar Agrobiodiversity region • Traditional variety of grapefruit (*Citrus paradisii*) • Wild Banana (*Musa velutina* Wendl & Drude)- NE India • Apatani traditional Paddy lands at Zero valley of Arunachal Pradesh • Weekly market at Tura, Garo hills, Meghalaya.

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शरद पवार
SHARAD PAWAR

सत्यमेव जयते

कृषि, उपभोक्ता मामले, खाद्य और
सार्वजनिक वितरण मंत्री
भारत सरकार
Minister of Agriculture & Consumer Affairs
Food & Public Distribution
Government of India

23rd December, 2008

FOREWORD

I am pleased to note that the Protection of Plant Varieties and Farmers' Rights Authority has taken steps to register the plant varieties and has formulated action plan under the 'Gene fund'. This Gene fund has been created to support conservation and sustainable use of Plant Genetic Resources; strengthen the capacity of the Panchayats in executing the conservation and sustainable use of plant material and to enable continued plant variety development. The Gene fund will be used to reward farming community, particularly the tribal and rural communities engaged in the conservation, improvement and preservation of Plant Genetic Resources in the agrobiodiversity hotspots of India.

Keeping this in view, the Authority constituted a Task Force to identify and characterize different agrobiodiversity hotspots in the country. The Report submitted by the Task Force titled "**Agrobiodiversity Hotspots in India: Conservation and Benefit Sharing"** also documents the useful plants in the hotspots. The Report has examined how the communities could be rewarded for their efforts. The Report has identified various botanical species, their close cultural and social linkage with the community, and has demarcated the 22 agrobiodiversity hotspots present in India.

Apart from facilitating Gene fund activities, this document prepared by the PPV&FR Authority will enable India to table our view point effectively and convincingly in various international forums to discuss issues connected with Farmers' Rights, Plant Genetic Resources and biodiversity conservation.

(Sharad Pawar)

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PREFACE

Agriculture including forestry, range management and sustenance of plant biodiversity have been the core of Indian civilization that dates back to several millenniums. The enormous plant diversity arising due to the varied soil, environment and altitude variations that India enjoys has resulted in the evolution of various crop species and varieties suiting to different domestic and commercial needs. This unique position of India has been well taken into account in the Protection of Plant Varieties and Farmers' Rights Act 2001.

The Gene Fund created under the law is designed to encourage, protect, promote, and utilize the plant biodiversity for plant breeding activity in perpetuity. The Gene Fund in turn gets nourished by the flow of annual fee arising out of the sale of seed of the registered varieties. Since plant species already existed and human intervention only created better performing ones, they are to assist to sustain the interest of the "keepers of plant variation" by way of institutionalizing a recognition and reward mechanism to acknowledge the services of the men and women; individuals and communities. These keepers of plant variation in the agrobiodiversity hotspots are to be beneficiaries of the Gene fund.

Following two rounds of national debate that was organized at Shillong and Annamalinagar in association with the National Biodiversity Authority, the PPV&FRA constituted a Task Force to characterize, demarcate and enlist the agrobiodivesity hotspots in India and suggest the broad principles that are to be adhered to in recognizing and rewarding the keepers of plant variation at these designated sites.

This virgin effort in defining the hotspots, listing the socio-cultural aspects of the area, listing the species of botanical and agricultural importance, the endemic species and the endangered species will enable India position its stand in various forums on the basis of well documented information. It is also felt that there can be well drafted case for "Access to Benefit Sharing (ABS)" on the basis of the information provided in these two volumes. The concerned states and agricultural universities can further elaborate and document the agriflora diversity details to further facilitate the issue of ABS. The foreword by the Honorable Union Minister for Agriculture further our position on such matters.

Apart from the Task Force members who went in to great depth and the experts who advised on specific issues, a catalytic role was played by Shri Dipal Roy Choudhury, Joint Registrar of the Authority in meticulously editing, assembling and getting this Treatise printed in two volumes.

(S. Nagarajan)

ACKNOWLEDGEMENTS

The members of the Task Force gratefully acknowledge Dr. S. Nagarajan, Chairperson, Protection of Plant Varieties and Farmers' Rights Authority, for having entrusted us with the task of identification of the hotspots of agrobiodiversity in India and formulation of the benefit sharing as per the terms of reference. We are indebted to Dr. S. Nagarajan for extending to us the necessary facilities for our travel and interactive discussions with experts on agrobioidversity. We are also thankful to him for giving us the road map for achieving our targets and steering us to the purpose of identification of agrobiodiversity hotspots in relation to the utilization of National Gene Fund for the benefit of traditional farming communities, especially the tribal societies and farming women who conserve traditional varieties.

Dr. S. Kannaiyan, Former Chairman, National Biodiversity Authority (NBA) has contributed substantially to the ideas of benefit sharing mandated in the Biological Diversity Act, 2002 and PPV& FR Act, 2001 at the National seminars at Shillong and Chidambaram. We are grateful to Dr.S.Kannaiyan for his support and the intiative he has taken during his tenure at NBA.

We acknowledge with gratitude several agricultural scientists of eminence whose help and advice were of immense value in the final shaping of this report. In particular we are indebted to Dr. Bhag Mal, Former Director, Indian Grasslands and Fodder Research Institute (IGFRI) and Honorary Research Fellow, Bioversity International-India for having given us the benefit of his vast experience and knowledge in plant genetic resources and sparing his valuable time for participating in the interactive discussions. We are grateful to him for meticulously going through and vetting the draft report. We are thankful to Dr. R.S. Rana, Former Director, National Bureau of Plant Genetic Resources (NBPGR) and Chairman, Bio –Links for his contributions in the interactive discussions and for suggesting his conceptual ideas on the definition of categories and sequence of presentation. Thanks are also due to Dr. A.K.Bhatnagar, Professor of Botany, University of Delhi for sharing his experience and scholarship.

We are grateful to Dr. K.S.Varaprasad, Officer-in-Charge, Regional Station, National Bureau of Plant Genetic Resources, Hyderabad for hosting the first interactive discussion at Hyderabad and providing valuable

inputs on agrobiodiversity hotspots of Bastar, Koraput, Deccan and South eastern Ghats. Our thanks are also due to all the scientists and staff of the Hyderabad Regional Station, NBPGR for the successful and productive meeting held at Hyderabad. We would also place on record our sincere gratitude to Dr. Anishetty, Former Scientist, FAO, Dr. Girish Pujar, Dr. C. Sudhakar Reddy, Dr. M.V. R. Seshasai, Senior Scientists of National Remote Sensing Agency and Dr. Ramana Murthy, State Biodiversity Board, Andhra Pradesh for participating in the discussions at Hyderabad and for their valued contributions. In the production of this work the office the PPV & FR Authority has helped us immensely. We particularly thank Shri. R. K. Trivedi, Registrar for his contributions to the interactive discussions and to Shri. Dipal Roy Choudhury, Joint Registrar for his keen interest and unstinted support during the printing of this report. The prompt secretarial assistance from Ms. Poonam Tiwari, P.S. to the Chairperson is gratefully acknowledged.

Several individuals and institutions have helped us with photographs of some important plant genetic resources and landscapes in different agrobiodiversity hotspots. We would like to place on record our sincere gratitude to all of them, specially Dr. S.K. Sharma, Director, NBPGR, New Delhi and Dr. M. Sanjappa, Director, BSI, Kolkata for having permitted us to use the photographs from their archives.

We acknowledge with thanks Dr. Babu Ambat, Director, Centre for Environmental Development (CED), Thiruvananthapuram for his help in digitizing the agrobiodiversity hotspot areas and Shri V. R. Vibhu Kumar, GIS System Analyst for his technical assistance. Our thanks are also due to Shri Roy Chacko, Environmental Resources Research Centre (ERRC), Thiruvananthapuram for his secretarial assistance and help.

M.P. Nayar
Chairman, Task Force 6/2007

Thiruvananthapuram
15th January, 2009

AUTHORS

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Anirudh K Singh, Ph D, educated at Aligarh Muslim University, 1962-1966; Patna University, Max-Planck Institute Köln and Cornell University, Ithaca, 1994-95. He has made significant contributions to the management of agro-biodiversity nationally and internationally, while serving as Cytogeneticist and Germplasm Specialist, ICRISAT during 1978-1997; Project Co-ordinator Pigeon pea, Indian Institute of Pulses Research (ICAR) and Head, Germplasm Conservation Division, National Bureau of Plant Genetic Resources, New Delhi, until 31st July 2008. He was awarded "The CGIAR Chairman's Excellence in Science Award" for "Outstanding Locally Recruited Scientist"(1997) & Fellow of the National Academy of Sciences, India.

K. Narayanan Nair, Ph D, is associated with Plant Biodiversity & Conservation Biology Division of the National Botanical Research Institute (NBRI/CSIR), Lucknow as Senior Scientist. He is a plant taxonomist with over 22 years of research experience in systematic and diversity studies on Indian Rutaceae. Dr Nair is currently working on molecular taxonomic and genetic diversity assessment in Indian Citrus and wild relatives. Dr Nair has to his credit 17 research papers, 4 scientific articles, 7 contributed chapters to books, 3 books (Co-authored/co-edited) and 2 patents (1 filed and 1 awarded).

CONTENTS

Volume 1

1 INTRODUCTION

1.1 Pursuant to the principles enunciated in the preamble of the Protection of Plant Varieties and Farmers' Rights (PPV & FR) Act, 2001, and as per the section 45 (2) (c) of the above cited Act for the operation of the Gene Fund, and under section 70 (2) under PPV & FR Rules, 2003 for the manner of applying the Gene Fund for supporting and rewarding farmers, community of farmers, the tribal and rural communities engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives, particularly in areas of agrobiodiversity hotspots, a Task Force (6/2007) was constituted by PPV & FR Authority on 8th October, 2007 under the Chairmanship of Dr. M. P. Nayar, Former Director, Botanical Survey of India with Dr. A. K. Singh, Head, Germplasm Conservation Division, National Bureau of Plant Genetic Resources (NBPGR) of the ICAR as Member Secretary and Dr. K. Narayanan Nair, Scientist, National Botanical Research Institute (NBRI-CSIR), Lucknow as Member. The terms of reference of the Task Force were:

i. To examine the documents on agrobiodiversity hotspot areas circulated in various meetings organized /attended by the PPV & FR Authority.

ii. To examine the seventeen agrobiodiversity hotspot sites in India identified by the Authority in the discussions held at North East Hill University, Shillong (Meghalaya) and Annamalai University, Chidambaram (Tamil Nadu).

iii. To list the botanical species of economic importance that are endemic to these hotspots.

iv. To identify the species that are endangered and that need protection so as to ensure sustainable agriculture activity in the country.

v. To advise on the type of reward that can be bestowed on the communities keeping in view of the provisions of the PPV & FR Act, 2001.

1.2. The Task Force had three meetings in New Delhi and one in Hyderabad. The methodology adopted/followed by the Task Force is given below:

1.2. 1 Preparation of the list of plant species related with agrobiodiversity: To identify the major components of agrobiodiversity i.e. cultivated species, wild relatives, keystone species, endemic species and wild economically important species occurring in the region.

1.2.2 Developing quantifiable criteria for general circulation among agricultural and farming communities and non-governmental agencies. The Task Force identified the following criteria/indices:

1.2.2.1 Richness in agrobiodiversity, having following components: number of crop species cultivated; number of varieties of crop species cultivated; number of wild relatives of crop species occurring in the region;

1.2.2.2 Social importance of agriculture providing livelihood to people;

1.2.2.3 Ancientness of agriculture to the region providing evolution, adaptation and development, including number of species and varieties domesticated suited to different agroclimatic regions of the area;

1.2.2.4 Uniqueness of the agro-ecosystem: Ingenuity and unique practices that are being followed for natural resource management, sustainable agriculture and development of production and farming systems in responses to the changing scenario ;

1.2.2.5 Interaction with external civilization, cultures and agricultural systems; agricultural practices associated with religion, culture, art, etc.

1.2.3 The Task Force reviewed the assessments based on the above mentioned indices. The Task Force members, with technical support by a group of resource persons, reviewed the identified hotspots on

the basis of richness of floristic diversity, crop diversity, endemism of plants of agrobiodiversity importance and their association with agroecosystems, local tribes and cultures.

1.2.4 The Task Force circulated a questionnaire to collect information from various stakeholders i.e. ethnic communities, particularly from social and farming communities and non-governmental organizations regarding the different indices, particularly socially relevant agricultural practices.

1.2.5 The revised list of 22 hotspots identified using the above indices were circulated among the various stakeholders, particularly among various social organizations working in different parts of the country. This helped to a large extent in ground verification of the facts documented in the literature.

1.2.6 The information thus collated were further discussed among resource persons who are specialized in agriculture, plant genetic resources, agrobiodiversity and production systems. This further helped in the validation of the information on agroecosystems, agrobiodiversity and cropping patterns.

2 PREAMBLE

2.1 One of the most serious environmental problems faced by humankind is the irretrievable loss of biodiversity, leading to extinction of plant and animal species and erosion of genetic resources, threatening the very survival of human race. Biodiversity, especially agrobiodiversity makes an essential contribution for feeding millions of population of the world. Presently, the greatest threat to agrobiodiversity, besides the loss of habitat, is the rapidly diminishing gene pool due to genetic homogeneity of high yielding varieties. The traditional varieties and landraces of most of our crops are disappearing from our fast changing agricultural landscape, from our farmlands and woodlands as high yielding varieties are making inroads into the islands of rural or tribal communities who conserve our heirloom genetic resources. The National Farmers Policy (2007) says that "the Gene Fund and Biodiversity Fund should be used exclusively for recognizing and rewarding the contributions of tribal and rural women and men and for supporting the revitalization of *in situ*/ on-farm conservation traditions of such communities".

2.2 Pursuant to the Stockhom Declaration in June 1972 at the United Nations Conference on the Human Environment, followed by the Brundtland Commission report on "Our Common Future" in 1987, and the First Earth Summit at Rio de Janiero in 1992, which adopted several environmental conventions such as Biological Diversity (CBD), Climate Change, Ozone Depletion, and India, being a signatory to the above mentioned conventions enacted national laws for the protection of our environment, biodiversity and plant varieties. Some of our salient laws are the Environment Protection Act (1986), Protection of Plant Varieties and Farmers' Rights Act (2001) and the Biological Diversity Act (2002). The Rio Earth Summit was an important milestone for sustainable development, which has now become a new paradigm in the conceptual framework of India's development scenario

for the protection of ecosystems and integrated management of land, water and living resources. Accepting the United Nations Millennium Development Goals and acceding to Kyoto Protocol to the United Nations Framework on Climate Change, India is a signatory for the reduction of green house gases. The Johannesburg Declaration (2002) on sustainable development for the welfare of marginal rural, tribal and ethnic communities and the provision of gender equity are the guiding principles in the enactment of India's new legislative laws on tribal welfare, for the development of grassroot Panchayat Raj institutions and for the protection of plant varieties and farmers' rights.

2.3 In view of the various projections of Climate Change, and postulated rise of 1.4-5.8°C in the global mean temperature and rise in sea level during 1990-2100, resulting in the pole-ward shifts of biomes and changes in the rainfall patterns, possibility of El Nino effect, flash floods and drought, and ecosystem changes, there would be drastic changes in agrobiodiversity affecting the agricultural production systems. As a result, agroecosystems and species, which are disturbed from their established landscapes would become extinct. Studies by experts already cautioned about the melting of Arctic and Antarctic Ice Caps and of glaciers in the Himalayas.

2.4 As a member of the World Trade Organization (WTO), India has the option under Article 27.3 (b) of the Trade Related Aspects of the Intellectual Property Systems (TRIPS) for the protection of the plant varieties either by patents, or by an effective *sui generis* system (the only one of its kind). As a corollary to this, India opted for the *sui generis* system for the protection of plant varieties giving importance to farmers' rights as compared to the provisions of International Union for the Protection of New Varieties of Plants (UPOV). Following this, the Government of India enacted "The Protection of Plant Varieties and Farmers' Rights Act" (PPV & FR Act) in 2001 and the Rules for implementing the Act in 2003. The Act is considered as an important milestone for Indian farmers against the backdrop of TRIPS- related global trade regimes. The PPV & FR Act is a *sui generis* system which recognizes the rights of farmers with respect to their contributions made in conserving, improving and making available plant genetic resources for the development of new plant

varieties and also as evolvers of Farmers' Varieties. It is seen that the PPV&FR Act recognizes explicitly the rights of farmers as conservers, breeders and cultivators. One of the many benefits as per the PPV & FR Act is the provision of National Gene Fund under section 45 (2) (c) of the Act and under rule 70 of Chapter VI on Farmers Rights of the Act. As per the Act, the National Gene Fund shall be used for supporting and rewarding farmers and farming communities, who are engaged in conservation and improvement of genetic resources of economic plants and their wild relatives, particularly from the areas identified as hotspots of agrobiodiversity.

2.5 The Article 8(j) of CBD mandates that the benefits arising from the utilization of traditional knowledge and practices that are relevant to conservation and sustainable use of biological diversity should be equitably shared with the communities concerned. This includes the contributions of the farming community to the critical foundational knowledge of agricultural biodiversity that led to development of new plant varieties. The PPV & FR Act (2001) recognizes the farmers' rights for the first time in the legislative history of India and is hailed as a path breaking initiative for the Indian farmers. Under section 39 (1) (i) of this Act, the farmer is entitled for registration of any variety he has bred and developed, and under section 39(1) sub-clause (iii), the farmer is entitled for reward from Gene Fund, if he conserves genetic resources of landraces and wild relatives of economic plants including any donor genes contained in the selected or improved material which is registerable under the Act. Besides, under 39(1) (iv), the farmer "shall be deemed to save, use, sow, resow, exchange, share or sell his farm produce including seed of a variety protected under this Act in the same manner as he was entitled before the coming into force of this Act".

2.6 Agrobiodiversity hotspots: The PPV&FR Act mentions agro-biodiversity hotspot for the purpose of channeling the Gene Fund to the beneficiaries. It is, therefore, necessary to define 'agrobiodiversity hotspot' and how it differs from the 'biodiversity hotspot', though there are commonalities. Fundamentally, agrobiodiversity is a subsystem under biological diversity governed by CBD and Biological Diversity Act 2002. The major constituents of agrobiodiversity are as follows:

centers of origin of cultivated species and varieties. It includes : (i) The harvested crop varieties, progenitors of cultivated plants, livestock breeds and their non-domesticated species; (ii) Non-harvested species including microorganisms, pollinators which support agro-sylvan-ecosystems; (iii) Non-harvested species in the environment, which support functioning of food production ecosystem. The richness of agrobiodiversity is also due to the interaction of culturally diverse ethnic groups over time and space on the selection and breeding of the progenitors of cultivated species. It includes the variety and variability of plants, animals and microorganisms which help the functioning and sustaining the key functions of the agroecosystems, including its structure and processes, assuring the food production and food security (FAO, 1998).

2.7 Broadly, agrobiodiversity is that part of biodiversity which nurtures people and which is being nurtured by people. The major indicators of the hotspots of agrobiodiversity are the occurrence of rich genetic resources useful to humans and the varied ethnic cultures which conserve, select, adopt and domesticate wild relatives of cultivated plants. Usually rich plant genetic resources occur in areas where the driving forces of adaptations and evolutionary mechanisms operate in time and space, i.e. heterogeneity of landscape, areas of extreme climatic fluctuations, areas of soil and altitudinal stresses. On the basis of the above criteria, it is proposed to designate areas rich in plant genetic resources, economic plant species, endemic species, progenitors of cultivated plants, their wild relatives, with vast array of variability in different ecosystems, i.e. farm lands, grasslands and woodlands, which have evolved under various environmental stresses and evolved or co-adapted through man's agro-pastoral interventions, as "Agrobiodiversity Hotspots".

2.8 National Gene Fund: One of the farmer friendly mechanisms enacted in the PPV& FR Act 2001 is the constitution of the National Gene Fund under Section 45 of the Act. This national kitty gets its fund from the credits received through benefit sharing, annual fee payable to the PPV&FR Authority by way of royalty, compensations and contributions from national and international agencies. It is further mentioned that the Gene Fund would be disbursed for benefit

sharing, expenditure for supporting the conservation and sustainable use of genetic resources and for strengthening the capability of the Panchayats for conservation and sustainable use.

The Gene Fund would get augmented from compensations received from the breeder who ignored the valuable contributions of any village or local community, which contributed significantly to the evolution of the variety, on the basis of any proven claims made by the farmers or communities as per law. The priorities for disbursing the Gene Fund are mentioned in the Rule 70 of the PPV & FR Rules. It is meant for supporting and rewarding farmers, community of farmers, particularly tribal and rural communities engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives in areas identified as agrobiodiversity hotspots. It is also for capacity building and for supporting *in situ* conservation at the level of the local body, particularly in regions identified as agrobiodiversity hotspots. Villages and Panchayats are also the beneficiaries of Gene Fund as per the PPV& FR Act, 2001. It was felt at a dialogue held at M. S. Swaminathan Research Foundation (MSSRF) in collaboration with FAO during 2002 that majority of primary conservers are women and there must be adequate representation of tribal and farm women in the decision making committees which award the benefits through Gene Fund and that the manner of utilizing the benefit may be left to the communities with appropriate linkages with the Biodiversity Management Committees of the region. It was also felt necessary that training programmes may be organized in local languages for explaining the various aspects of legislations on plant varieties, seeds and agrobiodiversity so that the farming community understands the intricacies and legalities of various farmer-friendly regulations.

2.9 The National Policy for Farmers has highlighted the benefits of National Gene Fund and Biodiversity Fund as follows: "Quite often, the conserved material of great value is the contribution of a community and not an individual. Therefore, the procedures adopted should be that community contributions must be recognized and suitably rewarded. The Gene Fund and Biodiversity Fund should be

used exclusively for recognizing and rewarding the contributions of tribal and rural women and men for supporting the revitalization of *in situ* on-farm conservation traditions of such communities. The National Commission on Agriculture further underlines the importance of gender equity as follows: "The provisions in the Biodiversity Act (2002) for prior informed consent and benefit sharing are equally important for tribal and rural women and men. Invariably, much of the conservation work has been done and is being done by women. Therefore, the recognition procedures should take into account gender roles in the conservation and enhancement of bioresources. The gender mainstreaming of the implementation procedures of both the Acts is important. A gender audit provision may be introduced in the operation of both the Gene and Biodiversity Funds." In the world's large canvas of sustainable development and gender equity, it would be appropriate to quote verbatim "the challenges we face" mentioned in the Johannesburg Declaration (2002): 'We are committed to ensure that women's empowerment and emancipation and gender equality are integrated in all activities encompassed within Agenda 21, the Millennium Development Goals and the Johannesburg Plan of Implementation."

2.10 To sum up, the maintenance and sustenance of *in situ* agrobiodiversity in India is linked to the conservation of entire biological diversity including heirloom species, initiation of appropriate mechanisms to prevent high yielding varieties swamping and overrunning the present pockets of agrobiodiversity hotspots and recognition of tribal and rural women and men as primary conservers of agrobiodiversity, especially in the areas identified as hotspots of agrobiodiversity.

3 Executive Summary

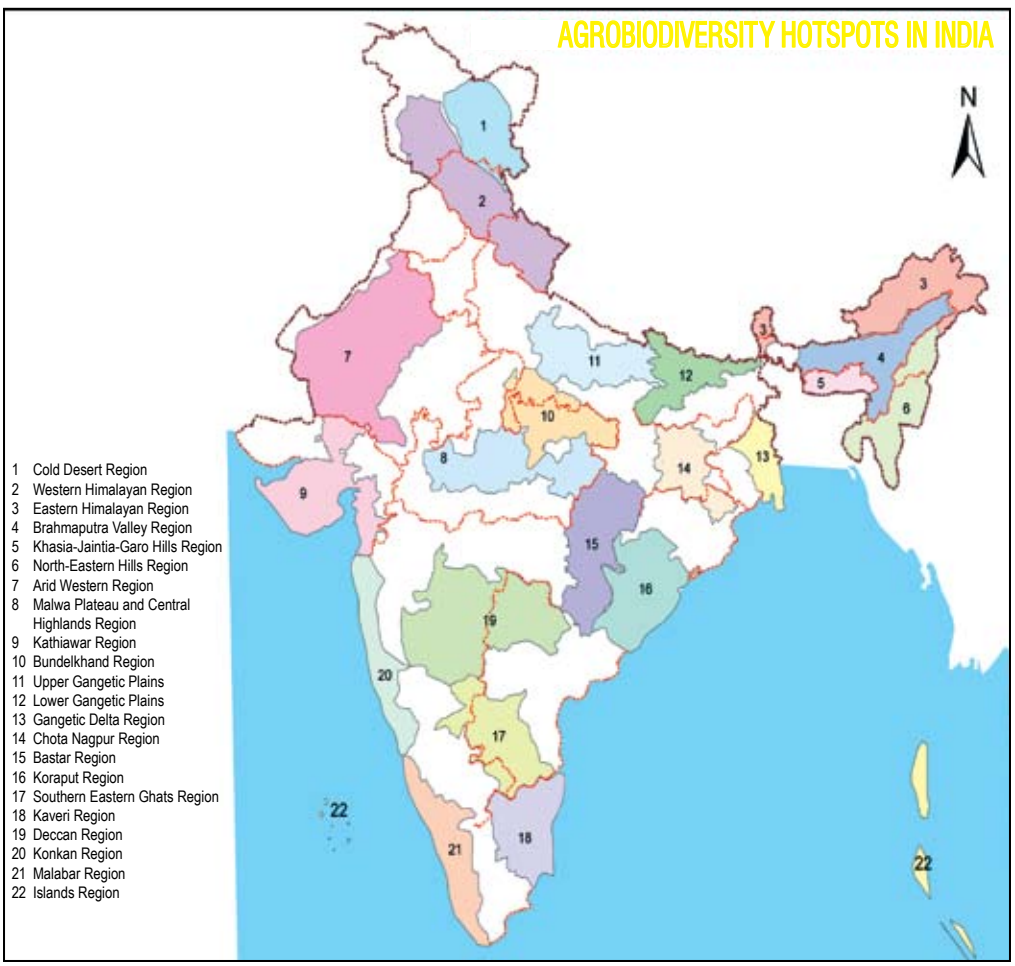
3.1 India is one of the twelve megadiversity countries of the world and is considered as a major centre of domestication of crop plants. Through millennia, India is known for its civilizations and cultures and also for the confluence of human migrations attracted by the fertile Indo-gangetic plains. Out of this rich biodiversity, the ancient farming communities from time immemorial had grown and developed a rich cornucopia of crop plants through selection and adaptations. India has over 45000 species of plants and fungi, representing 11% of the world's flora. India is rich in endemic species representing 33 % of its flora. There are three hotspots of biodiversity in the Indian subcontinent, i.e. The Western Ghats & Sri Lanka, the Himalayas and Indo-Burma Region, and 25 micro hotspots of flora. There are 16 forest types and 251 subtypes in India. The region has 21 agroecological regions. It is reported that at least 166 crop plants and about 320 species of wild relatives of cultivated plants originated in India. Within the spectrum of crop species and wild relatives, there are thousands of varieties, cultivars, landraces and ecotypes which occur in India.

3.2 India is inhabited by about 550 tribal communities of 227 ethnic groups having 84.5 million people, which represent about 8 % of the total population of the country. It is seen that large number of wild relatives of crop plants, primitive cultivars of cereals, millets, pseudo millets, pulses and vegetables, which almost disappeared from their original habitat, are found near tribal villages or backyard farms of tribal settlements.

3.3 On the basis of richness of agrobiodiversity, i.e. number of crop species, crop varieties, wild relatives of various crop species cultivated, social relevance and ancientness of the agriculture, wild relatives of

crop species occurring in the region, number of species domesticated and the uniqueness of the agro-ecosystems, the Task Force proposed the following 22 agrobiodiversity hotspot regions in India:

1. Cold Desert Region, 2. Western Himalayan Region, 3. Eastern Himalayan Region 4. Brahmaputra Valley Region, 5. Khasia-Jaintia-Garo Hills Region, 6. North-Eastern Hill Region, 7. Arid Western Region, 8. Malwa Plateau and Central Highlands Region, 9. Kathiawar Region, 10. Bundelkhand Region, 11. Upper Gangetic Plains Region, 12. Lower Gangetic Plains Region, 13. Gangetic Delta Region, 14. Chotanagpur Region, 15. Bastar Region, 16. Koraput Region, 17. Southern Eastern Ghats Region, 18. Kaveri Region, 19. Deccan Region, 20. Konkan Region, 21. Malabar Region and 22. Islands Region (Andaman & Nicobar Islands, Lakshadweep).



3.4 Within the framework of the 22 Agrobiodiversity regions, in order to channelise the National Gene Fund, the Task Force has identified the districts in each region as indicative hotspots of agrobiodiversity where there are species diversity, genetic diversity, ethnic and rural cultures which maintain and nurture the traditional crops and their varieties.

3.5 The Task Force has brought out a brief write up of the 22 agrobiodiversity regions giving the location and extent, agroclimate, floristic diversity, agriculture and agrobiodiversity (which includes crop species and wild relatives, other economic plants, endemic species, threatened species, associated culture and tribes and technology products as available). The list of crop speices and wild relatives mentioned under each agrobiodiversity region, however, is not exhaustive.

3.6 The names of tribes associated with each hotspot of agrobiodiversity is given, which might facilitate in channelising the Gene Fund, if required. The Task Force considered that rural agricultural communities, especially women play an important role in the conservation of wild relatives of cultivated plants as heirloom collections.

3.7 The Task Force has presented an updated list of about 1660 commonly cultivated plants of crop importance and their wild relatives with common names, botanical names, distribution in India and their uses. However, the list is not exhaustive, but indicative for the task in hand.

3.8 As per the terms of reference, a list of endemic species which are of general importance to the agrobiodiversity is presented under each agrobiodiversity hotspot. The list of endemic species is enumerated with the plants' botanical name, family, nature of habit, distribution and uses.

3.9 A list of threatened species, which includes Critcally Endangered, Endangered, Vulnerable, Rare and Indeterminate species is presented under each agrobiodiversity hotspot. The list is enumerated with botanical name, family, nature of habit, threat level and uses.

3.10 There is an urgent need for inventorying, surveying and evaluating the disappearance of large number of wild relatives, varieties and landraces of our crop plants as high yielding varieties swamp the agricultural cropping scenario. Unless a variety or a landrace is known and documented (vouchered, named and conserved), its extinction will remain unknown. The present estimates of the occurrence of native landraces and loss of native landraces are far from satisfactory and this issue needs to be addressed scientifically with qualified expertise. Appropriate action may be taken for preparing a Red Data Book of Cultivated Plants, Varieties and Landraces of India.

3.11 It is necessary to strengthen the existing network of institutionalized *ex situ* collections of NBPGR, specialized national crop institutions and agricultural universities with the upcoming *in situ* on- farm community gene banks envisaged under hotpsots of agrobiodiversity. It is necessary to document such collections as Green Data Book of Cultivated Plant Varieties and Landraces.

3.12 Institution of "**Community Agrobiodiversity Conservation Award".** The Task Force felt that there is an urgent need for the recognition of the role of farming community, particularly tribal and rural communities, farm women engaged in *ex situ* conservation of genetic resources or heirloom collections in their farms and backyard homestead gardens *per se* without any linkages to the production of a new variety. One of the objectives as mentioned in section 45 (2) c is that the Gene Fund shall be used for meeting 'the expenditure for supporting the conservation and sustainable use of genetic resources including *in situ* and *ex situ* collections and for strengthening the capability of the Panchayat in carrying out such conservation and sustainable use'. The Task Force recommends the institution of a national award called "Community Agrobiodiversity Conservation Award" for tribal and farming communities in Agrobiodiversity Hotspots for on-farm *in situ* conservation. The award value may be worth Rs.10.0 lakhs and be implemented as a one time grant project. The normal financial and administrative procedures as applicable in the case of nationally intiated award be followed in this case also.

4 Identifying Hotspots of Agricultural Biodiversity

4.1 India - a cradle of agricultural biodiversity is one of the twelve mega diversity centres of the world and is considered as a major centre of domestication of crop plants. By virtue of its location in the confluence of three major bio-geographic realms, i.e. Indo-Malayan, Palaeoartic and Ethiopian, Indian subcontinent is a crucible of tropical, temperate and semi-arid floristic elements, which in time and space, established, adapted and evolved to form the present spectrum of rich biodiversity of India. Through millennia, India is known for its civilizations and cultures and is also for the confluence of human migrations attracted by the fertile Indo-gangetic plains. Out of this rich biodiversity, the ancient farming communities from time immemorial had grown and developed a rich cornucopia of crop plants through selection and adaptations. By virtue of the physiographic features and climatic patterns with the highest snow clad mountain peaks in the Himalaya to the humid tropics of the Western Ghats and having the highest rainfall in Mawsynram in Meghalaya to one of the low rainfall areas of Thar desert, India has over 45000 species of plants and fungi, representing 11% of the world's flora. There are three hotspots of biodiversity in Indian subcontinent i.e. the Western Ghats & Sri Lanka, The Himalayas, Indo-Burma region (Mittermeir *et al.*, 2004) and 25 micro hotspots of flora (Nayar, 1996). India is rich in endemic species representing 33% of Indian flora (Nayar, 1996). There are 16 forest types and 251 sub-types in India. The region has 21 agroecological regions with varying crop growing periods from 90 to 270 days spanning across different ecosystems and having soil profiles from rich alluvium, black and red soils to shallow skeletal soils and saline soils. This admixture of soil profiles, crop growing periods, soil moisture and rainfall patterns with hyper humid to semi-humid, semi-arid to arid conditions offer different ecological niches for different crops (Sahgal *et. al.*, 1992). Each of these agroecological zones comprises

of myriad microhabitats. It is reported that at least 166 crop plants and about 320 species of wild relatives of cultivated plants originated in India (Khoshoo, 1988; Rana, 1993). Within the spectrum of crop species and wild relatives, there are thousands of varieties, cultivars, landraces, and ecotypes which occur in India. Over the millennia, the Indian farming communities have been developing and sustaining an amazing variety of crops to suit different habitats and ecological conditions.

4.2 Agroclimatic zones

India is characterized by a mosaic of distinct agroecosystems conditioned by its geological history, topographical features, climatic regimes, rainfall patterns, edaphic nature, crop-growing cycles and growing seasons. There is also a wide array of farming practices in the vast and varied cultures and ethnic groups which are the integral part of Indian agriculture scenario. On the basis of inputs received from agricultural experts, the Planning Commission of India during the mid-term appraisal of the 7th Five Year Plan, identified the following 15 broad agroclimatic zones. 1. West Himalayan region, 2. East Himalayan region, 3. Lower gangetic plains region, 4. Middle gangetic plains region, 5. Upper gangetic plains region, 6. Trans-gangetic plains region, 7. Eastern plateau and hills region, 8. Central plateau and hill region, 9. Western plateau and hill region, 10. Southern plateau and hill region, 11. East coast plains and hill region, 12. West coast plains and ghats region, 13. Gujarat plains and hill region, 14. Western dry region, 15. The Island region. The National Bureau of Soil Survey and Land Use Planning delineated 21 agroecological zones on the basis of bioclimate, soil types, and the length of crop growing period (Sahgal *et al.* 1992): 1.Western Himalayas, cold arid ecoregion with shallow skeletal soils and the length of growing period ‹90 days. 2. Western plain and Kutch peninsula, hot arid ecoregion with desert and saline soils and the length of growing period ‹90 days. 3. Deccan plateau: Hot arid eco-region with mixed red and black soils and the length of growing period ‹90 days, 4. Northern plains and Central highlands: hot semiarid ecoregion with alluvium derived soils and the length of growing

period 90-150 days, 5. Central (Malwa) highlands and Kathiawar peninsula: Hot semi-arid ecoregion with medium and deep black soil and the length of growing period 90-150 days, 6. Deccan plateau: Hot semi-arid ecoregion, with shallow medium black soils and the length of growing period 90-150 days, 7. Deccan plateau and Eastern Ghats: Hot semi-arid ecoregion with red and black soils and the length of growing period 90-150 days, 8. Eastern Ghats (Tamil Nadu uplands and Deccan plateau): Hot semi-arid ecoregion with red loamy soils and the length of growing period 90-150 days, 9. Northern plains: Hot subhumid ecoregion with alluvium derived soils and the length of growing period 150-180 days, 10. Central highlands (Malwa and Bundelkhand): Hot semi-humid ecoregion with medium and deep black soils and the length of growing period 90-150 days, 11. Deccan plateau and central highlands (Bundlekhand): Hot subhumid eco-region with mixed red and black soils and the length of growing period 150-180 days, 12. Eastern plateau (Chattisgarh): Hot sub-humid ecoregion with red and yellow soils and the length of growing period 150-180 days, 13. Eastern (Chotanagpur) plateau and Eastern Ghats: Hot subhumid ecoregion with red loamy soils and the length of growing period 150-180 days, 14. Eastern plains: Hot sub-humid ecoregion with alluvium derived soils and the length of growing period 180-210 days, 15. Western Himalayas: Warm subhumid ecoregion with brown forest podzolic soils and the length of growing period 180-210 days, 16. Assam and Bengal plains: Hot humid ecoregion with alluvium derived soils and the length of growing period ‹ 210 days, 17. Eastern Himalayas: Warm per humid ecoregion with brown and red hill soils and the length of growing period ‹210 days, 18. Northern eastern hills: Warm per humid ecoregion with red and laterite soils and the length of growing period ‹ 210 days, 19. Eastern coastal plains: Hot subhumid ecoregion with alluvium derived soils and the growing period 150-210 days, 20. Western Ghats and coastal plains: Hot humid, per humid ecoregion with red laterite and alluvium soils and the growing period ‹210 days, 21. Andamans & Nicobar islands and Lakshadweep islands: Hot per humid ecoregion with red loamy and sandy soils and the growing period ‹210 days.

4.3 Biogeographical zones of India

4.3.1 The Indian subcontinent represents the confluence of three major biogeographical realms, the Oriental, Paleoarctic and Ethiopian, of which the Oriental and Paleoarctic realms have major contributions. This indicates the rich and varied Indian flora and fauna, a meeting ground of tropical, temperate and arid biodiversity elements. As per Udvardy's (1975) classification, there are 12 provinces: 1. Malabar rainforest: the Western Ghats, 2. Bengalian rainforest: parts of West Bengal, Assam and other rainforests of the northeast, 3. Indo-Ganges monsoon forest. 4. Burma monsoon forest, 5. Mahanadian (Eastern coastal areas of Andhra Pradesh and Orissa) 6. Coromandel: the Eastern Ghats, 7. Deccan thorn forest, 8. The desert: the arid areas of Rajasthan and Gujarat, 9. Lakshadeep islands, 10. Andaman & Nicobar islands, 11. Himalayan highlands, 12. Tibetan trans -himalayan cold desert areas in Jammu & Kashmir and Himachal Pradesh.

4.3.2 As per physiography, climatic conditions, rainfall regimes and edaphic profiles, Rodgers *et al.,* 1988 classified biogeographic zones in India as follows: 1. Trans Himalayan zone having Tibetan province. 2. Himalayan zone having the following four provinces: North Western Himalaya, Western Himalaya, Central Himalaya and Eastern Himalaya, 3. Desert zone having two provinces: Kutch and Thar, 4. Semi-arid zone having two provinces: Punjab, Gujarat-Rajware, 5. Western Ghats zone having two provinces: Malabar coast and Western Ghats mountains, 6. Deccan Peninsula zone having five provinces: Deccan plateau, South central plateau, Eastern plateau, Chotanagpur, Central highlands, 7. Gangetic plains zone having two provinces: Upper Gangetic Plains and Lower Gangetic Plains, 8. North East India zone having two provinces: Brahmaputra valley and Assam hills, 9. Islands: Andaman and Nicobar Islands, 10. Coastal zone having the following two provinces: West coast and East coast.

4.3.3 The forests form the major component in the floristic compositions. Champion and Seth (1968) classified the forests of India on the basis of dominance of canopy species, flagship species and associated floristic elements in the background of ecosystems. The forest types are classified into 16 major groups and 34 sub-groups. The major

groups are: 1. Moist tropical forests, 2. Tropical moist deciduous forests, 3. Tropical semi-evergreen forests, 4. Littoral and swamp forests, 5. Tropical dry deciduous forests, 6. Tropical thorn forests, 7. Tropical dry evergreen forests, 8. Subtropical broad-leafed forests, 9. Sub-tropical alpine forests, 10. Sub-tropical dry evergreen forests, 11. Montane wet temperate forests, 12. Himalayan moist temperate forests, 13. Himalayan dry temperate forests, 14. Sub-alpine forests, 15. Alpine scrub, 16. Dry alpine scrub.

4.3.4 Based on species assemblages, topographical features, climatic conditions and endemic centres, Nayar (1996) identified 20 phytogeographical divisions covering the entire country.: 1. Andaman group of islands, 2. Nicobar group of islands, 3. Southern Western Ghats, 4. Northern Western Ghats, 5. Leeward Deccan Plateau, 6. Southern Eastern Ghats, 7. Northern Eastern Ghats, 8. Chotanagpur Malwa and Vindhya Plateau, 9. Western Himalaya, 10. Central Himalaya, 11. Eastern Himalaya, 12. North eastern India, 13. Assam plains, 14. Indo-gangetic plains, 15. Aravalli hills, 16. Arid Zone (Western Rajasthan), 17. Semi-arid zone (Kathiawar and Kutch, 18. Coastal zone, 19. Mangroves, 20. Lakshadeep islands.

4.3.5 On the basis of the presence of largest number of endemics and fragility of the habitat, Myers (1988,1990) initially identified 18 hotspots globally, which were further revised to 25 (Myers *et al.*, 2000) & 34 global hotspots (Mittermier *et al.*, 2004) and included three major hotspots for Indian subcontinent: 1. Western Ghats (including Sri Lanka), 2. The Himalayas, 3. Indo-Burman region. After a study of endemism in Indian flora, Nayar (1996) identified 25 micro hotspot areas in India: 1. Andaman group of islands, 2. Nicobar group of islands, 3. Agasthyamala hills, 4. Anamalai & High ranges (Cardamom hills), 5. Palni and high wavy mountains, 6. Nilgiris -Silent valley, Wayanad-Kodagu. 7. Shimoga-Kannada, 8. Mahabaleswar-Khandala ranges, 9. Konkan- Raigad, 10. Marathwada –Satpura ranges, 11. Tirupati-Cuddappa-Nallamalai hill ranges, 12. Vizagapatnam-Ganjam-Jeypore hills, 13. Southern Deccan (Leeward side), 14. Chotanagpur plateau, 15. Kathiawar- Kutch, 16. Rajasthan-Aravalli hills, 17. Khasia-Jaintia hills, 18. Patkoi- Manipur-Lushai hills, 19. Assam, 20. Aruncachal Pradesh Himalaya, 21. Sikkim Himalaya, 22. Garhwal- Kumaon

Himalaya, 23. Lahul-Himachal Pradesh Himalaya, 24. Kashmir-Ladakh Himalaya, 25. Nepal Himalaya (interface of E. Himalaya with W. Himalaya).

4.4 Footprints of domestication of crop plants

4.4.1 The history of domestication of crops goes back as far as 5000 B.C. judging from the Neolithic sites and Harappan sites (4500-3750 B.C.) and it is characterized by primitive farming. The post Harappan Chalcolithic cultures evolved and synergized with new local cultures. The neolithic culture sites have also been located in the south and northeast. Some of the footprints of domestication of crop plants are largely gleaned from the studies of paleobotanists (Vishnu Mittre, 1974; 1977) and plant breeders (Chang, 1989). On the basis of various carbonised remnants of crops enumerated below and on the basis of carbon dating, it can be considered that wheat, barley and rice are the oldest cereals (2500 B.C.) in India. However, ragi (finger millet) advented later during 1800 B.C. and sorghum established around (1725-110 B.C.). Pea (*Pisum arvense*), lentil (*Lens culinaris*), khesari (*Lathyrus sativus*) are the earliest leguminous crops cultivated in India followed by chickpea. The oldest oilseeds in India are mustard and sesame. It is seen that the carbonised data of crop plants represent only few shreds in the vast tapestry of genetic resources available in India since carbonization and fossilization differs from one locality to another due to the exigencies of geological formation and sedimentation.

4.4.2 The cultivation of wheat in Neolithic sites in the Kashmir valley is inferred from the occurrence of seeds of weedy species growing in the wheat fields, such as *Lithospermum arvense*, *Medicago denticulata*, *Medicago* spp., *Lotus corniculatus*, and *Ipomoea* spp. which are carbon dated about 2300-1500 B.C. Wheat is also known from Mohenjo-daro in the Sind valley and from Harappa in Punjab and they are carbon dated around 1755 B.C. From the distribution of wheat, it is seen that Harappan culture extensively cultivated wheat as one of the staple crops. During the post Harappan Chalcolithic period, the carbonized wheat were collected from Atranji Khera sites (1200 B.C.), from Uttar Pradesh, Navdatoli-Maheshwar (1960-1440 B.C) from Madhya Pradesh, and Sonegaon (1340-1290 BC.) from Maharashtra. The Neolithic wheat was discovered from Chirand, Sarna in Bihar

which is as old as 2500 B.C. Based on scientific analysis, it has been concluded that the ancient wheat in India is hexaploid *Triticum sphaerococcum*.

4.4.3 During the Chalcolithic period, rice was the most popular crop throughout India as obtained from the mass of information and the archaeobotanical records obtained from the pottery muds, impressions, charred grains, presence of husks and spikelets. Rice was one of the staple crops wherever there was rainfall. It is seen that there was no Harappan sites for rice. From the analysis of grain size, the following rice varieties were reported: *Oryza officinalis*, *O. perennis*, *O. rufipogon*, *O. sativa* var. *spontanea*, *O. sativa* var. *japonica*, *O. sativa* var. *indica*. Some of the important rice sites along with their dates are given in chronological order: Lothal, Saurashtra (2300 B.C.), Chirand, Bihar (2500-1800 B.C.), Rangpur, Saurashtra (2000-1800B.C.), Atranji Khera, Uttar Pradesh (2000-200 B.C.), Navdatoli -Maheshwar (1557-1400 B.C.), Ahar, Rajasthan, 1885-1070 B.C.), Kausambi, Uttar Pradesh (1400 B.C.), Maheshdal, Bengal (1385-1085 B.C.), Inamgaon, Maharashtra (1370 B.C), Dhibi, Bengal (1000 B.C.), Ambri, Assam (900 B.C.), Hallur, Mysore (870 B.C.), Kunnatur, Tamil Nadu (300 B.C.), Kolhapur, Maharashtra (100 A.D.). Though the wild progenitors of rice occur at present in southern and eastern India, there is only scanty information available from archaeobotanical collections. Jeypore-Koraput tract is known today as one of the primary centres of origin of cultivated rice, besides the neolithic husk discovered from Baidipur in Orissa.

Barley was widely used during the Harappan period (2300- 1750 B.C.). The barley found at Mohenjo-daro site is identified as *Hordeum vulgare* var. *nudum* and it was found along with wheat. The material found at Harappa is identified as *Hordeum vulgare* var. *hexastichum*. Along with Harappan records, there are large number of neolithic sites for barley in the gangetic plains at Atranji Khera, Uttar Pradesh (2000-1500 B.C.), Neolithic Chirand, Bihar (2500-1800 B.C.), Kashmir valley at Burzahom (1800 B.C.), and at Maheshwar, Madhya Pradesh (1600-1440 B.C.).

Though millets botanically are considered to be of African origin, archaeobotanical material collected in India were dated from Neolithic period i.e. jowar (*Sorghum bicolor*) were recorded from Ahar, Rajasthan

(1725-110 B.C.), ragi (*Eleusine coracana*) from Neolithic Hallur in Mysore (1800 B.C.), bajra or pearl millet (*Pennisetum glaucum*) from Rangpur, Saurashtra (1200-1000 B.C.) and kodo millet (*Paspalum scrobiculatum*) from Hallur, Mysore (1200-1000 B.C.). Besides the above, the following millets occur in India: *Echinochloa colonum*, *E. crus-galli*, *E. frumentacea*, *Eleusine indica* and *Paspalum miliaceum*. Today millets are the dryland crops and form the mainstay of farmers in semi-arid lands where there is a scanty rainfall.

In the Harappan sites besides wheat, barley and sorghum, there are leguminous and oil yielding species, i.e. pea (*Pisum sativum*), sesame (*Sesamum indicum*) and Indian mustard (*Brassica juncea*). There are also seeds of melon in the Harappan sites and charcoals of *Saccharum arundinaceum*. The carbonised seeds of pea are also found in the Neolithic site at Chirand in Bihar and Chalcolithic site at Navdatoli in Madhya Pradesh.

4.4.4 India is considered as one of the primary centres of origin of chickpea, *Cicer arietinum* (Vavilov, 1951). The oldest record of chickpea is from Aranji Khera in the Uttar Pradesh (2000 B.C.). At the Neolithic site at Tekkalkota in Mysore, there are records of kodo millet and horse gram (*Macrotyloma uniflorum*) dated 1780- 1540 B.C. The early records of barley, black gram (*Vigna mungo*), green gram (*V.radiata*), and horse gram (*Macrotyloma uniflorum*) were found from Ter in Maharashtra dated 200 B.C. The Neolithic sites at Chirand in Bihar, besides the rich records of wheat, rice, barley and pea, recorded othr leguminous species, such as lentils (*Lens culinaris*), and khesari (*Lathyrus sativus*). During Chalcolithic period at Navdatoli-Maheshwar in Madhya Pradeh, the crops recorded were wheat, rice, pea, black gram, green gram and lentil and carbonized seeds of *Lathyrus sphaericus*, *Linum usitatissimum*, *Vicia sativa*, *V. tetrasperma*, *Phyllanthus emblica* and *Zizyphus nummularia* (1600 B.C.) Cotton (*Gossypium spp.*) is known from Harappa and Mohenjadaro (2300-1500 B.C.) and also recorded during the Iron Age from Mysore about 1000 B.C. There are two species of *Gossypium*, which served as mother stocks: *Gossypium herbaceum* occurring across from the Nile valley to Sind and *G. arboreum* occurring from Kathiawar to Khandesh and Deccan.

4.5 Agrobiodiversity, tribal and cultural diversity

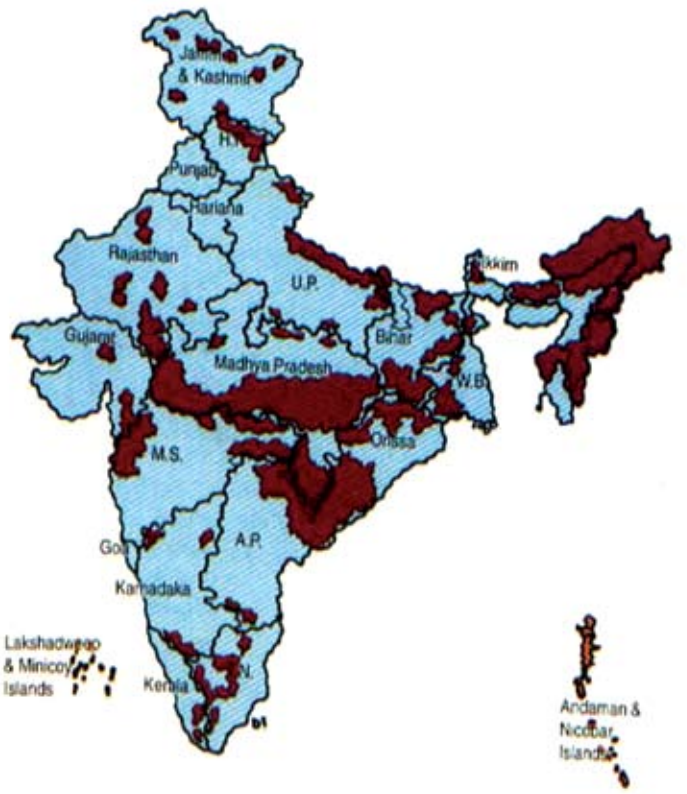
Agrobiodiversity and cultural diversity go together. Ethnic diversity and tribal diversity have played a major role in the diversification of crop genetic resources. The ancestors of many of our crop plants and landraces or folk varieties are interwoven with tribal and ethnic cultures. Besides the natural evolutionary causes, the diversity of crops to a large extent is the outcome of thousands of years of careful observation, selection and adaptation of crops. India is inhabited by about 550 tribal communities of 227 ethnic groups having 84. 5 million people, constituting 8 % of total population of the country. Two third of the tribal population is distributed in the states of Madhya Pradesh, Orissa, Bihar, Gujarat and Rajasthan, geographically spanning across from the Aravallis, Central highlands, Vindhyan –Satpura ranges, the Chotanagpur plateau, Bastar to North Eastern Ghats. Tribal population varies from state to state. Tribal population-wise, Madhya Pradesh ranks first having 12.2 million tribal communities followed by Maharashtra (8.5 million), Orissa (8.1 million), Bihar (7.5. millon), Gujarat (7.4 million), Rajasthan (7.0 million), Jharkhand (7.0 million), Chattisgarh (6.6 million), and Andhra Pradesh (5.0 million). The tribal population in Karnataka and West Bengal is about 4.0 million each and Assam has 3.3 millon tribal people. The states of Kerala, Tamil Nadu and Uttar Pradesh have about 1 million tribal communities each. The northeastern Indian states having more than 60 per cent of tribal populations are Arunachal Pradesh (63.7%), Meghalaya (85.5%), Mizoram (94.7%), Nagaland (87.7%). Usually, the tribal communities have only oral traditions. Their knowledge about specific plant usage is transmitted largely through word of mouth and tradition. Much of this ethno-agricultural knowledge has, therefore, remained localized or confined to certain regions or tribes. Since the tribal and rural village communities have a subsistence level economy, all useful plants including low yielding plant varieties are being cultivated as their heirloom collections. As per the report of the All India Coordinated Research Project on Ethnobiology (Ministry of Environment and Forests), out of 3900 wild plant species used as edible subsidiary food or vegetables by the tribal communities, about 800 species are new records and at least 250 of them require attention as alternative source of food.

It has been observed that a large number of wild relatives of crop plants, primitive cultivars of cereals, millets, pseudo millets, pulses and vegetables, which almost disappeared from its original habitat, are found near tribal villages or backyard farms of tribal settlements. Such rural and tribal communities are the traditional conservers of agrobiodiversity at the grassroot level as they conserve all genetic resources for their subsistence economy or for selling at the village market or "hat". The role of tribal communities and subsistence farmers in the conservation of crop genetic diversity is recognized throughout the world. It is seen that through millennia the farming and tribal groups have created, developed and maintained many traditional varieties through conscious selection and nurturing of their selected lines. The comparative data of proposed agrobiodiversity hotspots and the tribal cultural hotspots revealed some degree of synchronization. Admitting this fact, the tribal communities' mainstay is the forest environment and their habitat and settlements are near forests. However this synchronization reveals the cultural diversity and synergy of tribal communities. Of the proposed 22 Agrobiodiversity hotspots, the following 13 hotspots synchronise with the cultural tribal hotspots of the country:

4.5.1 **Eastern Himalayan Agrobiodiversity region:** The agrobiodiversity region includes all the districts of Arunachal Pradesh, Sikkim and Darjeeling district of West Bengal. The tribal population of Arunachal Pradesh is 0.7 million, representing about 64 % of its population. The tribes of Arunachal Pradesh are: Abor, Aka, Aptani, Dafla, Galong, Khampti, Khowa, Mishmi, Momba, Any Naga tribes, Sherdukpen, Singpho. The tribes of Sikkim are: Bhutia, Lepcha. The tribal population of Sikkim is 0.11 million, representing about 20.6% of its population.

4.5.2 **North-Eastern Hills Agrobiodiversity region:** The agrobiodiversity region includes all the districts of the states of Manipur, Mizoram, Nagaland and Tripura and the adjoining Cachar and North Cachar tribal autonomous districts of Assam The tribal population of Manipur is 0.74 million representing 34% of its population. The main tribes of Manipur are Aimol, Anal, Angami, Chiru, Chothe, Gangte. Himar, Kabui, Kacha Naga, Koirao, Koireng, Korn, Lampgang, Mao, Maram, Maring, Any Mizo (Lushai tribes),

Tribal Concentration In India



Jhum cultivation- a traditional practice in the North Eastern and Eastern Himalayan regions of India

Monsang, Moyon, Paite, Purulum, Ralte, Sema, Simte, Suhte, Tangkhul, Thadou, Vaiphul and Zou. The population of tribes in Mizoram is 0.83 million representing 94.7 % of its population. The notified Tribal Areas are Chakma district, Mara district, Lai district. The population of tribes in Nagaland is 1.7 million representing 87.7% of its population. The main tribes are Naga, Kuki, Kachari, Mhikir and Garo. The population of tribes in Tripura is 0.99 million which represents 31% of its population. The main tribes are Bhil, Bhia, Chaimal, Chakma, Garoo, Halam, Jamatia, Khasia, Kuki, Lepcha, Lushai, Marg, Munda, Noaita, Orang, Riang, Santal, Tripuri, and Uchai.

4.5.3 **Khasia-Jaintia-Garo Hills Agrobiodiversity region:** In this region, all the districts of Meghalaya are notified tribal areas. The population of tribals is 1.9 million representing 85.5% of its population. The main tribes are Chakma, Kachari, Garo, Hajong, Hmar, Khasi Jaintia, Any Kuki, Lakher, Mari (Tai-speaking), Any Mizo, Mikir, Any Naga, Pawi, and Synteng.

4.5.4 **Brahmaputra Valley Agrobiodiversity region:** The main agrobiodiversity areas are Dhuburi, Kokrajhar, Goalpara, Barpeta, Nalabari, Kamrup, Dispur, Darrang, Nagaon, Sonitpur, Karbi Anglong, Golaghat, Jorhat, North Lakhimpur and Dibruarh districts. The notifed tribal areas are North Cachar district and Karbi Anglong district. The tribal population is 3.3 million representing 12. 4 % of its population. The main tribes are Barmans. Boro, Chakma, Deon, Kachan, Garo, Hojai Hajong, Hmar, Kachari, Khasi, Jaintia, Lalung, Any Kuki, Lakher, Mari, Mech, Any Mizo, Mikir, Miri, Any Naga tribes, Pawi, Rabha, and Syntheng.

4.5.5 **Chotanagpur Agrobiodiversity region:** The main agrobiodiversity area includes the southern districts of Jharkhand mainly the areas of Singhbhum, Gumla, Ranchi, Lohardaga, Palamau and Hazaribhag and Santhal Pargana amd Mayurbhanj in Orissa. The tribal population in Jharkhand is 7.0 million representing 26.3% of its population. The main tribes are Asur, Baiga, Banjara, Bedia, Bhumji, Binjhia, Birhor, Birijia, Chero, Chik Baraik, Gond, Gorait, Ho, Karmali, Kharia,

Kharwar, Khond, Kisan, Kora Korwa, Lohara, Mahli, Muda, Oran, Parhaiya, Santhal, Sauri Paharia and Savar.

4.5.6 **Bastar Agrobiodiveristy region:** The area includes southern Chattisgarh. The hotspot areas are the districts of Bilaspur, Durg, Jashpur, Kabirdham, Kanker, Kirba, Koria, Mahasmu, Kondaigaon, and Rajnandagaon. The tribal population of Chattisgarh is 6.6 million, which forms 31.7 % of its population. The main tribes are Bhumiya, Gond, Kamar, Karku, Kharwar, Kondh, Kol, Korku, Korwar, Majhi, Munda, Pardhi, Parja, Saur, and Sawar.

4.5.7 **Koraput Agrobiodiversity region:** The Koraput agrobiodiversity area includes districts of south western Orissa i.e. Malkangiri, Sonabeda, Jeypore, Koraput, Nabrangpur, Kalahandi, Bolangir, Rayagada and districts of northeastern Andhra Pradesh i.e. Vijanagaram, Vizagapatnam, Srikakulam. The tribal population is 8.1 million representing 22.1% of the population of Orissa state. The main tribes are Bagata, Bhumia, Bhondo, Chenchu, Didayi, Gond, Lambadis, Kharwar, Kol, Koyas, Khondadora, Khondareddis, Kora, Korua, Lodha, Mahali, Mankidi, Manikirdia Oraon, Penta, Porja, Santhal, Daora and Tharua.

4.5.8 **South Eastern Ghats Agrobiodiversity region:** The region includes the districts of Nallamalai-Palkonda ranges, Tirupati hills and adjacent Rayalaseema area. The hotspot areas are the districts of Chittoor, Ananthapur, Cuddapah, Kurnool in Andhra Pradesh and districts of Bellary and Raichur in Karnataka. Though the tribal population in Andhra Pradesh is about 5.0 million, the south Eastern Ghats agrobiodiversity region represents only a part of Andhra Pradesh. The major tribes are Bagatas, Chenchus, Lambadis, Khondareddis and Khonda doras.

4.5.9 **Kaveri Agrobiodiversity region:** The hotspot area includes the districts of Chengalpettu, South Arcot, North Arcot, Thiuvannamalai, Tiruchirapalli, Pudukottai, Thiruarur, Vellore, Kanchipuram, Salem, Namakkal, Karur, Dindigual. The major tribes are Irular, Kadar, Kond Kapus, Konda reddis, Malai pandarams and Malayali.

4.5.10 **Deccan Agrobiodiversity region:** The semi-arid agrobiodiversity area includes the districts of Jalna, Hingoli, Pharbhani, Beed,

Nanded, Latur, Osmanabad, Solapur, Sangli, Gondia, Gadchiroli in Maharashtra; districts of Adilabad, Karimnagar, Warangal and Khamman in Andhra Pradesh; and districts of Bidar and Gulbarga in Karnataka. In Maharashtra, the tribal population is about 8.5 million and the major tribes are Andh, Baiga, Bavacha, Bhatra, Bhil, Bhunja, Chodhara, Dhanka, Dhondia, Gond, Kamar, Kathodi, Kanwar, Kol, Khond, Koya, Naikada, Oroan, Pardhan, Pardhi, and Sawar. In Andhra Pradesh, the tribal population is 5.0 million. The major tribes in Adilabad, Karimnagar, Warangal and Khamman districts of Andhra Pradesh are Chenchus, Lambadis, Khondareddis and Koyas.

4.5.11 **Malwa Plateau and Central Highlands Agrobiodiversity region:** The region includes the following districts of Madhya Pradesh: Shadol, Raisen, Sagar, Bhopal, Sehore, Shajapur, Indore, Ujjain, Mandsaur, Hoshangabad, Narsinghpur, Jabalpur, Mandla and Umaria. The population of tribals in Madhya Pradesh is 12.2 million, i.e. 20 % of the population of the state. The major tribes are Agariya, Andh, Baiga, Bharia Bhumia, Bhattara, Bhil, Bhil Mina, Mina, Binjwar, Dhanwar, Gadaba, Gond, Karku, Kanwar, Kondar, Kolam, Korwa, Munda, Khanika, Panika, Pardhan, Pardhi, Parja, Sahariya, Saunta, Sawar and Saur.

4.5.12 **Arid Western Agrobiodiversity region:** The region includes the following districts of Rajasthan: Sikar, Nagaur, Pali, Hanumangarh, Ganganagar, Jalore, Sirohi, Jodhpur, parts of Jaisalmer and Bikaner, Udaipur, Dungarpur, Churu and Jhunjhunun. The population of the tribals in Rajasthan is 7.0 million, which forms 12.5% of the state population. The major tribes are Bhil, Bhil Mina, Damaaria, Dhanka, Garasia, Kathodi, Koli Dhor, Mina, Naikada, Patelia and Sahariya.

4.5.13 **Kathiawar Agrobiodiversity region:** The region includes the following districts of Gujarat: Ahemadabad, Surendranagar, Jamnagar, Rajkot, Porbandar, Junagadh, Amreli, Bhavnagar, Bharuch, Surat, Navsari, Valsad, Banaskantha and Anand. The population of tribals is 7.4 million, which forms 14.7% of its population. The major tribes are Barda, Bavacha, Bhil, Charan, Chodhara, Dhanka, Dhodia, Gond, Kaathodi, Kokni, Koli, Kunbi, Nakda, Padhar, Paudhi, Patelia, Rathawa, Siddi, Vaghri, and Kotwalia.

5 PROPOSED TWENTY TWO HOTSPOTS OF AGROBIODIVERSITY

5.1 The Hindustan Centre of origin of crops and plant diversity is considered as one of the eight-mega centres of origin of cultivated plants by Russian botanist Vavilov (1951). Indian subcontinent is the home of 166 species of crops and 334 species of wild relatives of cultivated plants. Of this, India's major contribution to world's crops and wild relatives are Oryza, Vigna, Cajanus, Mangifera, Musa, Piper, Curcuma, Amaranthus, Brassica, Trichosanthes, Cucumis, Luffa, Sesamum, Abelmoschus, Saccharum, Artocarpus, Dioscorea, Elettaria, Ammomum, Zingber, Cinnamomum, Myristica, Corchorus, Crotalaria, Citrus & Allium. Besides the number of crop species at the species level, there is a vast genetic diversity at the varietal and landraces level throughout the agrobiodiversity rich areas. During ancient times, Indian farmers grew more than 50,000 different varieties of rice. There are more than 1000 varieties of mango and more than 500 varieties of pepper. Based on an ethnobiological survey by the Ministry of Environment and Forests it is reported that the tribal communities in India use about 3900 species of food plants. The major cultivated crops with their wild relatives were enumerated by Mehra *et al.*, (1982). There are about 686 wild relatives of cultivated plants and their distribution is enumerated as follows: Western Himalaya (125), Eastern Himalaya (82), North Eastern India (132), Gangetic Plains (66), Indus Plains (45), Malabar/W. Peninsular region (145), Deccan/Eastern Peninsular region (91) (Arora *et al.*, 1984). Pandey *et al.*, (2005) enumerated the wild and weedy relatives and related species collected by National Bureau of Plant Genetic Resources as a part of the National Agricultural Technology Project (NATP) during the period (1999-2004). These include 17 cereals and millets, 26 legumes, 16 oilseed crops, 19 fibre yielding plants, 58 vegetables, 24 tuber yielding plants, 111 fruit plants, 69 spice and condiment plants, 26 aromatic and medicinal plants and 16 other useful species.

5.2 As a precursor to the purpose of administering the Gene Fund of PPV&FR Act 2001, Nagarajan *et al.* (2007) traced the genesis and importance of agrobiodiversity in a white paper on "Agro biodiversity hotspots" in the background of biogeography, endemic plants and centres of origin of cultivated plants in India and proposed 17 agrobiodiversity hotspots for India: 1. Travancore-Malabar region, 2. Konkan coast, 3. Gulfs of Gujarat (Rann and Kutch), 4. Leeward Deccan Plateau, 5. North Gujarat/ Mewar, 6. Arid Jodhpur-Bikaner belt, 7. North West temperate Himalaya and Ladakh, 8. Sikkim Hills and Arunachal Himalaya, 9. Hills of Meghalaya, 10. Nagaland/ Manipur /Tripura /Mizoram, 11. Brahmaputra part of Assam, 12. Lower Ganges Plain, 13. Gangetic Delta, 14. Triveni- Allahabad belt, 15. Koraput region, Bastar and adjoining area, 16. Cauvery system 17. Andaman and Lakshadweep islands.

5.3 The above mentioned inputs were further studied on the basis of richness of agrobiodiversity i.e. number of crop species, crop varieties, wild relatives of various crop species cultivated, social relevance and ancientness of agriculture, wild relatives of crop species occurring in the region, number of species domesticated and the uniqueness of the agroecosystems. The study undertaken in delineating agrobiodiversity hotspots is supported by the richness of floristic diversity, endemism of plants of agrobiodiversity importance and their association with agroecosystems, local tribes and cultures. Based on a critical analysis of these indices, the Task Force identified the following 22 agrobiodiversity hotspot regions in India

1. Cold Desert agrobiodiversity region
2. Western Himalayan agrobiodiversity region
3. Eastern Himalayan agrobiodiversity region
4. Brahmaputra valley agrobiodiversity region
5. Khasia-Jaintia-Garo Hills agrobiodiversity region
6. North-Eastern Hills agrobiodiversity region
7. Arid Western agrobiodiversity region
8. Malwa Plateau and Central Highlands agrobiodiversity region

9. Kathiawar agrobiodiversity region
10. Bundelkhand agrobiodiversity region
11. Upper Gangetic Plains agrobiodiversity region
12. Lower Gangetic Plains agrobiodiversity region
13. Gangetic Delta agrobiodiversity region
14. Chotanagpur agrobiodiversity region
15. Bastar agrobiodiversity region
16. Koraput agrobiodiversity region
17. Southern Eastern Ghats agro biodiversity region
18. Kaveri agrobiodiversity region
19. Deccan agrobiodiversity region
20. Konkan agrobiodiversity region
21. Malabar agrobiodiversity region
22. Islands agrobiodiversity region

5.4 The above mentioned 22 agrobiodiversity regions may be classified under the following seven Agrogeographical zones: (Rana *pers. comm.*2008)

5.4.1 The Himalayan zone comprising the Western Himalaya region, Eastern Himalaya region, North Eastern Hill region, the Brahmaputra valley region and the Khasi-Jaintia-Garo region.

5.4.2 The Arid zone comprising the Cold Desert region and Arid Western region.

5.4.3 The Gangetic zone comprises the Upper Gangetic, Eastern Gangetic region and Gangetic Delta region.

5.4.4 The Gondwana tribal zone comprises the Chotangapur region, Bastar region and Koraput region.

5.4.5 The Central Indian zone comprising the Kathiawar, Malwa Plateau and Central Highlands and Bundelkhand regions.

5.4.6 Peninsular zone comprising the Konkan, Deccan, South eastern Ghats, Kaveri and Malabar regions.

5.4.7 Island agroecosystem: Andaman and Nicobar islands, Lakshadweep.

5.5 The details of the location and extent of each the agrobiodiversity regions are given separately under Chapter 7. However, within

each agrobiodiversity region, the hotspot areas, districts where there is richness of crop diversity, floristic diversity, endemic plants of agrobiodiversity importance and their association with agroecosystems, local tribes and cultures are also flagged for the purpose of channelising the benefit sharing to the communities, tribes or villages holding the genetic resources. The salient agrobiodiversity spectrum of species, which occur in each of these 22 agrobiodiversity regions is highlighted. It is seen that over centuries farmers cultivated and adapted large number of useful crops across the length and breadth of India within the limiting factors of climate, rainfall and seasonality and edaphic and altitudinal tolerance. The salient characteristics of the identified agrobiodiversity hotspots are given below in a synoptic overview:

5.5.1 Cold Desert Region

The cold desert agrobiodiversity hotspot is located in the upper limits of Western Himalayas covering Ladakh and Kargil districts and upper reaches of Lahual-Spiti districts of Himachal Pradesh. The genetic resources of the cold arid region are characteristically extreme cold tolerant species of *Allium* (*Allium carolnianum*, *A. chitralicum*, *A. gilgiticum*), Chickpea (*Cicer microphyllum*), Buckwheat (*Fagopyrum cymosum*, *F. tataricum*), Wild caraway (*Carum bulbocastanum*), Fenugreek allies (*Trigonella emodii*, *T. podperae*), Apricot (*Prunus armenica*, *P. tomentosa*), Wild Linseed (*Linum perenne*), Sea buckthorn (*Hippophae rhamnoides*, *H. salicifolia*, *H. tibetana*) and medicinal plants i.e. *Arnebia euchroma*, Aconite (*Aconitum heterophyllum*), *Ephedra* (*E. gerardiana* var. *gerardiana*), *Saussurea lappa*, *S. sacra*, *Prangos pabularia*.

5.5.2 Western Himalaya Region

The Western Himalayan agrobiodiversity region consists of the states of Jammu & Kashmir, Punjab (Shiwalik), Himachal Pradesh and Uttarakhand. It includes mostly temperate hills and warm subhumid foothills of the region. The agrobiodiversity hotspot area covers the districts of Srinagar, Anantnag, Udhampur, Riasi, Kathua in Jammu & Kashmir, all the districts of Himachal Pradesh except the cold arid region and all the districts of Uttarkhand.

The Western Himalaya is known for the genetic resources of temperate fruits: Almond (*Prunus amygdalus*), Sweet Cherry (*Prunus avium*), Sour Cherry (*Prunus cerasoides*), Common Plum (*Prunus domestica*), Peach (*Prunus persica*), *P. jacquemontiana*, *P. jenkinsii*, *P. prostrata*, *P. tomentosa*, *P. wallichii*, Pear (*Pyrus communis*), Kumaon Pear (*Pyrus kumaonii*), Apple (*Pyrus domestica*), Currant (*Ribes glaciale*), *R. nigrum*, Raspberry (*Rubus ellipticus*, *R. fruticosus*), Sorbus (*Sorbus aucuparia*, *S.lanata*). The region is known for several species of *Allium* (*Allium altaicum*, *A. fistulosum*, *A. porrum*, *A.roylei*, *A. schoenoprasum*, *A. tuberosum*, *A. victorialis*). The region has rich assemblage of wild rye (*Elymus dahuricus*, *E. dentatus* subsp. *ludoviciana*), Oats and Oats allies (*Avena sativa*, *A. barbata*, *A. fatua* subsp. *fatua*, *A. sterilis* subsp. *ludoviciana*), Barley and Barley allies (*Hordeum vulgare*, *H. aegiceras*, *H. brevisubulatum*, *H. distichon*, *H. spontaneum*), Wheat and wheat allies (*Triticum aestivum*, *T. aestivum* subsp. *sphaerococcum*, *Aegilops tauschii*).

5.5.3 Eastern Himalaya Region

The Eastern Himalaya agrobiodiversity region comprises of the states of Sikkim, Arunachal Pradesh and Darjeeling district of West Bengal. The hotspot area includes all the districts of Arunachal Pradesh, Sikkim and Darjeeling district of West Bengal.

Eastern Himalaya has rich genetic resources of temperate and subtropical fruits, such as citrus, mango, banana, wild relatives of kiwi fruits (*Actinidia*), cucurbits, yam, sugarcane, aromatic and spice plants: Citrus and wild relatives (*Citrus limon*) Karna Citrus (*Citrus karna*), Sweet Lime (*Citurs limettoides*), *C. medica* var. *medica*, *C. ichangensis*, *C. reticulata*, Crab apple (*Docynia hookeriana*, *D. indica*), *Eriobotrya dubia*, Sikkim Strawberry (*Fragaria daltoniana*), Mango (*Mangifera indica*) and *wild relatives* (*Mangifera andamanica*, *M. khasiana*, *M. sylvatica*), Banana (*Musa acuminata*, *M. balbisiana*, *M. cheesmanii*, *M. mannii*, *M. nagensium*, *M. sikkimensis*, *M. velutina*), wild cherries *Prunus bracteopadus*, *P. himalaica*, *P. imanishii*, *P. jenkinsii*, *P. napaulensis*, *P. rufa*. var. *trichantha*, Khasi Pear and allies: (*Pyrus khasiana P. pashia*, *P. pyrifolia*), Currant (*Ribes glaciale*, *R. acuminatum*), Raspberry: (*Rubus ellipticus*, *R. lineatus*, *R. foekeanus*, *R. fragarioides*, *R. ghanakantus*, *R. griffithii*, *R. hypargyrus* var. *niveus*, *R. senchalensis*, *R. sikkimensis*. var. *sikkimensis*), Sorbus, (*Sorbus himalaica*, *S. microphylla*, *S. vestita*), Rose

(*Rosa x odorata* nothovar. *gigantea*), *Vitis himalayana*, *V. lanata* var. *rugosa*, *V. heyneana*. The Alliums are well represented: Garlic (*Allium sativum*, *A. angulosum*), Onion (*Allium cepa*, *A. hysistum*, *A. pratti*, *A. rhabdotum*, *A. sikkimense*). The yams form important supplementary food and the genus *Dioscorea* is represented by *Dioscorea alata*, *D. esculenta*, *D. hispida*, *D. lepcharun*, *D. pentaphylla*, *D. prazeri*, *D. scortechnii* and *D. wallichii*. The cucurbits have number of species in Eastern Himalaya: Cucumber (*Cucumis sativus*), *C. hystrix*, *Cucurbita maxima*, *C. moschata C. pepo*; *Luffa acutangula*, *L. aegyptiaca*, *Momordica charantia*, *M. cochinchinensis*, *M. dioica*, *Solena heterophylla*, *Trichosanthes cucumeriana* var. *anguina*, *T. bracteata* var. *tomentosa*, *T. cordata*, *T. dioica*, *T. wallichiana*.

Important spice and aromatic plants are: Bengal cardamom: (*Amomum aromaticum*), *Amomum maximum*, *A. subulatum*, *Betel* nut (*Areca catechu*, *A. nagensis*), Tamala (*Cinnamomum bejolghota*, *C. pauciflorum*, *C. caudatum*, *Cinnamomum bejolghota*, *C. tamala, C. yabunikkei*), Gold thread (*Coptis teeta*), Turmeric and allies (*Curcuma longa*, *C. amada*, *C. aromatica*, *C. caesia*, *C. latifolia*, *C. montana*), Galanga (*Kaempferia galanga*), *Caulokaempferia sikkimensis*, Pepper and wild relatives (*Piper nigrum*, *P. attenuatum*, *P. hamiltonii*, *P. laxivenum*, *P. mungpooanum*, *P. peepuloides*, *P.ovatistigmum*, *P. sikkimense*, *P.tenuibracteatum*, *P. thomsonii*, *P. wallichii*, *P. schmidtii*), Perilla (*Perilla frutescens*), Ginger (*Zingiber officinale*, *Z. chrysanthum*, *Z. clarkei*, *Z. zerumbet*). The wild relatives of sugarcane are**:** *Saccharum fallax, S. longisetosum*, *S. ravennae*, *S. sikkimense*, *S. williamsii*, *Miscanthus nepalensis*, *M. nudipes*, *M. taylorii*, *M. wardii*.

5.5.4 Brahmaputra Valley Region

The Brahmaputra valley agrobiodiversity region includes the districts adjoining Brahmaputra river with its tributaries and Barak valley. The hotspot area includes the following districts: Dhubri, Kokrajhar, Bongaigaon, Barpeta, Nalbari, Goalpara, Kamrup, Golaghat, Darrang, Morigaon, Nagaon, Sonitpur, Jorhat, Lakhimpur, Sibsagar, Dibrugarh, Dhemaji, and Tinsukia.

The Brahmaputra valley is known for genetic resources of rice, banana, cucurbits, yam, *Garcinia*, jute and fibre yielding species, tea, *Hedychium* and bamboos and canes, Citrus (*Citrus assamensis*, *C. limon*, *C. maxima*), Mango and wild relatives (*Mangifera indica*, M. *sylvatica*), Plantain and

wild relatives (*Musa assamica*, *M. cheesmanii*, *M.mannii*, *M. paradisiaca*, *M. sapientum*, *M. velutina*). The important cucurbits occurring in this region are: Sponge gourd (*Luffa aegyptiaca*, *L. graveolens*), Bitter gourd (*Momordica charantia*), Cucumber (*Cucumis sativus*), *C. hystrix*, Pumpkin (*Cucurbita pepo*), Snake gourd and relatives (*Trichosanthes cucumeriana* var. *anguina*, *T. dioica*, *T. cordata*). The important tuber yielding plants are : Elephant-foot yam (*Amorphophallus bulbifer* var. *bulbifer*, *A. bulbifer* var. *tuberculiger*), Taro (*Colocasia esculenta*, *C. fallax*, *C. mannii*), Yams (*Dioscorea alata*, *D. pentaphylla*, *D. prazeri*, *D. trinervia*) The native fruits used for flavouring are : *Garcinia pedunculata*, *G. sopsopia*, *G. stipulata*, *G. xanthochymus.* The spice yielding plants are: Bengal cardamom (*Amomum aromaticum*), Mango ginger (*Curcuma amada*), *Alpinia malaccensis*, Cinnamon (*Cinnamomum bejholgota*, *C. glanduliferum*, *C. tamala*, *C. paniculatum*, *C. pauciflorum*), Lemon grass (*Cymbopogon jawarancusa* var. *assamensis*), Pepper (*Piper nigrum*, *P. peepuloides*), Ginger (*Zingiber zerumbet*), *Z. capitatum*. The beverage yielding plants are: Wild coffee (*Psilanthus bengalensis*);Wild tea: *Camellia caudata*, C. *kissi*, *C. sinensis* var. *assamica*; Areca nut (*Areca catechu*). The major fibre yielding species are Jute (*Corchorus capsularis*), C. *olitorius*; *Boehmeria macrophylla*, China grass (*Boehmeria nivea*). Native ornamenatal plants are represented by Butterfly lily, *Hedychium spicatum*, *H. coronarium*, *H. radiatum*, *H. robustum*.

5.5.5 Khasia-Jaintia-Garo Hills Region

The Khasia-Jaintia-Garo agrobiodiversity region includes the state of Meghalaya. The hotspot area includes all the seven districts, i.e. East Garo Hills, West Garo Hills, South Garo Hills, East Khasi Hills, West Khasi Hills, Jaintia Hills and Ri-Bhoi.

The Khasia-Jaintia-Garo region has rich genetic resources of Citrus, Banana, Mango, Myrica, *Garcinia*, Cucurbits, Coffee and Job's tears (*Coix lacryma-jobi* var. *mayuen*). Garo hills has a Gene Sanctuary for Citrus: Ginger Citrus (*Citrus assamenis*), Indian wild orange (*C. indica*), *Khasi papeda* (*C. latipes*), *C. medica*, C. *macroptera* var. *annamensis.* The region is known for wild relatives of mango: (*Mangifera khasiana*, *M. sylvatica*), Prunes (*Prunus cornuta*, *P. jenkinsii*, *P. napaulensis*) and Pear (*Pyrus pyrifolia*), Banana (*Musa assamica*, *M. flaviflora*, *M. velutina*), *Myrica* (*Myrica esculenta*, *M. integrifolia*, *M. rubra*) and *Garcinia* (*Garcinia*

xanthochymus, *G. atroviridis*, *G. pedunculata*, *G. sopsopia*, *G. stipulata*), Khasia Black Currant (*Antidemsa khasiana*).

The cucurbits and their wild relatives are well represented with *Cucumis hystrix*, *Luffa graveolens*, Bitter Gourd and allies (*Momordica charantia*, *M. macrophylla*, *M. subangulata*), Pointed Gourd and allies (*Trichosanthes dioica*, *T. bracteata*, *T. khasiana*, *T. majuscule*, *T. ovigera*, *T. wallichiana*). The genetic resources of coffee are Khasia wild coffee (*Psilanthus khasianus*), *P. jenkinsii*, *P. fragrans.*

5.5.6 North Eastern Hills Region

The Northeastern hills agrobiodiversity region includes the states of Manipur, Mizoram, Nagaland and Tripura and the adjoining districts of Cachar and North Cachar of Assam. The hotspot area includes all the districts of Manipur, Mizoram, Nagaland, Tripura and the adjoining Cachar and North Cachar districts of Asom.

The North-Eastern Region is a major centre of genetic resources of India and ranks as the largest repository of wild plant genetic resources which would be of potential use to the Indian agriculture. The Eastern Himalaya region is known for the wild relatives of tuber crops i.e. taro, yam and elephant-foot yam, vegetable crops i.e. cucurbits, solanums, temperate fruits such as citrus, crab apple, prunes, pyrus, tea, sugarcane and spices such as bengal cardamom, cinnamon, pepper, ginger, turmeric and galanga.

The major tuber crops are Elephant-foot yam (*Amorphophallus bulbifer* var. *bulbifer*, *A. bulbifer* var. *atroviridimaculatus*, *A. bulbifer* var. *tuberculiger*), Taro (*Colocasia esculenta*), East Indian Arrowroot (*Curcuma angustifolia*), *C. amada*, *C. aromatica;* Yam and yam allies (*Dioscorea decipiens*, *D. esculenta*, *D. lepcharum*, *D. pentaphylla*, *D. pubera*, *D. prazeri*, *D. trinervia*, *D. wattii*).

The cucurbits are represented by Cucumber (*Cucumis sativus*), *C. hystrix*, Sponge gourd (*Luffa aegyptiaca*, *L. graveolens*), Bitter gourd (*Momordica charantia*), Sweet gourd (*M. cochinchinensis*) *M. subangulata*, *M. macrophylla*; Snake gourd (*Trichosanthes cucumeriana* var. *anguina*), Pointed gourd (*T. dioica*), *T. cordata*, *T. ovigera*, *T. tomentosa*, *T. wallichiana*. The plantain has wild relatives of cultivated species and cultivars and

they are represented by *Ensete superbum*, *Musa assamica*, *M. itinerans*, *M. nagensium*, *M. velutina*; The genus *Solanum* is represented by *Solamum bracteatum*, *S. barbisetum*, Brinjal (*Solanum melongena*), *S. nigrum*, *S. spirale*, *S. kurzii*, *S. torvum*.

The major fruits are: Indian wild orange (*Citrus indica*), Khasi papeda (*C. latipes*), Rough lemon (*C. jambhiri*), Karna citrus (*C. karna*), Sweet Lime (*C. limettioides*), Melanesian papeda (*C. macroptera*), Citron (*C. medica*,) Sour pomelo (*C. megaloxycarpa*); Indian crab apple (*Docynia indica*, *D. hookeriana*), Mango (*Mangifera indica*), *M. sylvatica*. There are large number of fruits which are used by ethnic communities: Wild vine (*Ampelocissus barbata*), *Artocarpus heterophyllus*, *A. lakoocha*, *A. chama*, *Baccaurea ramiflora*; *Castnopsis indica* (nuts edible), *Coriaria nepalensis*, *Corylus ferox* (Hazel nut), *Clausena anisata*, *C. excavata* (fruits edible), Khachur (*Cornus macrophylla*), *Dillenia aurea*, *D. indica*, *Diospyros lanceafolia*, *D. nigrescens*, *Elaeagnus pyriformis*, *E. umbellata*, Saklang (*Elaeocarpus lanceafolius*), *E. prunifolius*, Saul-kari (*E. varunua*), *Eriobotrya angustissima*, *Garcinia atroviridis*, *G. cowa*, *G. pedunculata*, *G. sopsopia*, *G. stipulata*, *G. xanthochymus*, *Machilus edulis*, *Myrica esculenta*, *Pegia nitida*, *Prunus cornuta*, *P. cerasoides*, *P. jenkinsii*, *P. napaulensis*, *P. rufa*, *Pyrus pyrifolia*, *P. wattii*, *Pyrularia edulis*, *Ribes glaciale*, *Rosa x odorata* nothovar. *gigantea*, *Rubus ellipticus*, *Salacia roxburghii* (fruits edible), *Saurauia cerea*, *S. punduana*, *S. roxburghii* (fruits edible); The spice yielding plants form an important constituent of the rich genetic diversity: Galanga: *Alpinia galanga*, *A. calcarata*, *A. malaccensis*, Greater Cardamom: *Amomum subulatum*, Bengal Cardamom (*Amomum. aromaticum*), *A. corynostachyum*, *A. fulviceps;* Areca nut (*Areca catechu*), *Areca nagensis;* Cinnamon: *Cinnamomum cacharensis*, *C. glanduliferum*, *C. tamala*, *C. paniculatum*, *C. pauciflorum;* Turmeric allies: *(Curcuma aeruginosa*, *C. amada*, *C. aromatica*, *C. brog*, *C . comosa*, *C. caesia*, *C. latifolia*, *C. sylvatica*, *C. zedoaria)*, *Kaempferia galanga*, *Stahlianthus involucratus;* Pepper and pepper allies: *(Piper nigrum*, *P. peepuloides*, *P. attenuatum*, *P parvilimbus*, *P. falconeri*, *P. makruense*, *P. meeboldii*, *P. muneyporensis*, *P. nagense*, *P. phalagense*, *P. sylvaticum);* Ginger allies: *(Zingiber capitatum*, *Z. cernuum*, *Z. chrysanthum*, *Z. intermedium*, *Z. rubens)*.

The beverage crops, namely, tea and coffee have their wild realtives: (*Coffea arabica*), *Psilanthus jenkinsii*, *P. fragrans;* Tea (*Camellia*

sinensis), *C. drupifera*, *C. irrawadiensis*, *C. taliensis*, *C. caudata*. The wild genetic resources of sugarcane occurring in the region are *Erianthus filifolius*, *Miscanthus nepalensis*, *M. nudipes*, *M. taylorii*, *M. wardii*, *Saccharum fallax*, *S. longisetosum*, *S. procerum*, *S. ravennae*, *S. rufipilum*, *Sclerostachya fusca*.

5.5.7 Arid Western Region

The Arid Western agrobiodiversity region is part of the eastern extension of Saharo-Thar desert and is covered with shifting sands with rock outcrops in the Barmer-Jaisalmer-Bikaner tract. The Aravalli ranges from Khetri in the north-east and Khed –Brahma in the south- west forms a distinct geographical boundary on the eastern side of the arid western region. The hotspot area comprises of the following districts of Rajasthan: Sikar, Nagaur, Pali, Hanumangarh, Ganganagar, Jalore, Sirohi, Jodhpur, parts of Jaisalmer and Bikaner, Udaipur, Dungarpur, Churu, and Jhunjhunun.

The Arid Western region has rich genetic resources of millets, fodder crops and dryland agroforestry crops. Wherever irrigation facilities are available, there are drought tolerant vegetable crops. The millets cultivated are Ghant ghas (*Dactyloctenium scindicum*), *Digitaria cruciata*, *Echinochloa crus-galli*, *E. colonum*, *E. frumentacea*, *Eleusine coracana*, *E. indica*, *Panicum miliare*, *P. psilopodium*, Pearl millet (*Pennisetum glaucum*), *Pennisetum purpureum*, *Setaria italica*, *S. glauca*, *S. verticillata*. The agro-forestry species are *Acacia albida*, *A. nilotica*, *A.catechu*, *A. senegal*, *A. tortilis*, *Albizia lebbeck*, *Dichrostachys cinerea*, *Gliricidia sepium*, *Prosopis cineraria*, *P. juliflora*, *Pithecellobium dulce.*

The fodder species are *Andropogon gayanus*, *Brachiaria ramosa*, *Bothriochloa decumbens*, *Bothriochloa intermedia*, *Cenchrus ciliaris*, *C. setigerus*, *Chrysopogon fulvus*, *Eragrostis abyssinica*, *E. amabilis*, *E. cilianensis*, *E. gangetica*, *E. unioloides*, *Latipes senegalensis*, *Lasiurus sindicus*, *Panicum sanguinale*, *P. trypheron*, *P. turgidum*, *Paspalum notatum*, *Pennisetum pedicellatum*, *P. polystachyon*, *P. purpureum*, *Urochloa mosambicensis.* The well-known species of medicinal importance of the arid region are *Alhagi maurorum*, *Boswellia serrata*, *Citrullus colocynthis*, *Commiphora caudata*, *C. wightii*, *Euphorbia caducifolia*, *Withania coagulans*, *W. somnifera*. The locally important known vegetables are : *Citrullus lanatus*, *Cucumis prophetrum*,

Kacheri (*Cucumis melo* var. *agrestis*), Cluster bean/guar (*Cyamopsis tetragonolobus*), *Digera muricata*, Sponge gourd (*Luffa aegyptiaca*), *Moringa oleifera*, *M. concanensis*, Khejari, young pods (*Prosopis cineraria*).The salt tolerant Bikaneri nerma cotton variety (*Gossypium herbaceum*) is well known.

5.5.8 Malwa Plateau and Central Highlands

The Malwa plateau and central highlands agrobiodiversity region includes the Malwa plateau, Central highlands, the Mewar plateau and semi-arid south-eastern Rajasthan. The hotspot area comprises the following districts of Shadol; Raisen, Bhopal, Sehore, Shajapur, Indore, Ujjain, Mandasaur, Rajgarh Hoshangabad, Narsinghpur, Jabalpur, Mandla, Umaria.

The Malwa Plateau and Central Highlands is known for grain legumes and oilseed crops. The important grain legumes and their wild realtives are: Pigeon pea (*Cajanus cajan*), *C. scarabaeoides*, *C. sericea*, Chickpea (*Cicer arietinum*), Soybean (*Glycine max*), *Lablab purpureus*, Horsegram (*Macrotyloma uniflorum*), *Macroptilium atropurpureum*, Garden pea (*Pisum sativum*), *Vigna aconitifolia*, Black gram (*Vigna mungo*), *V. mungo* var. *silvestris*, *V. radiata* var. *sublobata*, *V. trilobata*, Cowpea (*Vigna unguiculata*).The oilseed crops are Ground nut (*Arachis hypogaea*), Niger (*Guizotia abyssinica*), Safflower (*Carthamus tinctorius*), Sesame (*Sesamum indicum*), Mustard (*Brassica juncea*). The other major crops are: rice, wheat, sorghum, maize, sugarcane and cotton. The region is the largest producer of opium (near eastern Rajasthan) and Marosona (near Katwa).

5.5.9 Kathiawar Region

Kathiawar Agrobiodiversity region: The hotspot area includes the following districts of Gujarat: Ahemadabad, Surendranagar, Jamnagar, Rajkot, Porbandar, Junagadh, Amreli, Bhavnagar, Bharuch, Surat, Navsari, Valsad, Banaskantha and Anand.

The Kathiawar -Gujarat region is known for edible oilseeds, grain legumes cotton, castor seeds and psyllium husks. The important crops are: Ground nut (*Arachis hypogaea*), Chickpea (*Cicer arietinum*), Pigeon pea (*Cajanus cajan*), Cluster bean (*Cyamopsis tetragonolobus*), Moth bean (*Vigna aconitifolia*), *V. khandalensis*, Black gram (*V. mungo*),

Green gram (*V. radiata*), Cowpea (*V. unguiculata*). Edible oilseeds are: Ground nut (*Arachis hypogaea*), *Brassica tournefortii*, *Eruca sativa*, Niger (*Guizotia abyssinica*), Sesame (*Sesamum indicum*). The notable spices cultivated here are: European dill (*Anethum graveolens*), Cumin (*Cuminum cyminum*), Psyllium (*Plantago ovata*.). The gum and resin yielding plants are: *Acacia senegal*, *A. nilotica*, *Alhagi pseudalhagi*, *Boswellia serrata*, *Commiphora wightii*, *Garuga pinnata*, *Prosopis juliflora*, *Pterocarpus marsupium* var. *acuminatus*, *Sterculia urens.* The aromatic oil yielding plants are: West Indian lemon grass (*Cymbopogon citratus*), Palmarosa grass (*C. martini*), Vetiver grass (*Vetiveria zizanoides*). The cotton cultivated are *:* Tula (*Gossypium arboreum*), Levant cotton (*Gossypium herbaceum*), American cotton. (*Gossypium hirsutum*).

5. 5.10 Bundelkhand Region

The Bundelkhand agrobiodiversity region includes Bhamder plateau and Kaimur hills. The hotspot areas include the districts of Jhansi, Banda, Chitrakoot, Hamirpur, Jalaun and Lalitpur in Uttar Pradesh and Damoha, Datia, Panna, Sagar, Tikamagarh and Chattarpur in Madhya Pradesh.

Bundelkhand region has varied cropping patterns as per seasonality, soil moisture and soil type**.** In double cropping system in black soils, the following crops are cultivated: sorghum (grain/fodder), cowpea, black gram, green gram. The crop combination for semi -arid region is: Cowpea /blackgram, Safflower/ chickpea, Soybean -mustard/safflower. Watermelon, musk melon and vegetables are raised along dried river beds, called "Zaid": Ground nut (*Arachis hypogaea*), Pigeon pea (*Cajanus cajan*), bold seeded varieties: *Cajanus scarabaeoides*, *C. sericea*, Chickpea (*Cicer arietinum*), Soybean (*Glycine max*), Garden pea (*Pisum sativum*), *Vigna aconitifolia*, Black gram (*Vigna mungo*), *V. radiata* var. *sublobata*, *V. trilobata*, Cowpea (*Vigna unguiculata*). Oil seeds: Mustard (*Brassica rapa* subsp. *campestris*), Niger (*Guizotia abyssinica*), Safflower (*Carthamus tinctorius*), Sesame (*Sesamum indicum*), *Sesamum laciniatum*. Wild relatives of Okra (*Abelmoschus manihot* subsp. *tetraphyllus* var. *pungens*, *A. tetraphyllus*, *A. tuberculatus*) and *Cucumber* (*Cucumis sativus*), *C. callosus*, *C. hardwickii*, *Musk* melon (*C. melo*), Snake cucumber (*Cucumis melo* var. *utlissimus*), *C. prophetarum*, *C. setosus*), Water melon (*Citrullus lanatus*).

5.5.11 Upper Gangetic Plains

The Upper Gangetic Plains agrobiodiversity region falls between the Himalaya in the north and the hill plateau in the south and comprises the major portion of upper Uttar Pradesh, irrigated by the important river network of Yamuna, Ganga, Gomati and Sarayu with their tributaries extending from south of the Shiwalik Range. The hotspot area includes the districts of Hardoi, Sitapur, Barabanki, Lucknow, Unnao, Rae Bareilly, Kanpur, Kannuj of Central Uttar Pradesh and the districts of Maharajganj, Sidharatnagar, Kushinagar, Deoaria, Sant Kabir Nagar, Gorakhpur, Basti of North -eastern Uttar Pradesh.

The fertile Indogangetic plains with plenty of water resources from time immemorial has become the centre of cultivated species and a recepient of introduced crop diversity from Central Asia and Africa, especially cereals, legumes, vegetables and oilseeds. The common crops grown in the area are rice, maize, and pigeonpea during the rainy (*kharif*) season and wheat, chickpea, rapeseed, mustard, potato and vegetables during cold (*rabi*) season. Sugarcane is cultivated as a post *rabi* crop during the months of February-March in the Upper gangetic plains.The largest area of kharif maize is in Uttar Pradesh and the alternate crops in maize areas are rice in *kharif* and wheat in *rabi*. However, in some areas, ground nut, sugarcane, ragi / finger millet and pulses are the alternate crops. The region is one of the major centres of cultivated varieties of tropical fruits, particularly mango (*Mangifera indica*). The other important fruits are amla (*Phyllanthus emblica*), jamun (*Syzygium cuminii*) and guava (*Psidium guajava*).

Vegetables**:** Okra (*Abelmoschus esculentus*), *A. manihot*, *A. tuberculatus;* Lasun/Garlic (*Allium sativum*), *A. wallichii*, *A. stracheyi*, Ras Dhana/ Ram Dana (*Amaranthus caudatus*), Lal sag (*A. gangeticus*), Chaulai (*A. paniculatus*), *A. polygamus*, Ash gourd (*Benincasa hispida*), *Beta vulgaris* subsp. *maritima* Cabbage (*Brassica oleracea*), Rapa (*B. napus*), Rai (*B. juncea*), Mustard, Benarasi Rai (*B. juncea*), Lal Mirchi/Red chilli (*Capsicum frutescens*), Bahu (*Chenopodium murale*), Round gourd (*Citrullus fistulosus*), Pumpkin (*Cucumis pepo*), Cucumber (*C. sativus*), Winter squash (*Cucurbita maxima*), Latmhuria (*Digera muricata*, pot herb), Faridbutti, used as pot herb (*Farsetia hamiltonii*, *F. jacquemontii*),

Dioscorea bulbifera, *D. deltoidea*, *Trigonella foenum-graecum*, *T. obcordata*, *T. occulta*. Legumes: *Cajanus scarabaeoides* (used as pot herb), Pigeon pea (*Cajanus cajan*), Chickpea (*Cicer arietinum*), Lentil (*Lens culinaris*), Garden pea (*Pisum sativum*), Black gram (*Vigna mungo*), *V. prainiana*, Mung bean (*V. radiata*); Edible oils: *Brassica juncea*, *B. quadrivalvis*, *B. tournefortii*, Safflower (*Carthamus tinctorius*), *C. oxycanthus*, Onion (*Allium cepa*), *A. ascalonicum*, Sugarcane: *Saccharum officinarum*. *S. ravennae*, *S. longisetosum*, *S. narenga*, *S spontaneum*, *S. williamsii*.

5.5.12 Lower Gangetic Plains

The Lower Gangetic Plains agrobiodiversity region comprises eastern gangetic plains mostly covering north and north-eastern part of Bihar and the central foot hills of Himalayas. The hotspot area includes the districts of Paschim Champaran, Purbi Champaran, Gopalganj, Siwan, Sitamarhi Muzaffarpur, Saran, Buxar, Bhojpur, Patna, Rohatas, Jahanabad, Vaishali, Samastipur, Darbangha, Madhubani, Sitamarhi, Sheohar in North Bihar.

Rice and maize are the major cultivated crops during rainy (*kharif*) season. Wheat and sugarcane are the alternate important crops cultivated in irrigated and rain-fed conditions. The main *rabi* crop is wheat in the northern districts of Bihar and the alternate crops in the *kharif* are rice, maize and sugarcane. Sugarcane is cultivated as a post-*rabi* crop from March onwards. The cropping system is rice-maize during rainy season and wheat-sugarcane with or without irrigation during winter season. The combination of cropping patterns is rice - chickpea, rice - mustard, rice - lentil, pulses- rabbi maize, sugarcane - pegion pea. The important vegetables, fruits, spices and sugarcane and their wild relatives are as follows: Okra (*Abelmoschus esculentus*, *A. manihot*), Amaranth (*Amaranthus gangeticus*, *A. paniculatus*), Rai (*Brassica juncea*), Benarasi Rai (*B. nigra*), *Rapa* (*B. napus*), *B. tournifortii*, *B. quadrivalvis*, Chilli (*Capsicum annuum*), Safflower (*C. tinctorius*), Wild safflower (*Carthamus oxycantha*), Kundri (*Coccinia indica*), Cucumber (*Cucumis sativus*), Snake cucumber (*Cucumis melo* var. *utilissimus*), Pumpkin (*Cucurebita pepo*), Soh-phlang, edible tubers (*Flemingia procumbens*, *F. strobilifera*), *Lactuca remotiflora*, Small bittergourd (*Momordica dioica*), *M. balsamina*, *M. subangulata*, Potato (*Solanum tuberosum*), Solanum: *S. incanum*, *S. melongena*, *S. indicum*,

Fenugreek (*Trigonella foenum-graecum*, *T. occulta*); WR Sugarcane: *Saccharum arundinaceum, S. narenga*, *S. procerum*, *S. ravennae*, *S. spontaneum*, Spices: *Carum villosum*, *Curcuma ferruginea*, *C. leucorhiza*, *C. rubescens*, Fruits: Bael tree (*Aegle marmelos*), Indian gooseberry (*Phyllanthus emblica*), Wood Apple (*Limonia acidissima*), Anjir (*Ficus carica*), Litchi (*Litchi chinensis*), Mango (*Mangifera indica*), Pomegranate (*Punica granatum*), *Phoenix paludosa*, *P. robusta*, Wild jamun (*Syzygium cuminii*), *Ziziphus oenoplia*.

5.5.13 Gangetic Delta Region

The Gangetic delta agrobiodiversity region broadly includes the deltaic 24-Parganas districts, but also the districts of Hoogly, Howrah, Nadia, Bardhaman, Birbhum and Murshidabad which flank on both sides of the river Hoogly flowing into the Bay of Bengal. The hotspot areas are the districts of South 24 Parganas, North 24 Parganas, Howrah, Hoogly, Nadia, Bardhaman, Birbhum and Murshidabad.

The main crop cultivated is rice both in *kharif* and *rabi* seasons. There are large number of flood tolerant and scented cultivars of rice. The wild realtives of rice are : *Oryza rufipogon*, *Porteresia coarctata*. Jute is also cultivated as an additional crop in the areas prone to flooding. Some of the horticultural and supplementary crops grown in the plains are aroids, banana, coconut, cucurbits, mango, papaya. The cropping system consists of following pattern of crops: rice -wheat, rice - potato, sesame - ground nut- sunflower, jute - rice - sunflower, jute-mustard.

Vegetables: Okra (*Abelmoschus esculentus*, *A. manihot*), Amaranth (*Amaranthus hypochondriacus*, *A. caudatus*, *A. gangeticus*, *A. paniculatus*, Ashgourd (*Benincasa hispida*), *Basella alba*, *B. rubra;* Pomello (*Citrus maxima*); Pumpkin (*Cucurbita pepo*), Kundri (*Coccinia indica*), Musk melon (*Cucumis melo*), Cucumber (*C. sativus*), Ridge gourd (*Luffa acutangula*), Sponge gourd (*Luffa aegyptiaca*), Bitter gourd (*Momordica charantia*), *M. cochinchinensis*, Small Bittergourd (*Momordica dioica*), Winged bean (*Psophocarpus tetragonolobus*), *Solanum incanum*, *S. lasiocarpum*. Tubers: *Amorphophallus bulbifer*, *A. paeoniifolius var. campanulatus*, *A. sylvatius; Colocasia esculenta*, *C. fallax*, East Indian arrow root (*Curcuma angustifolia*), *C. caesia*, *C. amada*, *C. aromatica*, *C. zedoaria*, *Dioscorea esculenta*, *D. pentaphylla*, Kukur alu

(*D. puber*), Yam bean (*Pachyrhizus erosus*), Potato (*Solanum tuberosum*). Fibres: Jute (*Corchorus capsularis*), *C. trilocularis.* The common fruits are: Jack fruit (*Artocarpus heterophyllus*), Bael (*Aegle marmelos*), *Borassus flabellifer*, Karonda (*Carissa carandas*), Wood Apple (*Limonia acidissima*), Indian gooseberry (*Phyllanthus emblica*), Jamun (*Syzygium cuminii*).

5.5.14 Chotanagpur Region

The Chotanagpur region constitutes south and eastern plateau of Jharkhand and contiguous districts in Orissa. It is generally referred as Chotanagpur Plateau, which comprises all the districts of Jharkhand, Mayurbhanj and Sundargarh districts of Orissa. The hotspot areas are the districts of Singhbhum, Gumla, Ranchi, Lohardaga, Palamau and Hazaribhag and Santhal Pargana in Jharkhand and Mayurbhanj district in Orissa.

The Chotanagpur agrobiodiversity region is a centre of genetic resources of pigeon pea, finger millet, yam, palas, tendu, mohua, lac insect tree. The major crops cultivated are rice, millets, pigeon pea during the rainy season. Rice and wheat are also cultivated under irrigated conditions. Direct sowing of ragi, red gram, black gram and ridge planting of maize is also followed. A number of horticultural crops are also grown as per topography and its climatic regimes. The cropping systems are as follows: rice - toria, rice - mustard, rice -niger, rice - ground nut, rice - lentil, rice - sesame. In red soil areas i.e. Ranchi zone: Rice - chickpea / linseed; Ground nut - barley; finger millet- chickpea. The keystone species supporting multi purpose agro-activities are Palas (*Butea monosperma*), Tendu (*Diospyros melanoxylon*), Mohua (*Madhuca longifolia*), Lac Insect tree (*Schleichera oleosa*). The following are the major crops: Millets: Sanwa (*Echinochloa frumentacea*), Barnyard millet (*E. crus-galli*), Finger millet (*Eleusine coracana*), Mandla (*E. indica*), *Pennisetum pedicellatum*. Pulses : Tur (*Cajanus cajan*), *C. cajanifolia*, *C. scarabaeoides* (wild relative of Pegion pea), *Vigna hainiana;* Vegetables: Amaranth (*Amaranthus hypocondriacus*), *A. viridis*, *Abelmoschus crinitus A. esculentus*, *Beta vulgaris* subsp. *maritima*, *Chenopodium album*, Kundri (*Coccinia indica*), Cucumber (*Cucumis sativus*), *Curcuma angustifolia* (source of starch), Bottle gourd (*Lagenaria siceraria*), *Moringa concanensis*, *M. oleifera*, *Musa*

sapientum, *Sesbania grandiflora*, Brinjal (*Solanum melongena*); Tubers: Taro (*Colocasia esculenta*), Country Potato (*Coleus forskohlii*), *Curcuma angustifolia*, Yam (*Dioscorea alata*), Pitharu Khanda (*D.belophylla)*, Lesser yam (*D. esculenta*), Potato yam (*D.bulbifera*), *D. kalkapershadii*, *Pueraria tuberosa*, edible tubers (*Flemingia vestita*).

5.5.15 Bastar Region

The Bastar agrobiodiversity region consists of part of the eastern plateau, mainly southern Chattisgarh state which includes the areas of Dandakaranya. The hotspot areas are the following districts: Bastar, Bilaspur, Durg, Jashpur, Kabirdham, Kanker, Kirba, Koria, Mahasamund, Kondaigaon, and Rajnangoan.

The Bastar agrobiodiversity region has rich genetic resources of grain legumes (pegion pea, lentil, khesari, millets, tendu and mohua.

The major crops cultivated are wheat, millets and pulses. Wheat is cultivated as a *rabi* crop during winter months. Wherever irrigation is not available, millets, pulses and ground nut are cultivated. Generally, *rabi* wheat-gram / chickpea cropping is followed. The *kharif* sorghum, oilseeds, and small millets are the alternate crops to wheat and gram / chickpea. The cropping systems are as follows: rice - chickpea, rice - lentil, rice - khesari (*Lathyrus sativus*), rice -linseed, rice - sesame. Millets: Finger millet (*Eleusine coracana*), Little millet (*Panicum sumatrense*), *Paspalum scrobiculatum*, Barnyard millet (*Echinochloa frumentacea*); Legumes: *Cajanus scarabaeoides*, Pigeon pea (*Cajanus cajan*), Chickpea (*Cicer arietinum*), *Lathyrus aphaca*, *Mucuna pruriens*, *Pueraria tuberosa*, *Vicia sativa*, Moth bean (*Vigna aconitifolia*), Black gram (*V. mungo*), Green gram (*V. radiata*);Vegetables: *Amaranthus paniculatus*, *A. polygamus*, *A. viridis*, *Abelmoschus crinitus*, *A. esculentus*, *Capsicum annuum*, *Chenopodium album*, *Coccinia cordifolia*, *C. indica*, *Cucurbita pepo*, *Musa sapientum*, *Sesbania grandiflora;* Tubers: *Amorphophallus paeonifolius*, *Colocasia esculenta*, East Indian arrow root (*Curcuma angustifolia*), Mango ginger (*Curcuma amada*), *Curcuma zedoaria*, Yam, (*Dioscorea bulbifera*, *D. hispida*, *D. pentaphylla*). The important life supporing species are: Jack fruit (*Artocarpus heterophyllus*), Bamboo (*Dendrocalamus strictus*), Beedi leaf (*Diospyros melanoxylon*), Mohua (*Madhuca longifolia*), Lac tree (*Schleichera oleosa*).

5.5.16 Koraput Region

The Koraput agrobiodiveristy region forms part of Northern Eastern Ghats in southwestern Orissa and northeastern districts of Andhra Pradesh (Vizagapatnam,Vijanagaram, Srikakulam.). The hotspot area includes the districts of Malkangiri, Sonabeda, Jeypore, Koraput, Nabrangpur, Kalahandi, Bolangir, Rayagada and districts of north eastern Andhra Pradesh i.e. Srikakulam,Vijanagaram,Vizagapatnam.

The Koraput agrobiodiversity region is one of the primary centres of origin of rice, pigeon pea, a major genetic resource area of tuber crops and millets. The rice is the predominant crop having about 40 per cent of land under its cultivation. There are number of wild relatives of rice : *O. sativa* var. *plena*, *Oryza jeyporensis*, *O. meyeriana* var. *granulata*, *O. rufipogon* and wild strains and several landraces of *O. Sativa*. The other crops are maize, finger millet (*Eleusine coracana*), green gram (*Vigna radiata*), and black gram (*Vigna mungo*), mustard (*Brassica juncea*), sesame (*Sesamum orientale*), ground nut (*Arachis hypogaea*), etc. The tribal communities in the hills grow millets (*Japanese barnyard millet*, WR Barnyard: *Echinochloa frumentacea*, Barnyard millet (*E. crus-galli*), *Panicum hippothrix*, *P. trypheron*, Kodo millet (*Paspalum scrobiculatum*), Finger millet (*Eleusine coracana*), Italian millet (*Setaria italica*); and it is one of the secondary centres of Pigeon pea (*Cajanus cajan*), with diversity in its wild relatives, *Cajanus cajanifolius*, *C. scarabaeoides*, *C. sericeus.* The region is also rich in medicinal and aromatic plants; more than 1200 medicinal plant species are recorded from this region. Among horticultural crops, cucurbits, Lablab bean (*Lablab purpureus*), Brinjal (*Solanum melongena*), Chilli (*Capsicum annuum*), Ridge gourd (*Luffa acutangula*), Sponge gourd (*Lufffa aegyptiaca*), Bitter gourd (*Momordica charantia*), Sweet potato (*Ipomoea batatas*), Karonda (*Carissa carandas*), Pomello (*Citrus maxima*), *Cinnamomum tamala*, *Curcuma domestica*, *Musa balbisiana*, Jack fruit (*Artocarpus heterophyllus*), Mango (*Mangifera indica*), *Phyllanthus emblica*, Date palm (*Phoenix dactylifera*), Pepper (*Piper nigrum*), *Zingber zerumbet*, Persimmon (*Diospyros kaki*), Tamarind (*Tamarindus indica*) are also cultivated.

The important tuber crops are yams, taro, kudzu vine: Elephant Foot Yam (*Amorphophallus paeoniifolius*), Taro (*Colocasia esculenta*), Yam (*Dioscorea alata*), Pitharu kanda (*D. belophylla*), Potato yam (*D. bulbifera*),

Pitta Khanda (*D. glabra*) , *D. hispida*, *D. intermedia*, *D. oppositifolia*, *D. pentaphylla*, *D. puber*, *D. tomentosa*, Tonga-alu (*D. wallichii*), *D. wightii*, Kudzu vine (*Pueraria tuberosa*), *Vigna vexillata* (edible root tubers).

5. 5.17 Southern Eastern Ghats Region

The Southern Eastern Ghats Agrobiodiversity region constitutes southern parts of Andhra Pradesh comprising areas south of river Godavari and includes Nallmalai-Palkonda ranges, Seshachalam hills, Rayalaseema areas, Tirupati hills. The hotspots are the districts of Chittoor, Ananthapur, Cuddapah, Kurnool in Andhra Pradesh and districts of Bellary, Raichur and Kolar in Karnataka.

The Southern Eastern ghats region is a major centre of millets, landraces of pigeon pea, landraces of field bean, onion, brinjal, sesame, mango and grapes. The important crops cultivated in the southern Andhra Pradesh are rice, millets, pulses and oilseeds in *kharif* season and sorghum and oilseeds in *rabi* season. Ground nut is cultivated in southern Andhra Pradesh and northeastern Tamil Nadu both under irrigated and non-irrigated conditions. In the dry districts of Anantapur and Cuddapah, shifting cultivation "Podu" and pastoralism are common. In the Anantapur Dry region, the following crops are cultivated: early maturing sorghum varieties, pigeon pea, castor, mesta. When there is late rains, Pearl millet, Foxtail millet and ground nut are grown (Rathore *et al.*, 1991). In the Kolar semi-arid region, *kharif* crops maize, red gram and ragi are grown, while in the eastern zone of this region, sorghum, pearl millet, ground nut and cowpea are grown. The cropping patterns are as follows: rice - sesame, rice - ground nut, rice -sunflower, sesame - fingermillet, mung bean / urd bean -ground nut, finger millet - rice - ground nut, rice - rice - ground nut, rice - rice -sesame - ground nut, rice-rice- sesame.

The Southern Eastern Ghats region is a major centre of millets, landraces of pigeon pea, landraces of field bean, onion, brinjal, sesame, mango and grapes. Millets: *Dactyloctenium aegypticum*, Digitaria (*Digitaria tomentosa*), Finger millet (*Eleusine coracana*), Thipa ragi (*Eleusine indica*), WR barnyard millet (*Echinochloa colonum*), Barnyard millet (*E. crus-galli*), Sanwa (*E. frumentacea*), *Panicum geradei*, Proso millet (*P. miliaceum*), *P. trypheron*, Kodo millet (*Paspalum scrobiculatum*), Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*); Legumes:

Ground nut (*Arachis hypogaea*) Pigeon pea (*Cajanus cajan*), *C. scarabaeoides*, *C. candollei;* Pigeon pea landraces*: Natu Kandi*, *Peda kandi*, *Tota kandi;* Chickpea (*Cicer arietinum*), Green gram (*Vigna radiata*), *V. triloba*, Hyacinth bean (*Lablab purpureus*)*;* Field bean landraces*: Anapa*, *Natu anumulu; Trigonella occulta*. Vegetables: *Abelmoschus esculentus*, *A. ficulneus*, *Allium cepa:* landraces of Onion: *Chinna erragada*, *Erra gada*, *Tella gadda; Amaranthus spinosus*, *A. tenuifolius*, *A. viridis*, *A. dubius;* Ash gourd (*Benincasa hipida*), *Cucumis pubesens*, *C. melo*, *Momordica balsamina*, *Pueraria tuberosa*, *Solanum erianthum*, Brinjal (*S. melongena*): landraces of Brinjal: *Sanna vanga*, *Saara vanga*, *Tella mulaka*, *Tella vanga; S. nigrum*, *S. surattense;* Sesame (*Sesamum indicum*), *S. alatum*, *S. laciniatum*, *S. prostratum*,Castor (*Ricinus communis*)*;* Fruits: *Aegle marmelos*, Karonda (*Carissa carandas*) *Carissa inermis*, Pomello (*Citrus maxima*), Khonda mavu (*Commiphora caudata*), Mango (*Mangifera indica*) landraces of Mango: *Baganapalli*, *Phyllanthus emblica*, *P. fischeri*, *Phoenix pusilla*, *P. sylvestris*, *P. robusta*, Clove tree (*Syzygium aromaticum*), *S. alternfolia*, *S. zeylanicum*, Rose apple (*S. jambos*), Jamun (*S. cuminii*), Grapes (*Vitis vinifera*). *Ziziphus horrida.*

5. 5.18 Kaveri Region

The Kaveri agrobiodiversity region includes the Coromandel plains comprising the districts of Chengalput, South Arcot, North Arcot and the alluvial plains of the Kaveri delta. The Kaveri delta has Delta head and Delta proper which includes Valar doab, Kaveri doab, main delta plains and marshy low and dune belt near Vedaranyam salt swamps. The hotspot area consists of the districts of Chengalput, South Arcot, North Arcot, Thiuvannamalai, Tiruchirapalli, Pudukottai, Thiruarur, Vellore, Kanchipuram, Dharmapuri, Salem, Namakkal, Karur and Dindigal.

The Kaveri agrobiodiversity region has genetic resources of rice and millets with large number of cultivars. In the semi-dry areas of Tamil Nadu hilly outcrops of Shevaroy, Javadi, Kolli and Pachamalai hills, rainfed farming is practiced while irrigated farming is undertaken along the hinterland of Kaveri basin and delta. The important crops cultivated in the semi dry hills are millets, pulses and oilseeds in *kharif* season and sorghum and oilseeds in *rabi* season. Ground nut is cultivated in the northeastern Tamil Nadu both under irrigated and non-irrigated conditions. The Kaveri basin is a granary of paddy as

the area is well irrigated being supported by network of canals. In the black cotton soil belt, cotton and sunflower crops are cultivated in large scale. Tapioca is cultivated in Erode and Salem for the flourishing starch industry. Plantain and coconut are cultivated on commercial scale wherever irrigation facilities are available. The important species of the Javadi and Dharmapuri forest is sandalwood (*Santalum album*), which is of commercial importance. M.S.Swaminathan Research Foundation (MSSRF) has identified Kolli hills in Tamil Nadu as an important agrobiodiversity centre for millets and rice.

Rice is the principal crop in the Kaveri delta and adjacent areas which have well developed irrigation canals. In the areas of northern and central Tamil Nadu where there are sporadic rains, cotton is grown. In the same region where irrigation facilities through tube wells are available, sugarcane is planted during December-January. Oilseed crops like sunflower (*Helianthus annuus*) is cultivated in black cotton soil areas of Tamil Nadu where tube well irrigation is prevalent.

The cropping patterns are as follows: rice - sunflower, sesame - finger millet, mung bean/ urd bean - ground nut, rice - rice - ground nut, rice - rice - sesame - ground nut, rice -rice- sesame.

Millets**:** Finger millet (*Eleusine coracana*), Thipa ragi (*Eleusine indica*), WR barnyard millet (*Echinochloa colona*), Barnyard millet (*E. crus-galli*), Sanwa (*E. frumentacea*), *Panicum geradei*, Proso millet (*P. bmiliaceum*), *P. trypheron*, Kodo millet (*Paspalum scrobiculatum*), Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*).

Vegetables: *Abelmoschus esculentus*, *A. ficulneus*, *Amaranthus spinosus*, *A. tenuifolius*, *A. viridis*, *A. dubius;* Chilli (*Capsicum annuum. C. frutescens;* Water melon (*Citrulus lanatus*), *Cucumis anguria*, *C. melo*, *C. sativus;* Pumpkin (*Cucurbita pepo*), *C. maxima;* Ridged gourd (*Luffa acutangula*), *L. aegyptiaca;* Bitter gourd *Momordica charantia*, *M. balsamina;* Drumstick (*Moringa oleifera*)*;* Brinjal (*Solanum melongena*), *S. nigrum*, *S. surattense*; Snake gourd (*Trichosanthes cucumeriana* var. *anguina)*, *T. cucumeriana*, *T. dioica;* Plantain (*Musa acuminata*, *M. sapientum*), Mango (*Mangifera indica*); *Phoenix pusilla*, Tamarind (*Tamarindus indica*); Grapes: *Vitis vinifera*, Oilseeds*:* Sunflower (*Helianthus annuus*), Pongam oil tree (*Pongamia pinnata*), Castor (*Ricinus communis*), Sesame (*Sesamum indicum*).

5.5.19 Deccan Region

The North Western Deccan Agrobiodiversity region is part of the hot semi-arid eco-region situated on the leeward side of the Western Ghats from the Satpura-Mahadeo hills in the north to the Dharwar in the south, which includes the leeward districts of Maharashtra, northern dry districts of Karnataka and northern Andhra Pradesh. The hotspot area includes the districts of Jalna, Hingoli, Parbhani, Beed, Nanded, Latur, Osmanabad, Solapur, Sangli, Gondia, Gadchiroli in Maharashtra and the districts of Adilabad, Karimnagar, Warangal and Khamman in Andhra Pradesh and districts of Bidar and Gulbarga in Karnataka.

The Deccan agrobiodiversity region is known for the genetic resources of millets and fodder grasses. The major rainy season crops cultivated in the area are sorghum, cotton and pearl millet. The post-rainy season crops are grown on soils which have residual moisture and the crops cultivated are sorghum, safflower and sunflower. It is seen that prolonged dry spell adversely affects the crop growth leading to frequent crop failures. The *kharif* sorghum is cultivated in the semi dry districts and cotton, pulses, ground nut and small millets are sown as alternate crops. Sugarcane is an important crop in the Deccan areas of Maharashtra and northern Karantaka where irrigation facilities through tube wells and irrigation canals are available. Sugarcane is planted during December-February for 12-month crop period which is called "eksali". In the extremely dry areas of Deccan in Andhra Pradesh which is a rain-shadow region, bajra / pearl millet are cultivated. In the ground nut based cultivated areas, the alternate crops are sorghum and small millets. Cotton is an important crop in the rainfed areas of Deccan which includes the semi-arid districts of northern Karnataka and western Andhra Pradesh. In this area, the alternate crops are sorghum (*kharif* and *rabi*), ground nut and small millets.

The cropping patterns in different areas of the Deccan Plateau are as follows: (i) Vertisols and related black soil zone: Sholapur dry land region: Green gram - sorghum; (ii) Bijapur dry land region: Cowpea-sorghum; green gram- safflower; (iii) Bellary dry land region: On the basis of annual rainfall (500 mm), the *rabi* crops are sorghum, safflower and grain crops are sown in September.

Millets: Makra (*Dactyloctenium aegypticum*), Finger millet (*Eleusine coracana*), Thipa ragi, (*Eleusine indica*), Barnyard millet (*Echinochloa crus-galli*), Sawa (*E. frumentacea*), Dhane (*Eragrostis tenella*), Chirka (*E. tremula*), Pearl millet (*Pennisetum glaucum*), Proso millet (*Panicum miliaceum*), Little millet (*Panicum sumatrense*), Foxtail millet (*Setaria italica*), *Trilobachne cookie;* Oilseeds: Mustard (*Brassica juncea*), Safflower (*Carthamus tinctorius*), Niger (*Guizotia abyssinica*), Castor (*Ricinus communis*), Sesame (*Sesamum indicum*)*;* Vegetables: Chilli (*Capsicum annuum*), *Cissus repanda*, *Cissus quadrangularis*, *Corchorus depressus* (Leaves as pot herb), Adavi gogu, leaves as pot herb (*Hibiscus aculeatus*), Deccan hemp (*Hibiscus cannabinus*); *Fibre: Cotton*, *Tula* (*Gossypium arboreum*), Levant cotton, cultivated (*Gossypium herbaceum*), Kapas, American cotton, cultivated (*Gossypium hirsutum*); Fodder: *Andropogon pumilus*, *Brachiaria ramosa*, *Chloris dolychostachya*, *Cynodon dactylon Dactyloctenium aegyptium*, *Dichanthium annulatum*, *Eleusine indica*, *Eragrostis tenella*, *E. unioloides*, *Eriochloa procera*, *Heteropogon contortus*, *Ischaemum rugosum*, *Panicum psilopodium*, *Pennisetum pedicellatum*, *Perotis indica*, *Sehima nervosum*, *Setaria pumila*, *Urochloa panicoides.*

5. 5.20 Konkan Region

The Konkan Agrobiodiversity region includes northern W.Ghats and Konkan plains. The Northern Western Ghats is locally referred as Sahyadri hills. The hotspot area includes coastal districts of Thane, Raigad, Ratnagiri, Sindhudurg and part of Sahyadri districts of Pune, Satara and Kolhapur of Maharashtra, all the districts of Goa and Uttar Kannda district of Karnataka.

The Konkon agrobiodiversity region has rich genetic diversity of rice, vigna, mango, kokum and spices. The Konkan region has intensive *kharif* cultivation of rice along with ragi, pulses, *rabi* cultivation of *jowar*, sugar cane and oilseeds. In the upper laterite zones in recent times, tapioca and cashewnut are also cultivated.

Legumes: Jack bean: *Canavalia gladiata*, *C. lineata*, Pigeon pea: *Cajanus cajan* (*cult.*) *Cajanus lineata*, *C. sericeus;* Chickpea (*Cicer arietinum*), Lab Lab Bean (*Dolichos lablab* (*cult.*), *D. bracteatus*)*;* Horse gram, (*Macrotyloma uniflorum*), *Vigna dalzelliana*, *V. grandis*, *V. giganteum*, *V. khandalensis*, Black gram (*V. mungo*), Green gram (*V. radiata*), *V. radiata* var. *sylvestris*, *V. radiata* var. *setulosa*, Cowpea (*V. unguiculata*), Rice bean

(*V. umbellata*), Pillipesara (*V. trilobata*) Cowpea (*V. unguiculata*), Rice bean (*V. umbellata*); Vegetables: *Amaranthus hybridus*, *A.paniculatus*, *A. polygamus*, *A. spinosus*, Okra (*Abelmoschus esculentus*), *A. angulosus*, *A. ficulneus*, *A. manihot* subsp. *manihot*, Chillis (*Capsicum annuum*), Kundri (*Coccinia indica*), Pumpkin (*Cucurbita pepo*) , Cucumber (*Cucumis sativus*), Kharbuj (*Cucumis melo*), *C. ritchei*, *C. setosus*, *Dolichos bracteatus*, *D. uniflorus*, *Lens culinaris*, Bottle gourd (*Lagenaria siceraria*), Ridge gourd (*Luffa acutangula*), Bitter gourd (*Momordica charantia*) *M. dioica*, *M. tuberosa*, Brinjal (*Solanum melongena*), Snake gourd (*Trichosanthes cucumeriana* var. *anguina*), Mango: *Mangifera indica* (landraces): Mango varieties: (Mancuradi, Maussarda, Fernandine, Xayer,Alphanso), *Mangifera sylvatica*, Kokkum tree: *Garcinia indica*, *G. morella*, *G. talbotii;* Turmeric relatives : *Curcuma inodora*, *C. purpurea*, *C. pseudomontana; Galangal Kaempferia galanga*) Nutmeg (*Myristica malabarica*, *M. dactyloides*); Pepper (*Piper argyrophyllum*, *P. galeatum*, *P. hookeri*, *P. hymenophyllum*, *P. nigrum*, *P. trichostachyon*); Ginger (*Zingiber macrostachyum*, *Z. officinale.*)

5. 5. 21 Malabar Region

The Malabar agrobiodiversity region is situated in the southern region of the Western Ghats extending from Dakshin Kannada in the north to Kanyakumari in the south. The hotspot areas are the districts of Kasargode, Kannur, Wayanad, Kozikode, Malappuram, Palakkad, Thrissur, Idukki, Ernakulam, Alappuza, Kollam, Kottayam, Pathanamthitta & Thiruvananthpuram in Kerala, Udhagamandalam (Nilgiri) and Kanyakumari districts of Tamil Nadu and districts of Dakshin Kannada, Kodagu and Udipi in Karnataka.

The Malabar agrobiodiversity region is known for the genetic diversity of rice, coconut, pepper, turmeric, cardamom, cinnamon, nutmeg, plantain, Amomum, snake gourd and allies, Jack fruit, aroids and ginger. Rice cultivation and harvesting is done two or even three times in a year. Among field crops, coconut is the major crop. In laterite dry zones tapioca is being cultivated. Beside these crops, the region is the main producer of spices, especially pepper and cardamom, which have been cultivated and traded for past 1000 years. The region produces 96 percent of the pepper of the country. The other important spices are cinnamon, clove, turmeric, nutmeg, ginger and vanilla. The commercial crops which play important role

in the agro-economy of Kerala state are coconut, rubber, tea, coffee and cashewnut. The region accounts for 91 per cent of India's rubber production. Besides rubber, the other plantation crops are banana and plantain. In the southern Western Ghats districts of Karnataka, besides rice, the alternate crops cultivated are arecanut and coffee.

There are number of varieties of rice and landraces of scented varieties, flood tolerant varieties, salt tolerant varieties and drought tolerant varieties.

Cereals*:* Rice (*Oryza sativa O. officianalis* var. *officianalis*, *O. officianalis* var. *malampuzhaensis*, *O. meyeriana* var. *granulata*, *O. nivara*. *O. rufipogon*, *O. spontanea*) Spices*: Amomum cannicarpum*, *Amomum pterocarpum*, *A. muricatum; Carum strictocarpum;* Cinnamon: *Cinnamomum veram* (cult.), *C. filipedicellatum*, *C. heyneanum*, *C. keralense*, *C. macrocarpa*, *C. malabatrum*, *C. nicolsianum*, *C. perrottetii*, *C. riparium*, *C. sulphuratum*, *C. travancoricum*, *C. walaiwarense*, *C. wightii;* Turmeric: (*Curcuma longa*), Mango ginger (*C. amada*), Wild ginger (*C. aromatica*), *C. albiflora*, *C. aurantiaca*, *C. caesia*, *C. cannanorensis*, *C. coriacea*, *C. decipiens*, *C. escalcarata*, *C. harita*, *C. karnatakensis*, *C. kudagensis*, *C. nilamburensis*, *C. neilgherrensis*, *C. oligantha*, *C. raktakanta*, *C. thalakaveriensis*, *C. vamana*, *C. zedoaria*, Cardamom (*Elettaria cardamomum*), Nutmeg: *Myristica fragrans* (cult.), *M. malabarica*, *M. dactyloides*; Pepper *: Piper nigrum*, *P. argyrophyllum*, *P. barberi*, *P. galeatum*, *P. hapnium*, *P. hookeri*, *P. longum*, *P. pykarahense*, *P. schmidtii*, *P. silentvalleyensis*, *P. trichostachyon*, Clove tree*: Syzygium aromaticum* cult., Ginger*: Zingiber officinale* (cult.), *Z cernum*, *Z. neesanum*, *Z. purpureum*, *Z roseum*, *Z. wightianum*, *Z. zerumbet;* Oilseeds: Coconut (*Cocos nucifera*), Oil Palm (*Elaeis guineensis*), Sesame: *Sesamum laciniatum*, *S. malabaricum*, *S. mulayanum*. There are large number of fruits for which Malabar is well known: Jack fruit*: Artocarpus heterophyllus*, *A. gomezianus* var. *zeylanicus*, *A. hirsutus*, *Baccaurea courtallensis*, *Buchanania barberi* (edible fruits), wild banana (*Ensete superbum*), Malabar Tamarind: *Garcinia gummigutta*, *G. gummigutta* var. *conicarpa*, *G. gummigutta* var. *papilla*, *G. travancorica*, *G. morella*, *G. wightii*, *G. indica*, *G. xanthochymus;* Mango*: Mangifera indica* (several varieties)*; Mimusops elengi;* Banana: *Musa balbisiana*, *M. kattuvazhana M. sapientum*, *M. rosacea;* Indian Gooseberry*: Phyllanthus emblica*, *P. indofischeri; Syzygium arnottianum*, *S. bourdillonii*, *S. bracteatum*,

(Jamun) *Syzygium cuminii*, *S. jambos*, *S. mundagum*, *S. malabaricum*, *S. montanum;* Grapes and grape relatives*: Vitis vinfera*. Aromatic oils: lemon grass*: Cymbopogon flexuosus* var. *coimbatorensis*, *Cymbopogon martini*, *Cymbopogon polyneuros.*

The Malabar agrobiodiversity region has also vast genetic resources of tuber yielding crops: aroids, yam and tapioca: Elephant-foot yam: *Amorphophallus paeonifolius* var. *campanulatus* (cultivated), *A.commutatus*, *A. hohenakeri*, *A. mysorensis*, *A. bonacordensis*, *A. smithsonianus*, *A. bulbifer*, *A. nicolsianus;* Taro (*Colocasia esculenta* var. *esculenta*). Taro (*Colocasia esculenta* var. *antiquorum*) with several cultivars and morphotypes; Yam*: Dioscorea alata*, *D. bulbifera* var. *bulbifera*, *D. bulbifera* var. *sativa*, *D. belophylla*, *D. intermedia*, *D. oppositifolia*, *D. pentaphylla*, *D. tomentosa*, *D. hispida*, *D. hamiltonii*, *D. spicata*, *D. wightii*, *D. wallichii;* Country Potato (*Coleus parviflorus*, *C. rotundifolius*), Tapioca (*Manihot esculenta*).

5.5.22 Islands Region

The island ecosystem consists of Andaman and Nicobar islands, which hold potential wild relatives of cultivated plants and potential genetic resources useful to agriculture. Lakshadweep islands have vast genetic resources of coconut.

The settled agriculture is of very recent origin. Farming is confined only to specific areas around habitations and the principal crop grown in Andamans is rice (*Oryza sativa*). While in Lakshadweep the principal crop is coconut. Generally, the land use is dominated by the planation crops such as coconut, arecanut and oil palm. There are plantations with inter cultivation of crops i.e. pineapple, tapioca, pepper and aroids. Some of the species cultivated are Green gram (*Vigna radiata*), Black gram (*Vigna mungo*), Bottle guard (*Lageneria vulgaris*), Brinjal (*Solanum melongena*), Jamun (*Syzigium cuminii*), Fig (*Ficus carica*), Garcinia (*Garcinia jalinekii*), Yam (*Amorphophallus muelleri*), Custard apple (*Annona squamosa*), Drumstick (*Moringa oleifera*), Noni (*Morinda citrifolia*). Cereals: Rice: *Oryza sativa*, wild rice (*Oryza indandamanica*)*;* Tubers: Yam: Elephant-foot yam: *A. muelleri*, *A. longistylus*, *A. onchophyllus;* Taro*: Colocasia esculenta*, *C. manii; Dioscorea bulbifera*, *D. glabra*, *D. vexans*; *Tacca leontopetaloides;* Fruits: Bael (*Aegle marmelos*), Jack fruit (*Artocarpus heterophyllus*, Bread fruit

(*Artocarpus. incisa*), *Baccaurea sapida*, Wild fig (*Ficus andamanica*), Garcinia (*Garcinia jalinekii*, *G. calycina*), Mango: (*Mangifera andamanensis*, *M. camptosperma*); *Mimusops andamanica*, *Manilkara littoralis*, Wild Jamun (*Syzygium andamanicum*, *Syzygium clavifolium*, *S. polyanthum*, *S. samarangense;* Wild and less known vegetables: *Canavalia turgida*, *Pandanus andamanensium*), *P. lerum*, *P. tectorius*, *Vigna marina;* Spices: Wild Cardamom (*Hornstedtia fenzlii*), Pepper: *Piper sarmentosum*, Nutmeg: *Myristica connaroides*, (*Horsfieldia macrocarpa*), *Knema andamanica*, *Vanilla andamanica*.

6

MECHANISM FOR BENEFIT SHARING

6.1 With the Convention on Biological Diversity (CBD) coming into force as a legal instrument in 1993, the world has moved from the earlier perception of biological resources as the common heritage of mankind to the concept of nation's sovereignty of genetic resources. The inequities of Trade Related Intellectual Properties of World Trade Organization (WTO-TRIPS), the disproportionate supremacy of biotechnologically advanced developed nations over developing nations and the patents regimes giving exclusive royalties as mandated in the new order of WTO regimes have become stumbling block for transparent mechanism of benefit sharing and technology transfers. Since agriculture and food security is the common concern of the world, FAO-International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) adopted in 2004 provides a unique multilateral system of access and benefit sharing of the plant genetic resources for food and agriculture.

The Biological Diversity Act (2002) provides regulated access and benefit sharing and they are dealt under Rule 14 (1-10) sub-rules of the Biological Diversity Rules (2004). The criteria for benefit sharing are dealt in Section 21 and Rule 20 of the Biological Diversity Rules (2004). The establishment of Local Biodiversity Fund and Biodiversity Management Committees are mandated in the sections 41 and 42 of the Biological Diversity Act (2002). The National Biodiversity Fund is at the disposal of the Chairman, National Biodiversity Authority which consists of receipts from the Central Government and also includes fees, royalties, license and other receipts deposited with the Authority. Although the Local Biodiversity Fund is a kitty of grants given by National Biodiversity Authority, the State Governments and other agencies, the role of Biodiversity Management Committees at the local level is of paramount importance for efficient management of administering

and monitoring the access and benefit sharing mechanism in a decentralized and transparent manner.

6.2 National Gene Fund

6.2.1 One of the farmer-friendly mechanisms envisaged in the PPV&FR Act, 2001 is the constitution of National Gene Fund under Section 45 of the Act. This national kitty gets its fund from the credits received through benefit sharing, annual fee payable to the PPV&FR Authority by way of royalty, compensations and contributions from national and international agencies. The Gene Fund will be further augmented from compensations received from the breeder(s) who ignored the valuable contributions of any village or local community which contributed significantly to the evolution of a variety on the basis of any proved claims made by the farmers or communities as per law. The Gene Fund shall be used for benefit sharing, meeting expenditure for supporting the conservation and sustainable use of genetic resources and for strengthening the capacity and capability of the Gram/Village Panchayats for undertaking conservation. The priorities for disbursing the Gene Fund is mentioned in the Rule 70 of the PPV & FR Rules. The first priority is for supporting and rewarding farmers, community of farmers particularly tribal and rural communities engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives in areas identified as agrobiodiversity hotspots. The second priority is for capacity building and for supporting *in situ* and *ex situ* conservation at the level of the local body, particularly in regions identified as agrobiodiversity hotspots. Since villages and Panchayats are also the beneficiaries of Gene Fund as per the PPV& FR Act, 2001, the Biodiversity Management Committees (BMCs) of the Panchayat or group of Panchayats of the region as envisaged in the Biological Diversity Act, 2002, have a major role in overseeing and monitoring the conservation activities envisaged.

6.2.2 The provision of Gene Fund and its operative mechanisms are generally acclaimed by stakeholders as an innovative mechanism for rewarding farmers engaged in conservation of genetic resousrces at the grassroot level. It was strongly felt at a dialogue held at M. S. Swaminathan Research Foundation (MSSRF, 2002), Chennai in

collaboration with FAO that since majority of primary conservers are women, there must be adequate representation of tribal and farm women in the decision making committees which award the benefits through Gene Fund and that the manner of utilizing the benefit may be left to the communities. The administering mechanism may be done through appropriate linkages with the Biodiversity Management Committees of the region. Some of the areas identified at the dialogue meet at MSSRF are Goa, Kutch in Gujarat, Kolli Hills in Tamil Nadu, Wayanad in Kerala, Jeypore tract in Orissa, States in the North East hills region as well as the Eastern and Western Ghats region. It was felt necessary that training programmes may be organized in local languages for explaining the various aspects of legislations on plant varieties, seeds and agrobiodiversity so that the farming community understands the intricacies and legalities of various farmer friendly regulations embodied in the PPV&FR Act.

6.2.3 The PPV &FR Authority has already notified **Plant Genome Savior Community Recognition** in 2007. The objectives of the notification are for (i) recognizing and rewarding the farmers for the contributions made by them in conserving and improving the plant genetic resources leading to the development of new plant varieties, (ii) recognizing and rewarding farming community including tribals and farm women for their contributions for agricultural growth, (iii) stimulating development of new high yilding and better quality plant varieties, (iv) facilitating the revival and awareness to conserve the agrobiodiversity leading to the development of new varieties in perpetuity, (v) conserving techniques and technologies for crop production and management (vi) promoting all kinds of plant based agrobiodiversity activities relating to plant variety development.

6.2.4 **Community Agrobiodiversity Conservation Award**: One of the vital and important constituency missing from the Plant Variety Genome Savior Community Recognition (2007) is the need for the recognition of the role of farming community particularly tribal and rural communities, farm women engaged in *ex situ* conservation of genetic resources or heirloom collections in their farms and backyard homestead gardens *per se* without any linkages to the production of

a new variety. There is also no mention of the recognition of the role of Gram/Village Panchayats and the capability of these bodies for undertaking activities on conservation of agrobiodiversity. One of the objectives as mentioned in section 45 (2) item (c) is that the Gene Fund shall be used for meeting the expenditure for supporting the conservation and sustainable use of genetic resources including *in situ* and *ex situ* collections and for strengthening the capability of the Gram/Village Panchayats in carrying out such conservation and sustainable use activities. Hence, there is need for instituting another award "**Community Agrobiodiversity Conservation Award"** for tribal and farming communities in Agrobiodiversity Hotspots for on-farm / *in situ* conservation of genetic resources.

The notification of such an award may be considered by the PPV&FR Authority with the following provisions:

6.2.4.1 The Notification inviting nominations for Community Agrobiodiversity Conservation Award may done annually through all national print and visual media.

6.2.4.2 The Nominations for the Awards may be done by the Eminent Agricultural Scientists, Fellows of the National Academy of Agricultural Sciences, New Delhi, Secretary, Department of Agriculture and Cooperation, Ministry of Agriculture, Secretary, Department of Agricultural Research and Education (DARE) & Director General, Indian Council of Agricultural Research (ICAR), Vice Chancellors of State Agricultural Universities, Directors of State Agricultural Departments, Deputy Director Generals of ICAR, Directors of ICAR Institutes, Chairpersons of Trusts for Advancement of Agricultural Sciences, Chairpersons of Non-Governmental Organizations and Presidents of Agricultural Science Societies in India.

6.2.4.3 The National Award shall be given annually to individuals, group of persons or institutions for significant contribution in the field of conservation of agrobiodiversity at local level.

6.2.4.4 The Award shall be used for the development of a "Gramin Seed Bank" and "Community Food Grain Banks", which would help popularizing and marketing neglected and underutilized crops and thereby generating

an economic stake in the conservation of agrobiodiversity at the local level.

6.2.4.5 The award shall be used for organisng nursery for children or crèches for the children of farm women.

6.2.4.6 The award shall be used for developing capability of Panchayats regarding general community welfare, i.e. infrastructure building activities in local schools, health clinics, vocational training programmes connected with agriculture, institution of scholarships and fellowships for the village communities.

6.2.4.7 Appropriate representation of farm women communities may be ensured while constituting the Selection Committees or Monitoring Committees.

6.2.4.8 The Award may be distributed to the Panchayat or village farming communities and monitored through one of the Registrars of the PPV & FR Authority who should dedicate sufficient time for issues connected with the Gene Fund and Farmers' Affairs.

6.2.4.9 The PPV & FR Authoirty may develop financial and administrative rules so that the annual "Community Agrobiodiversity Conservation Award" can be started in 2009. The Task Force recommends the value of this annual award to be Rs 10 lakhs for the selected group.

7 AGROBIODIVERSITY HOTSPOTS IN INDIA

7.1 Cold Desert Agrobiodiversity Region

Location and extent

The cold desert agrobiodiversity region is located in the upper limits of the Western Himalayas covering Ladakh and Kargil districts of Jammu & Kashmir and Lahual-Spiti districts of Himachal Pradesh. The salient landmarks are Nubra valley, Tsokar lake, Puga valley, Khardungla, Dras and Zanskar of the Ladakh region and Lahaul-Spiti of Himachal Pradesh. The region is characterised by mild summers and extreme winters.

Agroclimate

The average annual temperature ranges from -19^{0}C to 33^{0}C with mean annual soil temperature less than 8^{0}C. The temperature during winters is as low as -40°C. The annual rainfall is less than 150 mm. The precipitation covers only 15 per cent of the total potential evapo-transpiration, with a very short growing season that may get extended up to 90 days. Most of the landscape is represented by towering mountain peaks covered with snow. The agriculture is mainly confined to valleys which have skeletal calcareous soil. The soil is alkaline in nature and is low in organic matter.

Floristic diversity

The region is rich in unique and rare floristic resources, and is a constituent of one of the Global Biodiversity Hotspots. About 700 plant species have been recorded from the cold-arid region of the Western Himalayas. Because of the extreme climatic conditions, the region supports only sparse vegetation. The vegetation is "Artemisia-steppe" type. The cold desert flora is represented by genera *Acantholimon*,

Astragalus,*Artemisia*,*Anthriscus*, *Bergenia*, *Caragana*, *Cirsium*, *Cotoneaster*, *Halogeton*, stunted *Hippophae*, *Inula*, *Nepeta*, *Oxytropis*, *Saussurea*. The floristic elements prominent in the vegetation are *Hippophae rhamnoides*, *Arnebia benthamii*, *Tamarix indica*, *Astragalus zanskerensis*. Some of the cold tolerant species are: *Saussurea gnaphaloides*, *Caragana gerardiana*, *Thermopsis inflata*, *Thylacospermum caespitosum*. The region is covered with *Astragalus-Oxytropis-Acantholimon* associations. The vegetation is represented by stunted shrubs of *Berberis ulicina*, *Rosa webbiana* and trees belonging to the genera *Prunus*, *Populus*, *Salix* and *Ulmus*. In the North West part of Zanskar range, the vegetation consists of *Acantholimon lycopodioides*, *Astragalus zanskerensis*, *Ephedra gerardiana*, *Eremurus himalaicus*, *Hyoscyamus niger*, *Nepeta floccosa*, *Rosa webbiana*, *R. moschata*. Following tree species are cultivated along river valleys: *Salix alba*, *Populus ciliata*. It is seen that a number of plant species are being used in local medicines and they play an important role in the traditional medicinal system called 'Amchi'.

Agriculture and agrobiodiversity

The cropping season is during the thawing period of July-September, which coincides with scanty rains. The major crops are barley, pea, wheat, lucerne at high altitudes and wheat, apple, apricot at lower altitudes. The crops cultivated in the valleys are buckwheat, barley, and winter vegetables, while the horticultural crops are mainly apple and apricot. The field crops are cultivated on special stone built terraces. Some of the genetic resources endemic to Ladakh cold desert are: *Cicer microphyllum*, *Carum bulbocastanum*, *Vicia mollis*, *Trigonella podperae.* Important medicinal plants which grow here are: *Aconitum heterophyllum*, *Ephedra gerardiana* var. *gerardiana*, *Podophyllum hexandrum*, *Saussurea bracteata*, *S. clarkei*, *S. sacra*, *S. taraxicifolia*.

Crops and wild relatives

Barley (*Hordeum vulgare*), *Hordeum glaucum*, *H. spontaneum*, *H. turkestanicum;* Wheat (*Triticum aestivum*), *T. aestivum* subsp. *sphaerococcum;* Buckwheat (*Fagopyrum esculentum*), *Fagopyrum cymosum*, *Fagopyrum tataricum*, Linseed WR. *Linum perrene;* Wild caraway (*Carum bulbocastanum*); Potato (*Solanum tuberosum*), Cauliflower (*Brassica oleracea* var. *botrytis*), Cabbage (*B. oleracea* var. *capitata*); Mustard (*Brassica napus;* Allium and allies (*Allium cepa*), *Allium carolinianum*, *A. chitralicum*, *A. gilgitiacum*, *A. rubellum;* Chickpea: (*Cicer*

Landscape of Ladakh in the Cold Desert Region

Podophyllum hexandrum– **A threatened and high value medicinal plant of the Himalayas**

arietinum), *Cicer microphyllum;* Fenu-greek: (*Trigonella foenum-graceum*), *T. emodii*, *T. podperae*; Apple (*Malus domestica*), *M. baccata*; Apricot (*Prunus armeniaca*), *Prunus tomentosa*, Sea-buckthorn (*Hippophae rhamnoides*), *H. tibetana*, *H. salicifolia*.

Other economic plant species

Timber: Poplars (*Populus alba*, *P. augustifolia*, *P. candicans*, *P. ciliata*, *P. deltoides*, *P. euphratica*, *P. nigra*); Willows: (*Salix alba*, *S. babylonica*, *S. elegans*, *S. denticulata*, *S. fragilis*, *S. sclerophylla*); *Juniperus communis*, *J. indica*. Fodder: *Medicago sativa*, *Pisum sativum*.

Medicinal plants: *Allium carolnianum*, *Arnebia benthamii*, *Arnebia euchroma*, *Arnebia guttata*, *Artemisia absinthium*, *A. biennis*, *A. dracunculus*, *A. japonica*, *A. laciniata*, *A. macrocephala*, *Aster tibeticus*, *Astragalus rhizanthus*, *A. zanskariensis*, *Berberis ulicina*, *Bergenia stracheyi*, *Biebersteinia emodi*, *Bupleurum himalyense*, *Capparis spinosa*, *Carum bulbocastanum*, *C. carvi*, *Cimcifuga foetida*, *Cirsium arvense*, *Clematis alpina*, *Corydalis govaniana*, *Cousinia thompsonii*, *Cremanthodium arnicoides*, *Delphinium cachemirianum*, *Echinops cornigerus*, *Ephedra gerardiana*, *Erodium tibetanum*, *Gentiana decumbens*, *Gentianella moorcroftianum*, *Hyoscyamus niger*, *Inula obtusifolia*, *I. royleana*, *Jaeschkea oligosperma*, *Juniperus macropoda*, *Lactuca lessertiana*, *Macrotomia euchroma*, *Mentha longifolia*, *Myricaria elegans*, *Nepeta floccosa*, *Physochlaina praelata*, *Plantago himalaica*, *Podophyllum hexandrum*, *Potentilla argyrophylla*, *Saussurea bracteata*, *S. sacra*, *S. taraxicifolia*, *Sisymbrium brassiciforme*, *Viola biflora*

Endemic species: *Aconitum deinorrhizum*, *A. kashmiricum*, *A. violaceum* var. *robustum*, *Allium gilgitcum*, *Aquilegia fragrans*, *Arnebia benthamii*, *Atropa acuminata*, *Cicer microphyllum*, *Dianthus jacquemontii*, *Hippophae rhamnoides*, *Meconopsis aculeata*, *Potentilla brevicissa*, *Saussurea clarkei*.

Threatened species: *Aconitum deinorrhizum*, *A. kashmiricum*, *Allium auriculatum*, *Atropa acuminata*, *Bergenia ligulata*, *Berberis kashmiriana*, *Dioscorea deltoidea*, *Ephedra gerardiana*, *Inula racemosa*, *Meconopsis aculeata*, *Picrorhiza kurrooa*, *Podophyllum hexandrum*, *Saussurea costus.*

Associated culture and tribes

The region is predominantly inhabited by ladakhees of Mongoloid origin having influence of Buddhist culture/ religion. The associated tribes are Khampas and Bhods.

Technology and products

The traditional Ladakh agriculture is unique and representative of the Tibetan plateau. In addition to traditional agricultural practices, the region provides rare knowledge of management of natural resources and cultivation of suitable crops under severe cold-arid climatic conditions. The agricultural practices consist of diverting glacial-fed rivers into stone-built terraces. Sedimentation of soil and manuring facilitate cultivation of staple crop such as barley. Ladakh is rich in genetic resources of barley such as naked (hull-less) barley (Verma *et al.*, 2006). Naked barley has been used as staple food and also for making a local beverage called *Chhung*. Though low temperature regimes restrict plant growth and the growing period is very short and the soils are shallow, sandy and poor in organic matter, there is successful agriculture due to the ingenuity of the local communities who make use of the thawing period, which coincides with rainy season.

Traditional irrigation system is developed, where villagers tap the stream coming down from the glaciers with the help of small channels. It is diverted to small tanks called '*zing*' and then used for irrigating fields. Each village has vast network of canals and *zings*. Effective distribution of water is ensured by an official called '*Churpun*'. The cultivation of Sea-buckthorn (*Hippophae rhamnoides*) and development of various products from its fruits have contributed significantly to the economy of the region. It is seen that from ancient times, farming communities conserved their own local landraces and varieties which possess unique traits for drought resistance and frost resistance.

The indigenous knowledge regarding the potential values of plant resources, particularly the medicinal plants, eventually led to the establishment of a local medicine system called 'Amchi'. Hence, the Ladakh cold arid region has been declared as one of the Globally Important Agriculture Heritage Systems (GIAHS).

7.2 Western Himalayan Agrobiodiversity Region

Location and extent

The Western Himalayan region is a part of the Himalayas, one of the global biodiversity hotspots. The Western Himalayan region

encompasses the states of Jammu & Kashmir, Punjab (Siwaliks), Himachal Pradesh and Uttarakhand. It includes mostly temperate hills and warm sub-humid foot hills of the region. Nanga Parbhat (alt. 8125 m above MSL) in Jammu & Kashmir and Nanda Devi (alt. 7817 m above MSL) in Uttarakhand are some of the highest peaks in the Western Himalayas. The agrobiodiversity hotspot area covers the districts of Srinagar, Anantnag, Udhampur, Riasi, Kathua in Jammu & Kashmir, all the districts of Himachal Pradesh, except the cold arid region, and all the districts of Uttarakhand.

Agroclimate

The region is represented by cool humid and warm sub-humid climate with mild summers and cool winters. The mean annual rainfall varies from 1600 to 2000 mm, exceeding the potential evapo-transpiration during most part of the year, thereby ensuring availability of soil moisture between 150 to 210 days growing period in a year. The mean annual soil temperature ranges from 15^0C to 22^0C. The soil is podzolic and ranges from shallow to deep with medium to high organic matter content.

Floristic diversity

Being part of the Himalayas, the Western Himalayan region is very rich in floristic diversity. The types of natural vegetation in the Western Himalayas are as follows: Tropical dry deciduous: *Acacia catechu*, *Trema politoria*, *Terminalia bellerica*, *Dalbergia sissoo*; Himalayan subtropical pine forest: Chir pine (*Pinus roxburghiana*), *Pyrus pashia*, *Terminalia chebula*; Subtropical dry evergreen forest: *Quercus leucotrichophora*, *Morus serrata*, *Rhus punjabensis*; Dry temperate forest: *Cedrus deodara*, *Pinus wallichiana*, *Juglans regia*, *Picea smithiana*; Moist temperate forest: *Buxus wallichiana*, *Quercus dilatata*, *Populus ciliata*, *Prunus sp.*, *Rosa webbiana*; Subalpine forest: consists of conifers like *Abies pindrow*, *A. spectabilis*, *Picea smithiana*, *Pinus wallichiana* and broad leaved species of *Quercus semicarpifolia*, *Betula utilis*, *Acer caesium;* Alpine forest: The area consists of grass covered "Bugyals" and stunted formations of Juniperus scrub (*Juniperus wallichiana* and *J. communis*). On moist localities scattered bushes of *Rhododendron anthopogon* and *Berberis* spp. are common. On the moraines "Bramha Kamal" (*Saussurea obvallata*) is notable. The important herbaceous plants are : *Aconitum violaceum*, *Allium stracheyi*,

A. wallichii, *Anaphalis contorta*, *A. royleana*, *Bergenia stracheyi*, *Corydalis cashmeriana*, *Danthonia cachemyriana*, *Inula racemosa*, *Meconopsis aculeata*, *Poa alpina* and *P. jaunsarensis.*

Agriculture and agrobiodiversity

The cultivation of crops is done mainly in terraces along the slopes with contour bunding. The common crops grown are wheat, millets, maize and rice. The predominant production systems are rice-based or horticulture based plantation crops. The terraced uplands have paddy cultivation and/or horticultural crops like apples. Rice is a minor crop in the Kashmir area and is mostly grown in irrigated lands. Maize is an important crop in Himachal Pradesh area where rice and wheat are alternate crop. Apple (*Malus domestica*) is the main horticultural crop in Kashmir and Himachal Pradesh and is a good source of revenue. Almond (*Prunus amygdalus*) known for its high nutritive value is cultivated in the Kashmir valley. Other temperate fruits introduced and cultivated in Kashmir and Himachal Pradesh are apricot, peach, plum, sweet cherry and walnut.

Crops and wild relatives

Cereals and millets: Oat and allies : (*Avena sativa*), *Avena barbata*, *A. fatua*, *A. ludoviciana*, *Digitaria cruciata;* Wild Rye*: Elymus dahuricus*, *E. dentatus* subsp. *kashmiricus*, *E. himalayanus*, *E. semicostatus*; Barley and allies: (*Hordeum vulgare*), *H. aegiceras*, *H. brevisubulatum*, *H. brevisubulatum* subsp. *turkestanicum*, *H. brevisubulatum* subsp. *nevskianum*, *H. marinum* subsp. *gussoneanum*, *H. spontaneum;* Rice (*Oryza sativa*), *O. rufipogon*; Maize (Zea mays); Wheat and allies: (*Triticum aestivum*), *T. aestivum* subsp. *sphaerococcum; Aegilops tauschii;* Millets*: Digitaria cruciata* var. *esculenta*, *Eleusine compressa*, *Setaria viridis*, *Panicum psilopodium*.

Pseudocereals: Amaranth: *Amaranthus hypocondriacus;* Chenopods: *Chenopodium album*, *C. foliosum*, *C. glaucum*, *C. hybridum*, *C. murale; Dysphania ambrosioides, Dysphania botrys;* Buckwheat WR: (*Fagopyrum emarginatum*), *F. cymosum*, *F. tataricum*.

Legumes: Chickpea WR :(*Cicer arietinum*), *C. microphyllum;* Pigeon pea WR*: Cajanus scarabaeoides*, *C. mollis; Flemingia procumbens*, *F. strobilifera;* Sweet pea: *Lathyrus odoratus*, Grass pea *: Lathyrus sativus;* Horsegram

WR*: Macrotyloma sar-garhwalensis;* Fenugreek and allies*:* (*Trigonella foenum-graceum*), *T. balanse*, *T. cachemeriana*, *T. emodi*, *T. fimbriata*, *T. gracilis*, *T. podperae*; Vigna allies*: Vigna umbellata*, *V. trilobata*, *V. vexillata* var. *vexillata*.

Fruits: Citrus: Indian Rough lemon: *Citrus jambhiri;* Karna orange: *Citrus karna*, Bihi: *Cydonia oblonga;* WR Strawberry*: Duchesnea indica; Fragaria vesca*, Walnut**:** *Juglans regia*, Pista: *Pistacia vera*, *P. atlantica*, *P. integerrima*, *P. khinjuk*; Almond*: Prunus dulcis*, *Prunus jacquemontii;* Apricot*: Prunus armeniaca;* Sweet cherry*: Prunus avium;* Sour Cherry*: Prunus cerasus;* Common Plum: *Prunus domestica*, *P. jacquemontiana*, *P. jenkinsii*, Peach: *Prunus persica*, *P. prostrata*, *P. tomentosa*, *P. wallichii;* Pear: *Pyrus communis;* Kumaon Pear*: Prunus kumaonii;* Apple and WR: *Malus baccata*, *M. domestica*, *M. pumila;* European Plum*: Prunus domestica;* Pomegranate*: Punica granatum;* Currant: *Ribes glaciale*, *R. nigrum;* Raspberry*: Rubus ellipticus*, *R. fruticosus*, *R. hypargyrus* var. *niveus*, *R. hypargyrus, R. lanatus*, *R. nepalensis*, *niveus*, *R. molucannus*, *R. plicatus*, *Sorbus aucuparia*, *S. lanata;* Ber*: Ziziphus mauritiana*, *Z. oxyphylla*, *Z. xylopyra*.

Vegetables: Okra WR**:** *Abelmoschus manihot*, *A. moschatus*, *A. tuberculatus*; Onion allies: *Allium altaicum*, *A. ampeloprasum*, *A. cepa*, *A. cernuum*, *A. chinense*, *A. fistulosum*, *A. porrum*, *A. senescens*, *A. stracheyii*, *A. schoenoprasum*, *A. tuberosum;* Asparagus: *Asparagus ascendens*; Sugar beet: *Beta vulgaris*, Rapeseed*: Brassica napus* subsp. *napus* var. *qudrivalvis;* Black mustard*: Brassica nigra; Cauliflower. Brassica oleracea* var. *botrytis*; Brussels sprouts: B. *oleracea* var. *gemmifera;* Cabbage: *B. oleracea* var. *capitata B. oleracea* var. *gongylodes*; Turnip: *Brassica rapa*. var. *rapa;* Simla mirchi*: Capsicum annuum;* Kashmiri mirchi*: Capsicum annuum;* Cucumber allies*: Cucumis sativus*, *C. hardwickii;* Yam*: Dioscorea deltoidea*, *D. hispida*, *D. kumaonica;* Artichoke: *Cynara scolymus;* Lettuce WR: *Lactuca sativa*, *Lactuca serriola;* Garden cress (*Lepidium sativum*), Sponge gourd: *Luffa echinata*; French bean*: Phaseolus vulgaris;* Radish: *Rhaphanus sativus* var. *sativus*, *R. raphanistrum;* Bladder dock*: Rumex acetosa*, *R. acetosella R. patientia*, *R. vesicarius;* Brinjal*: Solanum melongena*, *S. aculeatissimum*, *S. incanum*, *S. xanthocarpum;* Potato*: Solanum tuberosum;* Tomato*: Lycopersicon esculentum; WR* Pointed gourd, *Trichosanthes dioica*, *T. ovigera*, *T. tricuspidata*.

Spices: Honey plant: *Ammi majus;* Saffron: *Crocus sativus*; WR Asafoetida: *Ferula asafoetida*, *F. jaeschkeana*, *F. narthex*, *F. wolfii;* Chamomile*: Matricaria chammomila;* Clover*: Medicago monantha;* Mint*: Mentha arvensis*, *M. arvensis* var. *haplocalyx*, *M. piperita*, *M. spicata*.

Sugarcane allies: *Miscanthus nepalensis. Saccharum narenga*, *Saccharum filifolium;* Tea*: Camellia sinensis.*

Other economic plants

Less known vegetables: *Chorispora bungeana*, *C. tenella*, *Coronopus didymus*, *Crambe cordifolia*, *C. cordifolia* subsp. *kotschyanam*, Meelo Karela (*Cyclanthera pedata*), *Dioscorea sagittata*, *Draba muralis*, *Epilobium palustre*, WR Sponge gourd: *Luffa echinata*, *L. graveolens;* WR Garden cress*: Lepidium capitatum*, *L. draba*, *L. latifolium*, *L. sativum;* WR Mallow: *Malva verticillata*, *M. rotundifolia*, *Phytolocca acinosa*; Wild radish: *Raphanus raphanistrum; Sisymbrium irio*, *Thlapsi arvense.*

Fruits: *Aesculus indicus*, *Alcimandra butyracea*, Chest nut (*Castanea sativa*), *Cotoneaster microphylla*, Hazelnut (*Corylus avellana*), *C.colurna*, *C. jacquemontii; Cotoneaster microphylla*, *Crataegus oxycantha*, *Cydonia oblonga*, Fox nut (*Euryale ferox*). *Eleaegnus angustifolia*, *E. hortensis*, *Flacourtia indica*, *F. sapida*, *Fagus sylvatica;* Common Fig (*Ficus carica*)*; Machilus edulis;* Kaiphal (*Myrica esculenta*)*;* Rose: *Rosa sericea*, *Rosa webbiana; Syzygium cuminii*, *S. jambos.* Oilseeds: Mustard Abyssinian (*Crambe abyssinica*)*;* Linseed WR: *Linum perenne*, *L. strictum*. Beverages: Coffee WR: (*Psilanthus benghalensis*)*;* Tea (*Camellia sinensis*).

Spices: WR Onion: *Allium humile*, *A. rubellum*, *Bunium persicum*, *Cleome icosandra*, Black caraway (*Carum bulbocastanum*), Caraway (*Carum carvi*), Ajmod (*Carum roxburghianum*); Burning Bush: *Dictamnus albus*; *Micromeria biflora;* Black cumin: *Nigella sativa;* Parsley: *Petroselinum crispum;* Aniseed: *Pimpinella anisum;* Winter Savory*: Satureja montana;* Common wormwood*: Artemisia absinthium*.

Medicinal & aromatic plants: *Achillea mllefolium*, *Aconitum heterophyllum*, *Allium humile*, *A. stracheyi*, Angelica *glauca*, *Arnebia benthamii*, *A. euchroma*, *Arnica montana*, *Artemisia annua*, *A. maritima*, *A. myriantha*, *Atropa acuminata*, *Berberis aristata*, *Berberis asiatica*, *B. chitria*, *B. lycium*, *Bergenia ligulata*, *B. ciliata*, *Colchicum luteum*, *Coleus*

barbatus, *Crocus sativa*, *Dactylorhiza hatagirea*, *Delphinium denudatum*, *Dictamus albus*, *Inula racemosa*, *Dioscorea deltoidea*, *Ephedra gerardiana*, *Ferula jaeschkeana*, *Fritillaria roylei*, *Gentiana kurooa*, *Hyoscyamus niger*, *Jurinea macrocephala*, *Meconopsis aculeata*, *Nardostachys jatamansii*, *Olea ferruginea*, *O. glandulifera*, *Picrorhiza kurrooa*, *Podophyllum hexandrum*, *Potentilla fulgens*, *Rheum australe*, *Rubia manjith*, *Saussurea costus*, *Saussurea obvallata*, *Saussurea lappa*, *Senna sophera*, *Swertia chirayita*, *Taxus wallichiana*, *Thalictrum foliolosum*, *Valeriana officinalis*, *Zanthoxylum armatum*.

Timber: Cedar wood (*Cedrus deodara*); Pine (*Pinus wallichiana*); Chir Pine (*Pinus roxburghii*), *P. gerardiana*, *P. sylvestris;* Poplars: *Populus ciliata*, *P. alba; Quercus leucotrichophora*.

Dyes: and tannins: Indigo WR: *Indigofera cedrorum*, *I. dosua* var. *simlensis*, *I. heterantha*, *Rheum australe*, *Rheum moorcroftinium*, *R. webbianum*, *Rubia cordifolia*.

Fodder: *Agrostis hissarica*, *A. munroana* subsp. *indica*, *Artemisia japonica*, *Avena fatua*, *Desmodium triquetrum*, *Digitaria cruciata* var. *esculenta*, *D. ischaemum*, *D. stewartiana*, *D.sanguinalis*, *Bromus danthoniae*, *B. gracillimus*, *B. himalicus*, *B. japonicus*, *B. scoparius*, *B. sericeus*, *B. staintonii* var. *staintoni*, *Festuca rubra*, *Lathyrus aphaca*, *Lespedeza cuneata*, *Lolium perenne*, *Lotus corniculatus*, Alfalfa: (*Medicago sativa*); *Melilotus albus*, *M. indicus*, *Mucuna atropurpurea*, *M. nigricans*, *M. pruriens* var. *pruriens*, *M. pruriens* var. *utilis*, *Trifolium repens*, *T. pratense.*

Multipurpose species: *Celtis australis*, *Ficus palmata*, *Ficus racemosa*, *Grewia optiva*, *Juglans regia*, Mulberry: *Morus australis*, *M. indica*, *M. nigra*, *M. serrata; Salix denticulata*.

Life supporting species: *Avena byzantina*, *Avena sterilis*, *Bromus inermis*, *Chenopodium murale*, *Dysphania botrys*, *Festuca arundinacea*, *F.gigantica*, *F. rubra*, *Rhus parviflora*, *R. punjabensis.*

Bamboos: *Dendrocalamus hookeri* var. *parishii*, *Yushania jaunsarensis.*

Ornamentals: *Calendula arvensis*, Pot Marigold (*Calendula officinalis*), Corn flower (*Centaurea cyanus*), Larkspur: *Delphinium ajacis*, Carnation : *Dianthus anatolicus*, *D. cachemiricus*, *D. jacquemontii*, *D. sinensis*, Foxtail lily (*Eremurus himalaicus*) Iris: *Iris duthiei*, *I. hookeriana*,

Alpinia smithiae- a wild relative of Galanga, a newly described endemic species from Periyar (Kerala)

Ampelocissus latifolia- fruits and tender leaves edible (Malabar, Konkan regions)

Artocarpus lakoocha- A life support species and valuable genetic resource in the subtropical forests in Southern peninsula, North-east and Gangetic plains

I. kashmiriana: Jasmine WR: Tree Jasmine (*Jasminum arborescens*), Yellow Jasmine (*J. humile*), *J. multiflorum*, Spanish Jasmine (*J. officinale*), *J. parkeri*, *J. ritchiei*, *J. rottlerianum*, True Lavender (*Lavandula angustifolia*), Wild lily: *Lilium roseum*, *Lilium thomsoniaum*, Water lilies: *Nymphaea alba*, *N. caerulea*, *N. tetragona;* Rose WR: *Rosa clinophylla*, *R. damascena*, *R. foetida*, *R. hirsuta*, *R. macrophylla*, *R. moschata; Rubia edgeworthii; Salvia moorcroftiana*, *S. officinalis;* Marigold: *Tagetes erecta*, *T. minuta*, *T. patula;* Tulip: *Tulipa clusiana* forma *stellata*.

Endemic species: *Acer acuminata*, *A. oblongum* var. *membranaceum*, *Aconitum deinorrhizum*, *A. falconeri* var. *falconeri*, *A. falconeri* var. *latilobum*, *A. moschatum*, *Agrostis monroana* subsp. *indica*, *Allium chitralicum*, *A. gilgitcum*, *A. roylei*, *Atropa acuminata*, *Campanula ovata*, *C. wattiana*, *Cassia davidsonii*, *Cicer microphyllum*, *Dianthus cachemiricus*, *D. jacquemontii*, *Delphinium koelzii*, *Eremurus himalicus*, *Fraxinus xanthoxyloides*, *Geranium pinetophium*, *Indigofera cedrorum*, *I. dosua* var. *simlensis*, *Iris duthiei*, *I. hookeriana*, *I. kashmiriana*, *Jasminum parkeri*, *Juglans regia*, *Lilium roseum*, *L. thomsonianum*, *Rosa hirsuta*, *R. macrophylla* var. *hookeriana*, *Rubia edgeworthii*, *Saussurea clarkei*, *Tulipa clusiana* forma *porphyrechrysantha*, *Ulmus wallichiana* var. *tomentosa*

Threatened species: *Acer oblongum* var. *membranaceum*, *Aconitum falconeri* var. *latilobum*, *A. moschatum*, *Allium roylei*, *A. stracheyi*, *Atropa acuminata*, *Aquilegia nivalis*, *Arnebia benthamii*, *Berberis huegelliana*, *Cremanthodium arnicoides*, *Dioscorea deltoidea*, *Eremurus himalaica*, *Heracleum cachemiricum*, *Hedysarum astragaloides*, *Hedysarum cachemirianum*. *Indigofera cedrorum*, *Indigofera himalayensis*, *Lactuca kashmiriana*, *Meconopsis aculeata*, *M. latifolia*, *Picrorhiza kurrooa*, *Rubia edgeworthii*, *R. himalayensis*, *Saussurea clarkei*, *S. costus*, *Ulmus wallichiana*.

Associated culture and tribes

The area is predominantly inhabited by Indo-Aryans. There is considerable Tibetan and Buddhist influence on Ladakhis and Dogries living in the high altitude mountains of the Himalayas. The associated tribes are Dogries (practicing agriculture) and Gujars (tending livestock). Since the ecosystem of the land is fragile and climate is harsh, the people adopt multicropping as a way of life.

A common practice in Garhwal Himalaya is the cultivation of twelve crops known as "*baranaja*" (twelve grains). The practice of *baranaja* involves sowing of a mixture of crop seeds: Rajma (*Phaseolus vulgaris*), Black gram (*Vigna mungo*), Green gram (*Vigna radiata*), Horsegram (*Macrotyloma uniflorum*), Ramdana (*Amaranthus caudatus*, *A.hybridus*), Finger millet (*Eleusine coracana*), Barnyard millet (*Echinochloa crus-galli*), Soybean (*Glycine max*), Cowpea (*Vigna unguiculata*). Since harvesting periods of these crops vary, these are harvested at different times, which would provide a regular supply of food grains and also help the retention of soil moisture (Jardhari *et.al.*, 1995). According to Navadanya (1993), a movement for the conservation of native and indigenous varieties which are fast disappearing, this practice of sowing multi - crop seeds ensures a sustainable yield to the farmers. Similarly, bunds along the fields are planted with multipurpose trees, like Bhimal (*Grewia optiva*), *Morus serrata*, *Ficus palmata* which yield fruits and fodder.

Technology and products

The topography of the Western Himalayas having different altitudinal ranges and folds of mountains offers different ecological niches and microclimatic synusia for different crop species. The high levels of genetic diversity of major temperate crops, fruit species and medicinal plants in the Western Himalayas is the cumulative result of interactions of climatic and topographical stresses and agro-pastoral interventions.

In Uttarakhand, the *Beej Bachao Andolan* (Save the Seed Movement) rediscovered over 300 cultivars of rice, 180 of kidney beans, 30 of wheat and 40 of minor millets. The region is known for variability in rice for several desirable traits, such as cold tolerance and aroma. The British official Atkinson reported in his Himalayan Gazetteer of 1882 that there were 48 distinct varieties and thousands of non-descriptive varieties of rice in the West Himalayas. These traditional varieties are being replaced by a handful of high yielding varieties (HYVs). The region is geographically associated with the genetic diversity for one of the most popular aromatic rice varieties, called *Basmati* Rice, of which Dehradun Basmati is well known for its aroma and grain quality. In wheat, Himachal region is known for variability

in growth habit, spike emergence, spike length, awn length, grain number/spike, spike- awn ratio and grain uniformity, etc. (Singh[3] *et al.*, 2006). Naphal, a local landrace of wheat conserved by sub- tribal community Marcha belonging to Bhotia in the Himalayan ranges of Uttarakhand is known for its soft-milling quality suited for biscuit making. Variability also exists in finger millet, where GE233 from Almora, Uttarakhand has been identified with low stomata number, low leaf area, and high photosynthetic efficiency.

The region has variability for seed size, shape, colour, maturity time and cold tolerance in lentil and peas. Varieties such as VL Masoor 4 and Pant L324 in the case of lentil have been selected from a local landrace of Pithoragarh, whereas VL Matar was selected from a local landrace of Uttarakhand (Singh[2] *et al.*, 2006). In mung bean the region is known for variability in number of seeds per pod. Wild forms of rice bean have been reported from Shimla and Chamba areas of the region (Singh[1] *et al.*, 2006).

Among oilseeds, variability has been reported in the case of brown sarson from hills of Jammu and Kashmir and Himachal Pradesh. In the case of *Brassica rapa* var. *toria*, variety Bhawani was developed from a local landrace of Uttarakhand. For soybean, the Himachal and Uttarakhand regions are known for black seeded rice called Bhatmash. Varieties, like JS-2 have been developed from a yellow seeded local landrace from Tehri Garwahl and Type 41 from another small yellow seeded landrace (Tiwari *et al.*, 2004). In sesame, local landraces have contributed to the development of varieties, like Type 12 from a landrace from Almora and Punjab Til No.1 from a landrace from Kangra (Duhoon[2] *et al.*, 2004). In the case of sugarcane, the sub-Himalayan region is known for maximum variability in *Saccharum spontaneum* with useful variability for resistance to diseases and drought, and tolerance to salinity and water logging (Sreenivasan *et al.*, 2004).

In horticultural crops, the region presents high variability in some of the solanaceous crops, like brinjal (*Solanum melongena*) and chilli (*Capsicum annuum*). The variability of landraces in chilli has been used in the development of varieties Nishat 1 (Sel. 12) from a local landrace of Jammu and Kashmir and varieties Punjab Mirch 27 having

higher yield and tolerance from another landrace (Kalloo *et al.*, 2005). In potato, Chamba red, Kufri safed, Kufri red have been developed through selection from the local cultivar Phulwa (Shekhawat *et al.*, 2005).

The region is known as one of the secondary centres of diversity of cucurbitaceous crops: In *Cucumis sativus*, varieties like Solan green have been developed from Solan local. From a collection of Himachal Pradesh, it is seen that landrace like Sadan Badami has evolved from introduced species, *Cucurbita moschata* (Sirohi *et al.*, 2005). In addition to this, there are several wild relatives of cucurbitaceous crops, such as *Cucumis hardwickii*, *Luffa graveolens*, *Trichosanthes lobata* having several desirable traits (Sirohi *et al.*, 2005). North western Himalayan region is known for rich genetic diversity of temperate fruits (Rana *et al.*, 2003). According to Vavilov (1951), one of the major centres of origin of temperate fruits is Central Asiatic region extending up to Kashmir. The native variability is available in sand pears, wild apricots, local *Prunus* species, almond, walnut, pomegranate, pecan nut, hazelnut and many minor fruits. The systematic characterisation and evaluation have resulted in selection of genotypes that are well adapted to Indian conditions. For example in Uttarakhand, the apple varieties Anupam, Chaubattia, Agrim, Chaubattia Swarnima, Red June, Early Shanburry are well known elite varieties (Prakash *et al.*, 1997). In pear, Red Blush and Punjab Sunehri are noteworthy examples of superior strains selected from plantations of Baggugosha (Uppal *et al.*, 1993). In peach, Strak Earliglo, Early White Giant, Starking Delicious and Candor are found suitable for cultivation in mid hills due to early maturing feature. Cultivars such as Prairie Dawn, Prairie Ramber and Prairie Rose are suitable for high altitude areas of dry temperate region (Sharma *et al.*, 1994). In plum, Green Gage, Frontier, Kantos, Kubio, Red Ace and Tarrol were found promising for mid hills (Bist *et al.*, 1996). Late maturing cultivar, Nubiana, Queen Ann and Friar are being evaluated for dry temperate regions. In sweet cherry, cultivars like Triumph Domini, Pietro Nigra, Bella Italia and Foaya Tardiva are found promising for yield, quality, early maturity and resistance to insect pests and diseases (Gautam *et al.*, 1992). Tripathi *et al.*, (1992) reported good performance of slections of almonds in Pithoragarh. In walnut, Bhat *et al.*, (1992) found selection P 3 and Wassan 4 from

Kashmir, suitable for nut and kernel export respectively. Based on these criteria, indigenous seedling selections such as Gobind, Roopa Akhrot and Kotkhai were found promising for export. Additionally, the region is known for several varieties of apples, such as Delicious from Jammu & Kashmir and Himachal Pradesh and Golden from Uttarakhand.

Rich genetic diversity for certain tropical fruits, like *Citrus* and lichi has also been recorded from sub-Himalayan region. The cultivars of litchi from Dehradun are well known. The local communities/farmers have conserved this variability and made significant contributions in adaptation/selection of these cultivars. Similarly, rich genetic diversity has been found in the case of ginger and turmeric. In ginger, variety Himgiri is a clonal selection from Himachal Pradesh.

Among the wild relatives found in the region, *Cucumis hardwickii* collected from Dehradun, has been identified as source of resistance to powdery and downy mildew, and is being used in cucumber breeding programme world over, while *Cajanus mollis* has been identified with highest protein contents (33.4%) for use in the nutritional breeding programme (Remanandan, 1996).

Similarly to facilitate effective use of water in crop cultivation, *Kuhls* water channel irrigation system, carrying water from mountains has been developed in Jammu and Kashmir; similar irrigation system, diverting natural flowing streams (*khuds*) through channels is developed in Himachal Pradesh. A typical community *Kuhl*, serves 6- 30 farmers, irrigating an area of around 20 ha. The *Kuhl* was provided with moghas (kachcha outlets) to draw out water and irrigate nearby terraced fields. It is seen that Khatris (structure of about 10 x 12 feet size and 6 feet depth) carved out in hard rock mountain are used in Hamirpur, Kangra and Mandi, for washing, drinking and for bathing animals. It is reported that the wild variety of Onion i.e. *Allium royelii*, occurring in this region is a source of resistance to powdery mildew and leaf blight (De Vries, 1992). The wild relatives of Okra, *Abelmoschus manihot* and *A. tuberculatus* are a source of resistance to yellow vein mosaic virus (Arumugam *et al.*, 1975; Sharma *et al.*, 1966; Sharma *et al.*, 1984). Similarly the trait mildew resitance to the crop species

Avena sativa is donated by the wild relative *Avena barbata* (Aung *et al.*, 1977). The crossability study in Oats (*Avena sativa*) with the wild relative *Avena sterilis* was used to evaluate the grain size in Oats (Lawrence *et al.*, 1975). The local communities / farmers have conserved these genetic resources from ancient times, thus making a significant contribution to the agricultural/ horticultural economy of the states of Jammu & Kashmir, Himachal Pradesh and Uttarakhand.

7.3 Eastern Himalayan Agrobiodiversity Region

Location and extent

The Eastern Himalaya Agrobiodiversity region comprises the states of Sikkim, Arunachal Pradesh and Darjeeling district of West Bengal. The hotspot area includes all the districts of Arunachal Pradesh, Sikkim and Darjeeling district of West Bengal.

The area includes some of the highest mountain peaks: Sikkim: Mt. Khanchendzonga (8598 m above MSL) is the third highest mountain in the world. The most important mountain passes are Nathu La (4392 m above MSL), Jelep La (4388 m above MSL), Donkta La (5520 m above MSL), Kongra La (4809 m above MSL). Teesta and Rangeet are the two main rivers of Sikkim Himalayas. Some of the important high peaks in Arunachal Pradesh are: Gorichen (7300 m above MSL), Kangto (7090 m above MSL), Namcha Barwa (7756 m above MSL), Kulangri (7544 m. above MSL), Chome Lhari (7344 m above MSL). Principal rivers in Arunachal Pradesh are: Kameng, Siang, Lohit, Tirap, Subansri and Dibang.

Agroclimate

The climate of the region is characterised by moderate to severe winters and mild summers. The mean annual rainfall exceeds 2000 mm. As a result of the availability of sufficient moisture for major part of the year, the growing period extends to more than 270 days. The area experiences water stress only during post rainy season. The soil temperature varies from 18°C to 22^{0}C. The region is typified by shallow to medium loamy, brown humus soil with rich organic matter. The *Tarai* soils are acidic in nature in various degrees.

Floristic diversity

The region is very rich in floristic diversity. The Eastern Himalaya is one of the hotspots of the world and is considered as a crucible of speciation. Due to the presence of the phylogenetically primitive families like Magnoliaceae, Eupteleaceae, Tetracentraceae, Lardizabalaceae, Hamamelidaceae it is also considered as a centre of "living fossils". Several widely distributed plant taxa, with high endemism and ornamental value are reported in the genera such as *Gentiana*, *Primula*, *Pedicularis, Rhododendron, Saxifraga*. Natural vegetation of the Eastern Himalaya comprises the following vegetation types: Tropical evergreen forest: canopy trees (30-50m) *Artocarpus chama*, *Dipterocarpus retusus*, *Shorea assamica*, *Terminalia myriocarpa*, *Tetrameles nudiflora;* Subtropical semi-evergreen forest: represented by tall trees (30-40 m) *Acrocarpus fraxinifolius*, *Artocarpus lakoocha*, *Duabanga grandiflora*, *Canarium strictum;* Subtropical forest: dominated by *Alnus nepalensis*, *Callicarpa arborea*, *Magnolia pterocarpa;* The Eastern Himalaya Pine forest: represented by *Pinus roxburghii*, *Pinus wallichiana*, *Pinus mercusii;* Temperate broad-leaved forest : represented by *Acer hookeri*, *Betula alnoides*, *Quercus glauca*, *Magnolia campbelli;* Temperate coniferous forest: represented by associations of *Tsuga dumosa- Pinus roxburghii*, *Rhododendron arboreum*, *R. hodgsonii*, *R. griffithianum*, *Abies spectabilis-Tsuga dumosa-Taxus wallichiana*, *Picea spinulosa- Abies spectabilis- Larix griffithiana*. The alpine vegetation consists of low stunted shrubs and herbs: *Rhododendron anthopogon*, *R. nivale* (smallest *Rhododendron* species having 9 cm. height), *Primula sikkimensis*, *Meconopsis nepaulensis*. The alpine zone is the home of several ornamental plants belonging to the following genera: *Anaphalis*, *Androsace*, *Cremanthodium*, *Corydalis*, *Cortia*, *Diapensia*, *Draba*, *Gentiana*, *Lagotis*, *Primula*, *Pedicularis*, *Rhododendron*, *Saxifraga*.

Agriculture and agrobiodiversity

In Sikkim and Arunachal Pradesh Himalayan region, cultivation of crops is done in terraced fields, along steep hillsides. In Sikkim, the main crops, which are economically important for the state are, cardamom and tea. In Arunachal Pradesh where rice is not grown exclusively, alternate crops cultivated are maize and oilseeds.

Crops and wild relatives

Cereals and millets*:* Oat WR: *Avena fatua*; Barley and WR: *Hordeum vulgare*, *H. agrocrithion; Eleusine indica*, used for fermentation of "Chiyang" drink by Lepchas; *Elymus dahuricus* subsp. *excelsus*, *Kengyilia thoroldiana*; Wheat: *Triticum aestivum*, *T. turgidum* subsp. *polonicum;* Wheat WR: *Eremopyrum bonaepartis*, *E. distans*, *E. orientale*; Rice: *Oryza sativa*, *O. meyeriana* subsp. *granulata*, *O. minuta*; Proso millet (*Panicum miliaeceum*); *Maize*: *Zea mays*.

Pseudocereals**:** Amaranth: *Amaranthus hypocondriacus; Chenopodium album*; *Coix lacryma-jobi* var. *mayuen;* Buck wheat and allies : *Fagopyrum esculentum*, *Fagopyrum tataricum*.

Legumes: WR Pigeon pea: *Cajanus elongatus*, *C. grandiflorus*, *C. mollis*, *C. scarabaeoides*, *C. villosus*; Sword bean (*Canavalia ensiformis*, *C. gladiata*), Dolichos (*Lablab purpureus* subsp. *purpureus*, *L. purpureus* subsp. *bengalensis*), Soybean (*Glycine max*), French bean (*Phaseolus vulgaris*), Kudzu vine : *Pueraria edulis*, *P. montana* var. *thomsonii*, *P. sikkimensis*, *P. strobilifera*, *P. tuberosa*; Winged bean (*Psophocarpus tetragonolobus*)*;* Adzuki bean (*Vigna angularis*), *Vigna clarkei*; Black gram (*Vigna mungo*); Rice bean (*Vigna umbellata*).

Fruits: WR Kiwi: *Actinidia strigosa*; Citrus: *Citrus limon*, *C. aurantifolia*, Karna orange: *C. karna*, Sweet lime*: C. limettoides*, *C. medica* var. *medica*, *C. ichangensis*, *C. reticulata;* Himalayan Hazel: *Corylus ferox;* Indian crab apple*: Docynia hookeriana*, *D. indica;* WR Loquat: *Eriobotrya dubia*, *E. hookeriana*, *E. petiolata;* Sikkim Strawberry: (*Fragaria daltoniana*). Mango (*Mangifera indica*), Wild Mango: *M. andamanica*, *M. khasiana*, *M. sylvatica;* Apple WR *Malus baccata*, *M. sikkimensis*; Banana*: Musa acuminata*, *M. balbisiana*, *M. cheesmanii*, *M. manii*, *M. nagensium*, *M. sikkimensis*, *M. velutina;* WR Prunus*: Prunus arborea*, *P. bracteopadus*, *P. carmesiana*, *P. himalaica*, *P. imanishii*, *P. jenkinsii*, *P. napaulensis*, *P. rufa* var. *trichantha*, *P. zippeliana;* Pear allies*:* Khasi Pear: *Pyrus khasiana*, *P. pashia*, *P. pyrifolia*; *Rhus griffithii;* Black currant*: Ribes glaciale*, *R. acuminatum*; Raspberry*: Rubus ellipticus*, *R. lineatus*, *R. foekeanus*, *R. fragarioides*, *R. ghanakantus*, *R. griffithii*, *R. hypargyrus* var. *niveus*, *R. rugosus*, *R. senchalensis*, *R. sikkimensis* var. *sikkimensis*, *R. wardii*; *Sorbus himalaica*, *S. microphylla*, *S. vestita;* Rose*: Rosa x odorata* nothovar. *gigantea;* WR Vitis*: Vitis flexuosa*, *V. heyneana*.

Vegetables: Garlic: *Allium sativum*, *A. angulosum*; WR Allium: *Allium cepa*, A. *hypsistum*, *A. pratti*, *A. rhabdotum*, *A. sikkimense*; Cauliflower: *Brassica oleracea* var. *botrytis*; Brussels sprouts: B. *oleracea* var. *gemmifera;* Cabbage: *B. oleracea* var. *capitata*, *B. oleracea* var. *gongylodes*; Turnip: *Brassica rapa*. var. *rapa; Chenopodium album;* Cucumber (*Cucumis sativus*), *C. hystrix; Cucurbita maxima*, *C. moschata*, *C. pepo*; WR Garden Lettuce: *Lactuca cooperi*, Indian Lettuce*: Lactuca indica*, *L. sativa;* WR Garden cress, *Lepidium sativum; Luffa acutangula*, *L. aegyptiaca; Momordica charantia; M. cochinchinensis*, *M. dioica*, *M. macrophylla; Flemingia procumbens; Phytolocca acinosa*; *Rumex acetosus; Rheum nobile;* Chayote: *Sechium edule; Solanum bracteatum*, *S. kurzii*, *S. sisymbriifolium*, *S. spirale*, *Stetragonum; Solena heterophylla; Trichosanthes cucumeriana* var. *anguina*, *T. tricuspidata*, *T. wallichiana*.

Tubers: Taro: *Alocasia indica;* Giant Taro, *Alocasia macrorrhizos;* Elephant-foot yam**:** *Amorphophallus paeonifolius* var. *campanulatus*, *A. bulbifer;* Taro*: Colocasia esculenta*, *C. fallax;* Yams: *Dioscorea alata*, *D. bulbifera D. esculenta*, *D. hispida*, *D. kumoonensis*, *D. japonica*, *D. lepcharum*, *D. pentaphylla*, *D. prazeri*, *D. puber*, *D. scortechnii*, *D. wallichii; Canna indica; Flemingia procumbens.*

Spices: *Angelica archangelica*, Bengal cardamom: *Amomum aromaticum*, *A. maximum*, *A. subulatum;* Galanga: (*Alpinia galanga*), *Alpinia malaccensis*, *A. zerumbet;* Betel nut*: Areca catechu*, *A. triandra; Bupleurum sikkimense;* Tamala :*Cinnamomum bejolghota*, *C. pauciflorum*, *C. caudatum*, *C . tamala, C. yabunikkei ;* Turmeric: *Curcuma longa*, *C. amada*, *C. aromatica*, *C. caesia*, *C. latifolia*, *C. montana;* Cardamom: *Elettaria cardamomum; Fraxinus floribundus*; Galanga*: Caulokaempferia sikkimensis, Kaempferia galanga*; Pepper: *Piper nigrum*, *P. attenuatum*, *P. hamiltonii*, *P. laxivenum*, *P. mungpooanum*, *P. peepuloides. P. ovatistigmum*, *P. sikkimense*, *P. tenuibracteatum*, *P. thomsonii*, *P. wallichii*, *P. schmidtii*; Perilla: *Perilla frutescens;* WR Aniseed *: Pimpinella urceolata;* White mustard*: Sinapsis alba;* WR Fenugreek *Trigonella emodi*, *T. gracilis* Ginger**:** *Zingiber officinale*, *Z. chrysanthum*, *Z. clarkei*, *Z. zerumbet*.

Sugarcane: Sugarcane & WR: (*Saccharum officinarum*), *Erianthus ravennae*, *Miscanthus nepalensis*, *M. nudipes*, *M. taylorii*, *M. wardii*, *Saccharum fallax*, *S. longisetosum*, *S. sikkimense*, *S. williamsii*.

Beverages : WR Tea*: Camellia caudata*, *C. kissii*, *C. drupifera*, *C. irrawadiensis*, *C. siangensis*, *C. taliensis;* WR Coffee*: Psilanthus benghalensis*, *P. khasianus*.

Other economic plants

Fruits: *Artocarpus heterophyllus*, *Artocarpus lakoocha*, *Capparis pachyphylla*, *Coriaria nepalensis*, *Corylus ferox*, *Drypetes assamica*, *Ficus carica*, *F. pomifera*, *Holboellia latifolia*, *Garcinia hombroniana*, *G. xanthochymus*, *Machilus edulis*, *Pyrus pyrifolia*, *Ribes glaciale.*

Less known edible fruits and vegetables: *Ampelocissus barbata*, *A. rugosa*, *A. repens; Cyclanthera pedata; Dendrocalamus hamiltonii; Diplazium esculentum*, *Gymnopetalum quinquelobum*, *Hodgsonia heteroclita.*

Less known beverages: *Diplospora singularis*, dried and roasted leaves as a substitute for coffee; *Eurya acuminata*, *E. arunachalensis.*

Medicinal plants: Mishmi Aconite (*Aconitum lethale*), Bengal cardamom (*Amomum aromaticum*), *Anisochilus carnosus*, Dharu harida (*Berberis aristata*), Barberry (*Berberis asiatica*), *Bupleurum sikkimense*, Qunine: (*Cinchona officinalis*); *Gold* thread (*Coptis teeta*); *Costus* (*Costus speciosus*), Curculigo (*Curculigo orchioides*), *Gynocardia odorata*, *Hedychium spicatum;* Juniper (*Juniperus communis*); Ipecac (*Cephaelis ipecacuanha*), Long pepper (*Piper longum*); *Panax sikkimensis*; Indian Podophyllum (*Podophyllum hexandrum*, *P. sikkimensis*); Himalayan cumin (*Rheum emodi*); *Saussurea gossypiphora*, *S. nimborum*, *S. pantlingiana*, *S. aculeatissimum; Strychnos nux-vomica;* Chireta (*Swertia chirayita*), Common Yew (*Taxus wallichiana*); *Chebulic* myrobalan (*Terminalia chebula*).

Ornamentals: *Allium wallichii*, *Corydalis cavei*, *C. changuensis*, *Cymbidium cyperifolium*, *Dendrobium chrysanthum*, *D. densiflorum*, *D. hookerianum*, *D. nobile*, *D. wardianum*, *Gentiana glabriuscula*, *G. pluviarum*, *Hedychium gardenerianum*, *Licuala peltata*, *Livistona chinensis*, *L. jenkinsiana*, *Jasminum attenuatum*, *J. azoricum*, *Juniperus indica*, *J. recurva*, *Meconopsis bella*, *Michelia champaca*, *Paphiopedilum fairieanum*, *P. wardii*, *Pleione praecox*, *Phalaenopsis mannii*, *P. lobbii*, *P. parishii*, *Primula ianthina*, *P. euosma*, *Prunus cerasoides*, *Renanthera imschootiana*, *Rhynchostylis retusa*, *Rhododendron arboreum*, *R. barbatum*, *R. hodgsonii*, *R. falconeri*, *R. nivale*, *R subansiriensis*, *Rosa calycinoides*, *Rosa macrophylla*, *R. sericea*, *Saxifraga coarctata*, *S. exigua*, *S. hookeri*, *Viburnum cordifolium*, *Wallichia triandra*.

Timber: *Albizia lebbeck*, *Artocarpus chama*, *Alnus nepalensis*, *Castnopsis indicum*, *Cupressus torulosa*, *Cryptomeria japonica*, *Dipterocarpus retusus*, *Juglans regia*, *Pinus kesiya*, *Pinus roxburghii*, *P. wallichiana*, *Quercus acutissima*, *Q. lamellosa*, *Shorea assamica*, *Terminalia myriocarpa*, *Toona ciliata*, *Tsuga dumosa*.

Dye yielding plants: *Bixa orellena*, *Dichroa febrifuga*, *Mahonia nepalensis*, *Rumex nepalensis*, *Symplocos glomerata*.

Fodder: *Brassaiopis hainiana*, *Dactylis glomerata*, *Desmodium kulhaitense*, *D. triquetrum*, *Digitaria cruciata*, *Erianthus sikkimensis*, *E. longisetosum*, *Festuca arundinacea*, *Ficus auriculata*, *F. benghalensis*, *F. benjamina*, *F. hirta*, *F. infectoria*, *F. racemosa*, *Grewia asiatica*, *Lespedeza cuneata*, *Lolium perenne*, *Paspalum ciliatum*, *Stylosanthes guianensis.*

Multipurpose species: *Ficus cunia; Parkia timoriana*, *P. roxburghii*, *Grewia oppositifolia*, *Morus alba*, *Phoenix acaulis.*

Bamboos: *Bambusa bambos*, *B. pallida*, *Chimonobambusa callosa*, *C. hookeriana*, *Chimonocalamus longispiculatus*, *Dendrocalamus brandisii*, *D. hamiltonii*, *D. skkimensis*, *D. sahnii*, *D. strictus*, *Gigantochloa auriculata*, *S. macrostachys*, *Melocalamus gracilis*, *M. mastersii*, *Melocanna baccifera*, *Neomicrocalamus clarkei*, *N. mannii*, *Schizostachyum capitatum*, *S. griffithii*, *S. mannii*, *S. macrostachys*, *S. seshagirianum*.

Endemic species: *Acer hookeri* var. *majus*, *Acer oblongum* var. *microcarpum*, *Acer sikkimense* var. *serrulatum*, *Aconitum lethale*, *Albizia arunachalensis*, *Argyreia sikkimensis*, *Biermannia jainiana*, *Boehmeria tirapensis*, *Bulbophyllum obrienianum*, *Camellia siangensis*, *Capparis pachyphylla*, *Chimonocalamus longispiculatus*, *Cleisostoma tricallosum*, *Desmodium kulhaitense*, *Diplomeris josephii*, *Elaeocarpus dubius*, *Epipogium sessanum*, *Eria connata*, *Eria jengingensis*, *Eurya arunachalensis*, *Gastrodia arunachalensis*, *Glycosmis boreana*, *Hopea shingkeng*, *Lithocarpus kamengii*, *Panax sikkimensis*, *Lactuca cooperi*, *Lithocarpus kamengii*, *Oberonia sulcata*, *Piper clavilimbum*, *P. filipedunculum*, *P. isopleurum*, *P. laxivenum*, *P. mungpooanum*, *P. sikkimense*, *Pholidota convallariae* var. *brevicapsa*, *Podophyllum emodii* var. *axillaris*, *Rhododendron concinnoides*, *R. falconeri* var. *exiimium R. santapaui*, *R. subansirensis*, *Rubus niveus* var. *micranthus R. senchalensis*, *Salix pseudocalyculata*, *S. oreophillia*, *S. stomatophora*, *Saussurea gossypiphora*, *S. pantlingiana*, *Wallichia triandra*, *Xanthophyllum burkillii*, *Zanthoxyllum burkillianum*, *Z. pseudoxyphyllum*.

Threatend species: *Acer hookeri* var. *serrulatum*, *A. osmastonii*, *Acer sikkimense* var. *serrulatum*, *Boehmeria tirapensis*, *Cajanus sericeus*, *Calamus inermis*, *Capparis pachyphylla*, *Cissus spectabilis*, *Coptis teeta*, *Dendrobium aurantiacum*, *Gleditsia assamica*, *Hedychium longipedunculatum Livistonia jenkinsiana*, *Nardostachys grandiflora*, *Panax pseudo-ginseng*, *Paphiopedilum fairieanum*, *Picrorhiza kurrooa*, *Rhododendron concinnoides*, *R. formosum*, *R. santapaui*, *Vanda coerulea*, *Wallichia triandra*.

Associated culture and tribes

Agriculture is the main occupation, contributing to the economy of the states of Arunachal Pradesh, Sikkim and Darjeeling district of West Bengal. The region is inhabitated predominantly by Indo-Mongloids having influence of Tibetan culture. The major tribes in Arunachal Pradesh are Abhor, Aka, Apatanis, Dafla, Galong, Khampti, Khowa, Mishmi, Momba, Naga tribes, Singpho. The major tribes in Sikkim and Darjeeling Himalayas are Bhutia, Dukpa, Sherpa, Tibetan, Trompoa and Lepcha. 'Bayul Demojong' is the core of the sacred land system of Sikkim below Mount Khangchendzonga in West Sikkim, where agriculture, particularly rice cultivation is practiced.

In general, *Jhum or* shifting cultivation is the traditional farming system. The shifting cultivation has led to deforestation and severe soil erosion. The extreme climatic conditions restrict the choice of crops. Traditional cultivation of rice and millets is done predominantly in the valleys or along the slopes protected by well-constructed contour bunding. It is seen that indigenous people in this region have developed traditional methods for soil conservation and effective use of water resources.

From ancient times, wet rice cultivation by the Apatanis of Arunachal Pradesh, (one of the relatively advanced tribal societies in the North-eastern region of India), is the highly developed valley cultivation. The Apatanis have also developed technology for sustainable soil conservation through recycling of crop residues and use of organic wastes of the village. They have also developed sophisticated cooperative system under the effective managerial responsibility of village headman for optimum use of water and nutrient in the soil. Besides, rice cultivation has been supplemented with cultivation of millets (especially *Eleusine coracana* grown in between rows) in order

to increase productivity and thereby assuring food security during lean season. Apatanis village ecosystem is a good example of village self-sufficiency in a traditional agricultural society that practices ecologically sustainable agriculture.

Technology and products

Arunachal Pradesh is known for rich rice genetic resources. The desirable genetic variability traits for short stature, short duration, stem borer resistance and low amylose (Japonica from Kamang) sources have been identified in the rice genetic resources (Siddiq *et al.*, 2006). In wheat, the Sikkim region is known for variability in spike -awn ratio, grain colour, grain shrivelling (Singh[3] *et al.*, 2006). In the Northeast Himalayan region because of the occurrence of primitive maize type, the region is considered as the possible Asiatic secondary centre of origin of maize. One of the main Sikkim maize germplam accession is identified as 'Sikkim Primitive' and some of the landraces identified are Anantnagar, Basssi, Chamba, Sikkim, Sathi, Samri, etc. These landraces have been used in the breeding programme for increasing the number of cobs per plant, exploiting their multiple cob features. Among oilseeds, rich diversity has been recorded in the case of soybean among the local black seeded landraces. In niger, useful landraces have been reported for cold tolerance (Duhoon[1] *et al.*, 2004).

Eastern Himalayan region has large genetic diversity in sugarcane. It is reported that *Sacchraum spontaneum* and the related *Saccharum arundinaceum* have desirable variability for cold tolerance, disease resistance and higher yield. The natural hybrid between the two species has resulted in the high incidence and variability for desirable traits (Sreenivasan *et al.*, 2004).

In horticultural crops, the region in continuation of the high variabilities of genetic resources recorded in the Himalayas, shares some of the natural variability in the case of potato i.e. Darjeeling red round. In addition, the region has recorded variability in Okra for fruit and plant types (Sirohi *et al.*, 2005). The region is known for cultivation of certain temperate fruits such as apple, prune and pear; but the level of variability is low. However, the region along with Northeast hills is very rich in genetic diversity of certain tropical

A traditional variety of the grapefruit- ***Citrus paradisii*** from Garo Hills of Meghalaya

Citrus reticulata- The Khasi mandarin

Citrus indica- The Indian wild orange, a threatened wild species in the Garo hills of Meghalaya

fruits, particularly *Citrus*. Mandarin (*C. reticulata*) is well represented in Sikkim.

Among spices, the region has variability in pepper (*Piper nigrum*), large cardamom and turmeric. Sikkim is known for the rich genetic variability in large cardamom (Awasthi *et al.*, 2000), besides tea and coffee. Among wild relatives, *Glycine max* occurring in the region has been identified as source of resistance to leaf yellow mosaic virus and being used in the national breeding programme.

7.4 Brahmaputra Valley Agrobiodiversity Region

Location and extent

The Brahmaputra valley agrobiodiversity region includes the districts adjoining Brahmaputra river with its tributaries and Barak valley. The hotspot area includes the following districts: Dhubri, Kokrajhar, Bongaigaon, Barpeta, Nalbari, Goalpara, Kamrup, Golaghat, Darrang, Morigaon, Nagaon, Sonitpur, Jorhat, Lakhimpur, Sibsagar, Dibrugarh, Dhemaji, and Tinsukia.

The valley is a flat plain alluvial land having a steady slope from its northeast corner Saidya to Dhubri in the west. The northern bank of Brahmaputra is often inundated by the quick flowing tributaries from the Arunachal Himalayas discharging into the river Brahmaputra.

Agroclimate

The area is characterised by hot summers and mild to moderately cool winters. The mean annual rainfall ranges from 1600 – 2000 mm. The potential evapo-transpiration ranges from 1000-1400 mm, ensuring the availability of moisture throughout the year, except for one or two months. Therefore, the length of the growing period is more than 270 days in a year. The annual soil temperature is around 22^0C or higher. The soil is acidic and have low to moderate base saturation.

Floristic diversity

The region is very rich in floristic diversity. The vegetation includes the following forest types: Tropical wet evergreen forest: The canopy

trees are: *Dipterocarpus retusus*, *Mesua ferrea*, *Shorea assamica*, *Tetrameles nudiflora;* Tropical semi-evergreen forest: Tall canopy trees (30-40 m) are: *Acrocarpus fraxinifolius*, *Ailanthus excelsa*, *Chukrasia tabularis*, *Bombax ceiba*, *Duabanga grandiflora*; Riverine semi-evergreen forest: *Bombax ceiba*, *Canarium strictum*, *Dillenia indica*; Subtropical forest: Important subtropical canopy trees are: *Alnus nepalensis*, Indian Chest nut (*Castanopsis indica*), *Engelhardtia spicata*, *Magnolia pterocarpa*, *Schmia wallichii*, *Ulmus lancifolium*; Pine forest (at altitudes ranging from 1000 - 1800 m): The prominent species are *Pinus merkusii*, *Pinus roxburghii*, *Pinus wallichiana*.

Agriculture and agrobiodiversity

Agriculture forms the major occupation of the people and it plays an important role in the economy of the state. The lowland valleys have rice fields, inundated flood plains have jute fields, while tea plantations are seen on the hill slopes. The climate with high rainfall favours agri-horticultural crops. Jute is an important commercial crop in the region. The cropping patterns are as follows: rice-rice; rice - rape seed –mustard; rice-potato –sesame; rice –chickpea-lentil; rice-mung bean; rice –urdbean. Intercropping combination of crops are as follows: toria + lentil, toria + chickpea, maize + mung bean.

Crops and wild relatives

Cereals: Rice (*Oryza sativa*): rice varieties: *Bala*, *Cauvery*, *Ratna*, *Jaya*, *Mancharsali*, *Jaya*, *Sona*, *Manoharsali*, *Kalinga*, *Vani*, *Jayanthi*, *Jagnath*, *Mahsuri*, *Negheri Bao*, *Changri Bao*, *Senga Bao*, *Giwai Bao*, *Tulasi Bao*; *Oryza rufipogon*; *Maize* (*Zea mays*); Wheat (*Triticum aestivum*).

Millets: *Eleusine coracana*, *E. indica;* Foxtail millet (*Setaria italica*). Legumes: Pigeon pea (*Cajanus cajan*), Chickpea : *Cicer arietinum*, Lentil : *Lens culinaris; Vigna clarkei*, Black gram (*Vigna mungo*), Rice bean (*Vigna umbellata*); Asparagus bean: *Vigna unguiculata* subsp. *sesquipedalis* Cowpea: *V. vexillata;* Rice bean*: Vigna umbellata*, Vigna WR*: Vigna trilobata*.

Fruits : Citrus relatives: *Citrus assamensis*, *C. limon*, Pumello (*C. maxima*); Coconut (*Cocos nucifera*), Mango (*Mangifera indica*), *M.*

sylvatica; Banana: *Musa acuminata*, *M. assamica*, *M. cheesmanii*, *M. mannii*, *M. paradisiaca*, *M. sapientum*, *M. velutina; Prunus cornuta*, *P. Jenkinsii*. Vegetables**:** Luffa: *Luffa aegyptiaca*, (*syn. L. cylindrica*), *L. graveolens*; Cucumber (*Cucumis sativus*), *C. hystrix;* Winter squash: *Cucurbita maxima*, Crook necked squash*: C. moschata*, Pumpkin, (*Cucurbita pepo*)*;* Bitter gourd (*Momordica charantia*) *M. macrophylla*; Sweet gourd: *Momordica cochinchinensis*, Brinjal: *Solanum melongena*, *S. incanum*, *S. kurzii*, *S. nigrum;* Snake gourd: *Trichosanthes cucumeriana* var. *anguina;* Pointed gourd*: Trichosanthes dioica*, *T. cordata*.

Tubers: Elephant-foot yam*: Amorphophallus bulbifer* var. *bulbifer*, *A. bulbifer* var. *tuberculiger;* Taro (*Colocasia esculenta*), *C. fallax*, *C. mannii ;* Yam (*Dioscorea alata*), *D. bulbifera*, *D. decipiens*, *D. hamiltonii*, *D. hispida*, *D. pentaphylla* var. *kussok*, *D. puber*, *D. prazeri*, *D. trinervia*, *D. wattii ;* Yam bean *: Pachyrhizus erosus.*

Spices*:* Galangal*: Alpinia malaccensis;* Betel nut: *Areca catechu*, *A. triandra;* Bengal cardamom (*Ammomum aromaticum*)*;* Turmeric: *Curcuma longa*, *C. amada*, *C. aromatica;* Cinnamon: (*Cinnamomum tamala*), *Cinnamomum bejholgota*, *C. paniculatum*, *C. pauciflorum;* Lemon grass*: Cymbopogon jawarancusa* var. *assamensis;* Spirit weed: Jungali–memedo (*Eryngium foetidum*)*;* Pepper*: Piper nigrum*, *P. peepuloides;* Ginger (*Zingiber zerumbet*), *Z. capitatum;* Jerusalem Artichoke (*Helianthus tuberosus*)**.**

Oilseeds: Toria: *Brassica napus*, Mustard*: Brassica juncea;* Sesame : *Sesamum indicum*.

Beverages and narcotics: Wild coffee : *Psilanthus bengalensis*, *P. fragrans*; Wild tea: *Camellia kissi*, *C. sinensis* var. *assamica*; Areca nut (*Areca catechu*).

Fibres: Jute (*Corchorus capsularis*), *C. olitorius*; *Boehmeria macrophylla*, China grass (*Boehmeria nivea*)*;* Nepal hemp (*Maoutia puya*)*; Musa textiles.* Fodder: *Digitaria cruciata*, *Leersia hexandra*, *Lespedeza cuneata*, *Ficus auriculata*, *F. benghalensis*, *F. fistulosa*, *F. racemosa*, *F. variegata*, *Stylosanthes guianensis.* Sugarcane : (*Saccharum officinarum*), *S. longisetosum***,** *S. ravennae*, *S. rufipilum* **,** *S. wardii***,** *Erianthus filifolium***,** *Narenga fallax*, *Miscanthus nepalensis*, *M. nudipes*, *M. wardii*.

Other economic plants

Fruits: *Artocarpus heterophyllus*, *A. lakoocha*, *Baccaurea ramiflora*, *Drypetes assamica*, *Elaeocarpus floribundus*, *Ficus carica*, *F. pomifera*, *Holboellia latifolia*, *Garcinia hombroniana*, *G. pedunculata*, *G. sopsopia*, *G. stipulata*, *G. xanthochymus.*

Less known Vegetables: *Cissus repens*, *Cyclanthera pedata*, *Dendrocalamus hamiltonii*,

Medicinal plants: *Acorus calamus*, *Alpinia galanga*, *Aquillaria malaccensis*, *Canarium strictum*, *C. resiniferum*, *Costus speciosus*, *Gynocardia odorata*, *Mucuna pruriens*, *Solanum aculeatissimum*, *Strychnos nux-vomica*, *Zingiber zerumbet*.

Timber: Kadam (*Artocarpus chama*), Hollong (*Dipterocarpus macrocarpus*), *Mesua ferrea*, Chir pine (*Pinus roxburghii*), *Shorea assamica*, *Schima indica*, Hollock (*Terminalia myriocarpa*). Bamboos and canes: Makal (*Bambusa pallida*), *B. cacharensis*, Bijili (*Bambusa tulda*), Kakua (*Dendrocalamus hamiltonii*), Katabans (*Dendrocalamus strictus*), *Melocanna baccifera; Calamus flagellum*, *C. floribundus*, *C. latifolius*, *C. tenuis.* Ornamentals: Butterfly lily: *Hedychium spicatum*, *H. coronarium*, *H. radiatum*, *H. robustum*, *Jasminum attenuatum*, *J. azoricum*, *Michelia champaca*, *Phoenix rupicola*. Multipurpose species: *Phoenix dactylifera*, *Parkia timoriana*, *Zanthoxylum rhetsa*.

Endemic species: *Acacia diadenia*, *Bambusa cacharensis*, *Camellia sinensis* var. *assamica*, *Cinnamomum cacharensis*, *Citrus assamensis*, *Cymbopogon jwarancusa* var. *assamensis*, *Dendrobium auranticum*, *Dendrocalamus patellaris*, *Dioscorea pentaphylla* var. *kussok*, *Dipterocarpus mannii*, *Eulophia kamarupa*, *Euonymus assamicus*, *Gigantochloa macrostachya*, *Glycosmis singuliflora*, *Heriteria dubia*, *Ixora goalparensis*, *Euonymus assamicus*, *Magnolia caveana*, *M. gustavii*, *Michelia mannii*, *Musa assamica*, *M. velutina*, *Ormosia assamica*, *Pandanus assamensis*, *Phyllostachys assamica*, *Piper gullatlyi*, *P. jenkinsii*, *Saccharum wardii*.

Threatened Species: *Dendrobium auranticum*, *Magnolia gustavii*.

Associated culture and tribes

The area is predominantly inhabited by Indo- Mongoloids, Indo-Aryans and Austrics races. Bhutia and Bodos are the main tribes

associated with agriculture. Bodos represent one of the largest ethnic tribal groups in Bramhaputra valley and they cultivate rice and tea and undertake pig and poultry farming and rear silkworms. The traditional favourite drink of the Bodos is Zu Mai (Rice wine). Bodos weave their own clothes (*Dokhnas*) and shawls using their own silkworms and they are expert craftsman in bamboo products.

Technology and products

There is a rich genetic diversity of rice, jute, vegetable crops due to selection pressures caused by topography, tectonic interventions, land slips, heavy rainfall causing flooding and inundation. The intense cultivation of rice and jute and identification of elite species by farmers through selection have resulted in the development of high yielding cultivars. There are a large number of landraces and varieties in major crops, with a very wide spectrum of variability for different traits. For example, more than 5000 distinct accessions of rice have been recorded from this region generally referred as Assam rice collections. These collections include disease resistant landraces, flood tolerant or submergence tolerant rice varieties. The traditional varieties of rice have a very large spectrum of variability for different traits particularly for stem borer, tungro virus, drought resistance, deep water floating rice, waxy endosperm, scent, soft cooking rice, etc. These collections include landraces, referred as boiled rice or soft cooking rice (cooked at 60^0C water temperature), waxy endosperm type, submergence tolerant rice, etc. and they have been extensively used in crop improvement (Siddiq *et. al.*, 2006). The region has high variability in rice bean, particularly for early maturity. In the case of oilseeds, significant variability has been recorded for Indian mustard, particularly in the case of *Brassica napus*, where local landraces have contributed to the development of several varieties, such as M2, M3, M27, M18, and T TS-29 from a landrace from Nagaon, Assam (Kumar *et al.*, 2004). In the case of castor, the region is known for purple morphotype with all purple parts and the morphotype has trait for resistance to leaf miner.

The Brahmaputra valley is known for variability in tree cotton (*Gossypium arboreum* race *cernuum*), jute (*Corchorus capsularis*), and

mesta (*Hibiscus sabdariffa*) (Saha *et al.*, 2004). The region is known for variability in brinjal (*Solanum melongena*) for fruit shape, size and colour (Kalloo *et al.*, 2005). Similarly in Okra several variabile traits have been observed. Among fruits the region is known for variability in Jack fruit (Karihaloo *et al.*, 2005). In the case of spices such as ginger and turmeric, there are many local cultivars (Ravindran *et al.*, 2005).

7.5 Khasia-Jaintia-Garo Hills Agrobiodiversity Region

Location and extent

The Khasia-Jainitia-Garo hills fall within the state of Meghalaya and geographically the area lies 26°0' N to 26°10' N and 89°45' E to 92°45' E. The hill ranges are undulating in nature with an east-west orientation with Surma ravines and other small rivulets cutting across the state. The Meghalaya plateau is a table land and the altitude varies from 610 - 1950 m with its Shillong Peak (1950 m above MSL). The hotspot area includes all the seven districts of Meghalaya i.e. East Garo Hills, West Garo Hills, South Garo Hills, East Khasi Hills, West Khasi Hills, Jaintia Hills and Ri-Bhoi

Agroclimate

The soil is lateritic in origin and vary from sandy loam, red loam to clayey loam. The climate of the region is characterised by warm summers and cold winters. There is perceptible variation in rainfall within the region from south to north. The place with highest rainfall recorded in the world, Mawsynram (13,923 mm) is situated in the southern part. The annual rainfall varies from 2000–4000 mm exceeding the potential evapotranspiration throughout the year. Rainfall pattern varies from place to place and from altitude to altitude. The region experiences dry spell only during the post monsoon period. Therefore, the growing period extends up to 270 days. This variation in agroclimate helped the development of genetic diversity in crops.

Floristic diversity

The Khasia-Jaintia-Garo region is a part of Indo-Burma biodiversity hotspot, which has a wide variety of flora. The region is a centre

of endemic species and has a unique assemblage of economic and horticultural and ornamental plants where about 68 species bear the specific epithet "*khasiana*". The region is known for the representation of one and only endemic insectivorous pitcher plant of India known as *Nepenthes khasiana*. The vegetation represents floristic elements of peninsular India, Eastern Himalayan and Indo-Burma flora. Meghalaya has an array of vegetation ranging from tropical, subtropical to sub-temperate. The natural vegetation comprises of the following forest types: 1.Tropical evergreen and semi- evergreen forests with dominant species: *Castnopsis indica*, *Bischofia javanica*, *Tetrameles nudiflora*, *Elaeocarpus floribundus*, *Firmiana colorata*. 2. Tropical moist and dry deciduous forest with dominant species: *Albizia lebbeck*, *Shorea robusta*, *Toona ciliata*. 3. Subtropical pine forest: *Pinus kesiya*, *Schima wallichii*, *Lyonia ovalifolia*. 4. Temperate forest: *Lithocarpus fenestratus*, *Quercus griffithii*, *Schima khasiana*, *Betula alnoides*, *Pinus kesiya*. 5. Bamboo forest: *Bambusa khasiana*, *B. jaintiana*, *Bambusa pallida*, *Bambusa tulda*, *Melocanna baccifera*, *Dendrocalamus hamiltonii*.

Agriculture and agrobiodiversity

Meghalaya is basically an agricultural state with about 80% of its total population depending on agriculture for their livelihood. The most common crop is rice, which is grown in the valleys and on hills in terraces. The traditional farming system is the *Jhum* cultivation, practised by a large majority of subsistence farmers. With the introduction of high yielding varieties in different crops during the mid-seventies, remarkable increase in food grain production has been achieved, which however is at the cost of local traditional varieties. Considering the multi-cropping system being followed for increased productivity; some of the paddy varieties, such as Masuri, Pankaj, and other improved varietal series, contribute significantly to the increased productivity. The rice cultivation is alternated with cotton, vegetable and fruit crops in this region.

Besides the major food crops of rice and maize, this region is also known for its horticultural crops like orange, lemon, pineapple, guava, litchi, banana, Jack fruit and temperate fruits, such as plum, pear, peach, etc. Some of the important cash crops of the state are

potato, ginger, turmeric, black pepper, arecanut, tezpatta, betelvine, short-staple cotton, jute, mesta, rapseed, mustard, etc. The State has also achieved significamt success in the cultivation of non-traditional crops like tea, cashewnut, oilseeds, tomato, mushroom, wheat, etc.

Crops and wild relatives

Cereals: Oryza sativa: rice varieties: Konorolu, Jaya, Ngoba, Rylie white, Manocharsali, Mirikrek, Sarngma; Maize (Zea mays). Millets and pseudocereals: Amaranth (*Amaranthus hypocondriacus*), *Coix lacryma-jobi* var. mayuen (soft-shelled forms), *Setaria pallide-fusca*. Legumes: Pigeon pea WR (*Cajanus cajanifolius*), Rice bean (*Vigna umbellata*), *Vigna clarkei*.

Vegetables: Amaranth: *Amaranthus cruentus*, *A. gangeticus*, *A. viridis*; Cucumber WR: (*Cucumis sativus*) *C. hystrix; Luffa graveolens;* Bitter gourd: (*Momordica charantia*), *M. macrophylla*, *M. subangulata;* Banana*: Musa assamica*, *M. cheesmanii*, *M. flaviflora*, *M. superba*, *M. velutina;* WR Snake gourd: *Trichosanthes cucumeriana* var. *anguina*, *T. cucumeriana* var. *cucumeriana*, *T. dioica*, *T. majuscula*, *T. ovigera*, *T tricuspidata*, *T. wallichiana*.

Fruits**:** Pineapple: *Ananas comosus*; Citrus: *Citrus assamenis*, *C. aurantifolia*, *Citrus limon*, Karna orange *C. karna*, Sweet lime*: C. limettoides*, *C. indica*, *C. latipes*, *C. medica*, *C. macroptera*, *C. reticulata;* Litchi (*Litchi chinensis*)*;* Mango: WR (*Mangifera indica*), *M. khasiana*, *M. sylvatica*. Pear allies*:* Khasi Pear *(Pyrus khasiana*, *P. pashia*, *P. pyrifolia);* Guava*: Psidium guajava;* Prunus*: Prunus napaulensis*, *P. jenkinsii*, P. *arborea*, *P. cornuta*. Tubers: *Colocasia affinis*, *C. fallax;* Yam*: Dioscorea pentaphylla* var. *hortorum*, *D. prazeri*, *D. trinervia; Flemingia procumbens;* Potato*: Solanum tuberosum;* Kudzu vine*: Pueraria tuberosa*, *P. montana* var. *thomsonii*.

Spices: Galangal: *Alpinia malaccensis;* Betel nut*: Areca catechu; Tamala*: *Cinnamomum bejolghota*, C. *pauciflorum*, *C. caudatum*, *C. tamala, C. yabunikkei;* Turmeric: *Curcuma longa*, C.*amada*, *C. aromatica*; Lemon grass: *Cymbopogon khasiana*, *C. martinii*; Pepper: *Piper nigrum*, P. *attenuatum*, *Piper khasianum*, *P. cornilimbum*, *P. parvilimbus*, *P. oldhamiii P. peepuloides*, *P. schmidtii*; *Trachyspermum khasianum;* Perilla: *Perilla frutescens;* Ginger**:** *Zingiber officinale*, *Z. zerumbet*. Beverages*:* Tea*: Camellia caudata*, *C. sinensis;* Khasia wild coffee: *Psilanthus khasianus*, *P. jenkinsii*, *P fragrans.*

Other economic plants

Less known vegetables**:** *Cissus repens*, *Clerodendron viscosum*, *Corylopsis himlayana; Cyclanthera pedata;* Bans kaban (*Dendrocalmus hamiltonii*).

Fruits: wild edible fruits: *Aporusa roxburghii*, *Benthamidia capitata*, Khasia black currant (*Antidesma khasianum*), *Ardisia floribuda*, *Clausena excavata*, Khachur (*Cornus macrophylla*), *Diospyros lanceafolia*, D. *nigrescens***,** *Docynia indica*, *Docynia hookeriana*, *Elaeagnus pyriformis*, *Elaeocarpus lanceafolius*, *E. floribundus; Eriobotrya angustissima; Ficus drupacea*, *F. pomifera; Garcinia. atroviridis*, *G. pedunculata*, *G. sopsopia G. stipulata;G. xanthochymus; Myrica esculenta*, *M. integrifolia*, *M. rubra; Phoenix rupicola*.

Medicinal plants: *Acorus calamus***,** *Bupleurum khasianum*, *Costus speciosus***,** *Eryngium foetidum*, *Gynocardia odorata*, *Panax pseudoginseng*, *Plumbago zeylanica*, *Solanum aculeatissimum Zanthoxylum armatum*.

Fibres: Jute WR: *Corchorus capsularis*, *Boehmeria macrophylla*, *Trema orientalis.*

Fodder *: Ficus auriculata*, *F. fistulosa*, *F. racemosa*, *Ischaemum hubbardii*, *Panicum auritum*, *P. maximun*, *P. sanguinale.*

Bamboos: *Bambusa jaintiana*, *B. khasiana*, *B. polymorpha*, *B. pseudopallida*, *Dendrocalamus hamiltonii*, *Drepanostachyum khasianum*, *Melocanna baccifera*.

Ornamentals: *Chrysanthemum coronopifolium*, *Hedychium aurantiacum*, *H. hookeri*, *H. burtii*, *H. calcaratum*, *H. ellipticum*, *H. elwesii*, *Michelia champaca*, *Nymphaea alba* var. *rubra*, *N. candida*, *N. micrantha*, *Paphiopedilum insigne*, *P. hirsutissimum*, *P. venustum*, *Rosa x odorata* nothovar. *gigantea*, *R. longicuspis.*

Multipurpose species**:** *Alnus nepalenis*, *Elaeocarpus floribundus*, *Zanthoxylum rhetsa;* Bamboos: *Bambusa jaintiana*, *B. pseudopallida*, *B. tulda*, *Dendrocalamus hamiltonii*, *Drepanostachyum khasianum*, *Melocalamus gracilis*, *Melocalamus indicus*, *Phyllostachys mannii*, *Neomicrocalamus clarkei*, *Pseudotenanthera albociliata*, *Schizostachyum dullooa*, *S. grifithii*.

Endemic species: *Bambusa pseudopallida*, *Baliospermum micranthum*, *Bupleurum khasianum*, *Chrysanthemum coronipifolium*, *Coix lachryml jobi*

var. *mayuen*, *Cinnamomum pedumculatum* var. *angustifolium*, *Corybas purpureus*, *Dalbergia millettii* var. *oldhami*, *D. rimosa* var. *griffithii*, *D. volubilis* var. *assamica*, *Eriobotrya angustissima*, *Euonymus lawsonii*, *Goodyera recurva*, *Ilex embelioides*, *Hedychium aurancticum*, *H. ellipticum* var. *asraoi*, *H. urophyllum*, *Ilex embelioides*, *Impatiens depauperata*, *I. khasiana*, *I. striolata*, *Indigofera bracteata* var. *khasiana*, *Jasminum adnophyllum*, *Jejosephia pusilla*, *Liparis assamica*, *Mahonia simonsii*, *Micromeles meghalayensis*, *M. polycarpa*, *Pennilabium proboscideum*, *Peristrophe acuminata* var. *khasiana*, *Phlogacanthus wallichi*, *Polyalthia meghalayensis*, *Pyrenaria khasiana*, *Selenium striatum*, *Sterculia khasiana*, *Thrixspermum muscaeflorum*, *Trichosanthes majuscule*, *Viburnum simonsii*.

Threatened species: *Citrus latipes*, *Hedychium dekianum*, *Ixonanthus khasiana*, *Mangifera khasiana*, *Nepenthes khasiana*, *Sterculia khasiana*.

Associated culture and tribes

The region is predominantly inhabited by Khasia and Garo tribes of Indo-Mongoloid origin and Austrics races. The dominant tribes associated with agriculture are Khasi, Garo, Jaintia, and Hajong. The Khasi tribes practice jhoom cultivation and they cultivate betel vine and arecanut in the lower slopes. Rice is the staple food of Khasis and they traditionally offer betel nut to the guests as a symbol of welcome.

Technology and products

The rich genetic diversity of rice in different ecological niches includes, resistance to stem borer, Tungro virus, Gall midge, and drought tolerance, waxy endosperm rice landraces (Siddiq *et al.*, 2006).

The region is known for variability in Indian mustard especially for higher number of seeds per pod. The region is also known for the occurrence of wild relative of sugarcane, i.e. *Saccharum arundinaceum* which has thick stem, broad leaves with resistance to insect pests, high tillering, high yield and low nutritional requirement (Sreenivasan *et al.*, 2004). There is rich genetic diversity in brinjal (*Solanum melongena*) for fruit and plant characteristics. In chilli, a genotype having highest pungency is reported from the region (Kalloo *et al.*, 2005). In *Citrus*

rich genetic diversity is seen in *Citrus indica*, *C. macroptera*, *C. latipes*, etc. (Karihaloo *et al.*, 2005). Pepper (*Piper nigrum*) has high variability, second only to Malabar agrobiodiveristy region. Significant levels of variability have also been recorded in ginger and turmeric. Studies by Dao *et al.,* 1999 have identified disease resistance and borer resistance traits in the wild species *Solanum incana* which has been used as a donor for the transfer of trait to the cultivated species *Solanum melongena*.

There are prestine sacred groves in Mawphlong facilitating and supporting conservation of biodiversity including components of agrobiodiversity. Meghalaya has developed indigenous system of channelizing mountain streams and spring water by using bamboo pipes for irrigating plantations. Appropriate manipulation and positioning of bamboo pipes would control the even flow of water.

7.6 North Eastern Hills Agrobiodiversity Region

Location and extent

The Northeastern hills agrobiodiversity region includes the states of Manipur, Mizoram, Nagaland and Tripura and the adjoining districts of Cachar and North Cachar of Assam. The hotspot area includes all the districts of Manipur, Mizoram, Nagaland, Tripura and the adjoining Cachar and North Cachar districts of Assam.

The Nagaland state is situated in northeastern part of India and extends between 25°05' N and 27°10' N latitude and 93°28' E and 95°05' E longitude. The mountains of Nagaland are in parallel folds running from north to south. Saramati Peak (alt. 3841 m above MSL) is the highest peak in Nagaland. The region has eight districts, i.e. Kohima, Dimapur, Phek, Mokokchung, Mon, Tuensang, Wokha, and Zunheboto.

Manipur state is situated in the northeastern part of India adjacent to and south of Nagaland and extends between 23°50' N and 25°41' N latitude and 92°59' E to 94°47' E longitude. The State has hilly terrain ranging from 850 - 3000 m, and folds of mountains run north to south. They are the continuation of the Patkoi and Naga

hills. There are nine districts: Imphal (East), Imphal (West), Bisnupur, Thoubal, Senapati, Ukhrul, Tamenglong, Ukhrul, and Chandel.

Mizoram State is located between 21°58' N and 24°35' N latitude and 92°16'E and 93°29'E longitude and has international borders on the east and south with Myanmar and on the west with Bangladesh. The mountain ranges run parallel from north to south and the main mountain range is the Blue mountains (Phawngpur, 2165 m above MSL). There are eight districts: Aizwal, Lunglei, Champhal, Kolasib, Lawngtlai, Marnit, Chhimtuipui, and Serchhip.

Tripura State is situated in the eastern part of India bordering Bangladesh on three sides and on the eastern side bordering with Mizoram and Assam. It is located between 22°56' N and 24°32' N latitude and 91°10' E and 92°21' E longitude. The state is divided in to four districts: North Tripura, West Tripura, South Tripura, and Dhalai.

Agroclimate

The climate of the North eastern region is characterised by the warm summers and cold winters. The mean annual precipitation varies from 1600-2600 mm, which exceeds potential evapotranspiration for most of the year. The length of the growing season with availability of moisture exceeds to 270 days. The water deficit for a short period occurs during post-rainy season causing seasonal dry spell. The major soil of the region includes shallow to vary deep, loamy, red and lateritic and red yellow soils. They are highly acidic and have moderate bases.

Floristic diversity

The North eastern hill areas are a part of Indo-Burma biodiversity hotspot which has a wide variety of ecosystems. The natural vegetation comprises mainly evergreen and tropical moist deciduous forests. The forest types are as follows: 1. Tropical evergreen and semi-evergreen forests with dominant species: *Castnopsis indica*, *Bischofia javanica*, *Terminalia citrina*, *T. arjuna*, *Artocarpus heterophyllus*, *A. chama*, *Elaeocarpus floribundus*, *E. rugosus*, *Polyalthia cerasoides*, *Dipterocarpus turbinatus*, *D. macrocarpus*, *Amoora wallichii*. 2. Tropical moist and dry

deciduous forests with dominant species: *Albizia procera*, *Anthocephalus chinensis*, *Sterculia villosa*, *Tectona grandis*, *Shorea robusta*, *Artocarpus chama*. 3. Temperate forest: In temperate forests at lower elevations there are mixed forest of *Acer*, *Betula*, *Juglans*, *Magnolia*, *Quercus* and *Rhododendron*. The prominent species are: *Lithocarpus fenestratus*, *Quercus griffithii*, *Schima wallichii*, *Betula alnoides*, *Michelia doltsopa*, *Castnopsis hystrix*, *Pinus kesiya*. 4. Bamboo forest: *Bambusa tulda*, *B. pallida*, *Chimanobambusa khasiana*, *Melocanna baccifera*, *Dendrocalamus hamiltonii*. 5. Subalpine forest: The dominant tree species are: *Abies spectabilis*, *Picea excelsa*, *Cotoneaster spp.*, *Juniperus spp.*, *Rhododendron spp* and *Salix spp.* Some of the important species are *Aconitum elwesii*, *Berberis micropetala*, *B. manipurensis*, *B. wardii*, *B. sublevis*, *Rhododendron wattii* and *Spiraea callosa*.

Agriculture and agrobiodiversity

Agriculture is the main occupation of the region and is a main source of income. The traditional farming system is '*Jhum*' cultivation. In addition to *Jhum*, terrace cultivation is widely practised by the tribal communities. A typical *Jhum* system is a mixed cropping system where seeds of all the crops which require planting are mixed at the seed stage and broadcasted in the field during the first rainy days of the season (Ramakrishnan, 1992). The land is prepared after burning, levelling and furrowing the forest land. Maize and rice seeds are dribbled into the furrows at regular intervals. Tuber crops like aroids, ginger and tapioca, banana are planted or sown throughout the growing season. Castor (*Ricinus communis*) is planted along the hedges for rearing silkworms. The crops are routinely harvested at different seasons and they are replaced by other seasonal crops, namely, *Ipomoea batatas*, *Eleusine coracana*, *Dioscorea alata*, *Coix lachrynma-jobi* at regular intervals.

Some of the major crops are: rice, maize, millets, tobacco, oilseeds, potato, fibres, sugarcane, yams and arums. It is seen that farmers also cultivate different varieties of vegetables, which include carrots, chillies, onion, melon, spinach, cucumber, brinjal, tomato and mustard. All along the mountain slopes, split bamboos are being used as water carrying channels or pipes for irrigating the crops. This is a cost-

effective indigenous practice developed by the farmers for irrigation of field crops and plantation crops like coffee, tea and cardamom.

Crops and wild relatives

Cereals: Rice (*Oryza sativa*) with number of rice cultivars: *Bala*, *Cauvery*, *Padma*, *Ratna*, *Jaya*, *Vijaya*, *Sona*, *Yukara*, *Tanz moy*, *Lakokulak*, *White Naguvanu*, *Red Naguvanu*, *Annapurna*, *Mahsuri*, *Sakti*, *Norin*. Maize (*Zea mays*), Barley (*Hordeum vulgare*), Sorghum (*Sorghum bicolor*). Millets: Finger millet (*Eleusine coracana*), Foxtail millet (*Setaria italica*). *S. pallide-fusca*.

Pseudocereals: Chenopodium (*Chenopodium album*), Amaranth (*Amaranthus hypocondriacus*, *A. paniculatus*); *Coix lacryma-jobi* var. *mayuen* (soft-shelled forms).

Legumes: Pigeonpea (*Cajanus cajan*), Rice bean (*Vigna umbellata*), Kuduzu vine: *Pueraria edulis*, *P. montana* var. *thomsonii, P. tubersoa*, Rice bean (*Vigna umbellata*), *Vigna clarkei*.

Vegetables: Onion (*Allium cepa*); Musk melon: (*Cucumis melo*); *Cucumber* (*Cucumis sativus*), *C. hystrix;* Winter Squash*: Cucurbita maxima;* Pumpkin*: Cucurbita pepo;* Carrot (*Daucus carota*) Banana: *Ensete superbum*, *Musa assamica*, *M. itinerus*, *M. nagensium*, *M. paradisiaca*, *M. superba*, *M. velutina;* Sponge gourd*: Luffa aegyptiaca*, *L. graveolens;* Sweet gourd*: Momordica cochinchinensis;* Bitter gourd: *Momordica charantia*, *M. macrophylla*, *M. subangulata;* Spinach (*Spinacia oleracea*); Brinjal (*Solanum melongena*), *S. nigrum*, *S.spirale*, *S. kurzii*, *S. torvum;* Snake gourd*: Trichosanthes cucumeriana* var. *anguina*, *T. cordata*, *T. dioica*, *T. ovigera*, *T. tomentosa*, *T. wallichiana*.

Tubers*: Alocasia indica*, *A. macrorhizos*, *A. acuminata*, *A. cucullata;* Elephant -foot Yam: *Amorphophallus bulbifer* var. *bulbifer*, *A. bulbifer* var. *atro-viridi*, *A. bulbifer* var. *tuberculiger*; Taro (*Colocasia esculenta*), East Indian Arrow root (*Curcuma angustifolia*), *C. amada*, *C. aromatica;* Yam*: Dioscorea decipiens*, *D. bulbifera*, *D. esculenta*, D. *hamiltonii*, *D. hispida* *D. lepcharum*, *D. pentaphylla* var. *hortorum*, *D. pentaphylla, D. pubera*, *D. prazeri*, *D. trinervia*, *D. wattii;* Potato (*Solanum tuberosum*); Yam bean: *Pachyrhizus erosus.*

Fruits: Pineapple (*Ananas comosus*); *Citrus indica*, *C. latipes*, *C. jambhiri*, *C. karna*, *C. limettioides*, *C. macroptera*, *C. medica*, *C. megaloxycarpa;* C. *reticulata* Melon (*Cucumis melo*); Indian Crab apple (*Docynia indica*, *D. hookeriana*); Loquat WR: *Eriobotrya angustissima*, *E. benghalensis;* Mango (*Mangifera indica*), *M. sylvatica;* WR Date Palm: *Phoenix acaulis*, *P. rupicola*.

Spices: Galanga: *Alpinia galanga*, *A. calcarata*, *A. malaccensis*, Greater Cardamom: and *allies: Ammomum subulatum*, *A. aromaticum*, *A. corynostachyum*, *A. fulviceps;* Arecanut (*Areca catechu*), *Areca nagensis;* Cinnamon: *Cinnamomum cacharensis*, *C. paniculatum*, *C. pauciflorum C. tamala;* Turmeric allies: *Curcuma aeruginosa*, *C. amada*, *C. aromatica*, *C. brog*, *C. comosa*, *C. caesia*,*C. latifolia*, *C. sylvatica*, *C. zedoaria;* Chandramula: *Kaempferia galanga*, *Stahlianthus involucratus*; Pepper and allies: (*Piper nigrum*), *P. peepuloides*, *P. attenuatum*, *P parvilimbus*, *P. falconeri*, *P. makruense*, *P. meeboldii*, *P. muneyporensis*, *P. nagense*, *P. phalagense*, *P. sylvaticum;* Ginger allies: *Zingiber capitatum*, *Z. cernum*, *Z. chrysanthum*, *Z. intermedium*, *Z. rubens.*

Beverages and narcotics: Coffee (*Coffea arabica*), *Psilanthus jenkinsii*, *P. fragrans;* Tea (*Camellia sinensis*), *C. drupifera*, *C. irrawadiensis*, *C. taliensis*, *C. caudata;* Tobacco (*Nicotiana tabacum*) *N. excelsior*, *N. rustica*.

WR Sugarcane: *Erianthus filifolium*, *Miscanthus nepalensis*, *M. nudipes*, *M. taylorii*, *M. wardii*, *Saccharum fallax*, *S. longisetosum*, *S. procerum, S. ravennae, S. rufipilum*, *Sclerostachya fusca*.

Dyes: Indigo WR: *Indigofera dosua* var. *dosua*, *I. heterantha*.

Other economic plants

Vegetables: *Amaranthus caudatus*, *Alternanthera sessilis*, Bamboo shoots (*Bambusa tulda*); *Canavalia ensiformis; Chenopodium album; Clinogyne dichotma.* Less known vegetables: *Cissus repens*, *Diplazium esculentum*, *Polygonum alatum*, *P. hydropiper*, *Vitis repens.*

Fruits: Wild and less known fruits: Wild vine (*Ampelocissus barbata*); Jack fruit: *Artocarpus heterophyllus*, *A. lakoocha*, *A. chama*, *Baccaurea ramiflora; Castnopsis indica*, *Coriaria nepalensis*, Hazel nut (*Corylus ferox*); *Clausena anisata*, *C. excavata*, Khachur (*Cornus macrophylla*);

Dillenia aurea, *D. indica;* WR Persimmon: *Diospyros lanceafolia*, *D. nigrescens;* *Elaeagnus pyriformis*, *E. umbellata;* WR Rudraksh (*Elaeocarpus lanceafolius*), *E. prunifolius*, *E. varunua*), WR Loquat*: Eriobotrya angustissima; Figs.: Ficus auriculata;* Common fig*: Ficus carica*, *F. cunia*, *F. pomifera;* WR Mangosteen: *Garcinia atroviridis*, *G. cowa*, *G. pedunculata*, *G. sopsopia*, *G. stipulata*, *G. xanthochymus; Machilus edulis;*WR Kaiphal: *Myrica esculenta*, *M. nagii; Pegia nitida;* Himalayan bird cherry*: Prunus cornuta;* Wild Himalayan cherry*: Prunus cerasoides*, *P. jenkinsii;* WR Peach: *Prunus jenkinsii*, *P. napaulensis*, *P. rufa;* WR Pear*: Pyrus khasiana* China birne*: Pyrus pyrifolia*, *P wattii*, *Pyrularia edulis;* WR Black currant*: Ribes glaciale; Rosa x odorata* nothovar. *gigantea;* Himalayan Yellow Rapsberry*: Rubus ellipticus*, *R. lineatus;* *Salacia roxburghii*, *Saurauia cerea*, *S. punduana*, *S. roxburghii; Solanum kurzii*, *S. torvum*.

Medicinal plants: Bengal cardamom (*Amomum aromaticum*), Barberry (*Berberis feddii)*, *B. micropetala*, *Berberis wardii*; Costus (*Costus speciosus*); Tejpata (*Cinnamomum tamala*)*;* Curculigo (*Curculigo orchioides*); *Dichroa febrifuga*; *Embelia subcoriacea; Eryngium foetidum; Gynocardia odorata; Hodgsonia macrocarpa; Hydnocarpus kurzi; Mucuna bracteata; Morinda angustifolia; Panax pseudoginseng*,*; Piper brachystachyum*, *P. diffusum;* Long pepper (*Piper longum*)*; Prunus cerasoides; Rhus javanica; Smilax lanceaefolia; Solanum aculeatissimum, S. torvum; Strychnos nux-vomica;* Chireta: *Swertia paniculata*, *S. macrosperma;* Chebulic myrobalan (*Terminalia chebula*)*; Tinospora cordifolia*, *Trochosanthes cucumeriana* var. *anguina;Vitis quadrangularis*, *Zanthoxylum rhetsa*.

Fibres: Jute WR *Corchorus capsularis*, *C. pseudo-olitorius*, *Boehmeria macrophylla; Crotalaria meeboldii*, China grass: *Boehmeria nivea*, *B. platyphylla;* Nepal hemp: *Maoutia puya*.

Orchids: *Arachnis labrosa*, *Bulbophyllum guttulatum*, *Cymbidium elegans*, *Coelogyne corymbosa*, *Dendrobium chrysanthum*, *D. heterocarpum*, *D. longicornu*, *D. nobile*, *D. ochreatum*, *D wardianum*, *Paphiopedilum hirsutissimum*, *Pleione maculata*, *Pleione praecox*, Red Vanda (*Renanthera imschootiana*), *Rhynchostylis retusa*, Blue Vanda (*Vanda coerulea*).

Ornamentals: Dog wood (*Benthamidia capitata*), *Hedychium coronarium*, *H. gardenerianum*, *H. greenii* var. *urophyllum*, *H. speciosum*, *Ixora*

acuminata, *I. roxburghii*, *I. undulata*, *Jasminum attenuatum*, *J. azoricum*, *J. flexile*, *J. fructicans*, *J. lanceolarium*, *Livistona jenkinsiana*, Manipur Lily (*Lilium mackliniae*), Dancing girl (*Mantisia saltatoria*), *Michelia champaca*, *Pinanga gracilis*, *P. griffithii*, Rose: *Rosa odorata*, *Rosa longicuspis*, *Rosa macrophylla*, *Rosa sericea* subsp. *sericea*.

Bamboos: *Arundinaria clarkei*, *A. rollana*, *Bambusa balcooa*, *B. cacharensis*, *B. griffithiana*, *B. pallida*, *B. polymorpha*, *B. tulda*, *B. vulgaris*, *Dendrocalamus hamiltonii*, *D. strictus*, *Melocanna baccifera*, *Melocalamus gracilis*, *M. indicus*, *Phyllostachys mannii*, *Neomicrocalamus clarkei*, *Pseudotenanthera albociliata*, *Schizostachyum dullooa*, *Thyrsostachys oliveri*.

Timber: *Albizia lebbeck*, *Artocarpus chama*, *Alnus nepalensis*, *Castnopsis indicam*, *Cupressus torulosa*, *Cryptomeria japonica*, *Dipterocarpus retusus*, *Julgans regia*, *Pinus roxburghii*, *P. wallichiana*, *Shorea assamica*, *Swietenia macrophylla*, *Terminalia myriocarpa*, *Toona ciliata*, *Tsuga dumosa*.

Dye yielding plants: Roots of *Rumex nepalensis*, bark of *Mahonia nepalensis*, fruits of *Dichroa febrifuga*, leaves of *Symplocos glomerata*, species of *Indigofera dosua*, *I. heterantha*, *I. tinctoria*, fruits of *Bixa orellena*.

Multipurpose species: *Alnus nepalenis*, *Elaeocarpus floribundus*, *Ficus cunia*, *Grewia oppositifolia*, *Morus alba*, *Parkia timoriana Phoenix acaulis*, *Zanthoxylum rhetsa*.

Forage: *Desmodium heterocarpum*, *D. podocarpum*, *Ficus auriculata*, *F. benghalensis*, *F. glaberrima*, *F. hirta*, *F.hispida*, *F. racemosa*, Subabul (*Leucaena leaucocephala*), *Macroptilium atropurpureum*, *Stylosanthes guianensis.*

Endemic species: *Agrostis wardii*, *Albizia kalkora*, *Areca nagensis*, *Berberis feddii*, *B. micropetala*, *B. sublevis* var. *sublevis*, *B. wardii*, *Capparis cinerea*, *Carex asraoi*, *Cotoneaster nagensis*, *Crotalaria meeboldii Dalbergia wattii*, *Derris lushaiensis*, *Hedychium gratum*, *H. venustum*, *Impatiens cuspidifera*, *Lilium imacklineae*, *Mahonia feddii*, *M. magnifica*, *M. roxburghii*, *Piper aurorubrum*, *P. makruense*, *P. meeboldii*, *P. muneyporensis*, *Rhododendron elliottii*, *R. johnstoneanum*, *R. macabeanum*, *R. wattii*, *Rhynchosia meeboldii*, *Saussurea nagensis*, *Trichosanthes tomentosa*.

Threatend species: *Capparis cinerea*, *Dendrobium auranticum*, *Dioscorea deltaoidea*, *Elaeocarpus prunifolius*, *Euonymus assamicus*, *Gleditsia*

assamica, *Hedychium calcaratum*, *H. marginatum*, *Ilex khasiana*, *I. venulosa*, *Lilium macklineae*, *Magnolia gustavii*, *Mangifera khasiana*, *Paphiopedilum fairrieanum*, *P. spicerianum*, *P. villosum*, *Panax pseudoginseng*, *Renanthera imschootiana*, *Rhododendron elliottii*, *R. formosum*, *R. johnstoneanum*, *R. macabeanum*, *R. triflorum* var. *bauhiniflorum*, *R. wattii*, *Vanda coerulea*.

Associated culture and tribes

The area is predominantly inhabited by Indo-Mongloids. The tribes associated are Airnol, Anal, Angami, Mao, Any Mizo, and Gongte in Manipur, Kuki, Nagas and Kachan in Nagaland and Bhil, Chakma, Kuki, and Khasia in Tripura. The Angami tribal communities are conscious of ecology and they value land property. They till the rice fields intensely and irrigate the fields by diverting watercourses through channels into terraced rice fields. Rice water called *"zumho"* is a symbolic ritual during the ten days festival "Phousanyi" in the Angami month of *Kezei* i.e. falling in the month of February. Tribal communities maintain and conserve genetic diversity of wild and less known crop species in their *Baris* (land attached to their houses and huts), kitchen gardens and in their backyard fields. i.e. *Piper peepuloides*, *Moghania vestita*, *Vigna umbellata*, *Coix lacryma-jobi*, *Digitaria cruciata* var. *esculenta*. Tribal communities cultivate several species of *Alocasia*, *Amorphophallus*, *Colocasia*, and *Dioscorea* in their backyard home gardens. Another dimension for assuring food security is the "Swidden farming" adopted by the Angamis tribal community of Nagaland. This involves cultivation of 15-30 crop species in the same plot of land after Jhum forest clearing. This is also called "female farming system" as women folk of the village are involved in sowing, manuring, weeding, seed selection, harvesting and storage (Raju *et al.*, 2001).

Technology and products

The region is very rich in floristic diversity particularly orchids, which may be used to promote floriculture industry. Some of the prized orchids occurring in this region are Red Vanda, Blue Vanda, Slipper orchids and Jewel orchids. The area is rich in genetic resources of spices and cucurbits.

The landraces of rice from the region have shown variability for short stature, gall midge resistance, waxy endosperm, etc. Latisail, a landrace collected from Tripura has genetic relationship with rice landraces from Indonesia, namely, Intan, Mas and Peta. It is considered that over 80 per cent of dwarf varieties of rice cultivated in Asia have genetic relationship with 'Latisail' germplasm, a land race from Tripura.

The region is also known for genetic diversity in oilseed crops. Significant variability has been recorded in Indian mustard and sesame. There are cold tolerant strains in the case of niger. The Northeast region is known as one of the primary centres of diversity for cucumber and snake gourd. The wild relatives of several species of cucurbits have also been reported from the region with significant genetic variability, such as *Cucumis hystrix*, *Luffa graveolens*, *Momordica cochinchinensis*, *Trichosanthes cucumeriana* var. *anguina*, *T. dioica*, *T. ovata*, *T. khasiana*, etc. (Sirohi *et al.*, 2005). Similarly, the region has rich diversity of solanaceous species with several wild relatives, such as *Solanum incanum*, *S. lasiocarpum*, *S. pubscence, S. surattense*, *S. torvum*, *S. indicum, S. Incanum, S. surattense, S. pubscence* (Kalloo *et al.*, 2005).

Among the fruits, the region is known for variability for special characteristics in mango, such as precocity, polyembryony and dwarfness. Similarly, the region is very rich in *Citrus* genetic resources with 17 species, 52 cultivars and 7 natural hybrids (Bhattacharya *et al.*, 1956). In a recent revision on the genus *Citrus* only 11 species (*Citrus aurantifolia*, *C. aurantium*, *C. indica*, *C. limon*, *C. maxima*, *C. medica*, *C. reticulata*, *C. sinensis*, *C. ichangensis*, *C. latipes*, *C. macroptera* var. *annamensis*) and 8 cultivated species of hybrid origin (*Citrus assamensis*, *C. karna*, *C. jambhiri*, *C. limetta*, *C. x madurensis*, *C. megaloxycarpa*, *C. nobilis*) have been recognised (Nair *et al.*, 1997). The Mandarin, (*C. reticulata*) is well represented in Khasi hills, whereas, Lemon (*C. lemon*) is known with large number of traditional cultivars such as Hill lemon, Assam lemon, Nepali oblong, etc. The tree *Alnus nepalensis* is planted along the margins of farms for increasing the soil fertility in lands which are under shifting cultivation.

The farmers have developed indigenous practice of channelising water through hollow bamboo poles for irrigating plantation crops

like coffee, tea and cardamom. In Nagaland, Zabo (impounded run-off water) irrigation system is practiced. The agrosystem combines agriculture, animal husbandry and forestry. The run-off water along slopes, is diverted through various terraces and finally the water gets discharged into the paddy fields situated at the foothills.

Cheo-ozihi is another indigenous system which would bring river water through long channels and this is being practiced in Kwigwma village. From the main channel, many branch channels divert the water to terraces through bamboo pipes. *Cheo* is the person responsible for laying channels and water budget is shared among the villagers.

7.7 Arid Western Agrobiodiversity Region

Location and extent

The Arid Western region is one of the twelve biogeographical provinces of India (Rodgers *et al.*, 1988) and one of the twenty one agroecological zones of India (Sahgal *et al.* 1992). The extreme climatic conditions, aridity, drought, shifting sand dunes, salinity ingress and desert storms are hostile for the survival of vegetation. Though the vegetation is scanty, the adaptative strategies of desert vegetation are unique especially in relation to moisture conservation. Physiographically, the Western Rajasthan desert is part of the eastern extension of Saharo-Thar desert and is covered with shifting sands with rock outcrops in the Barmer-Jaisalmer-Bikaner tract. The Aravalli ranges from Khetri in the northeast and Khed –Brahma in the south- west forms a distinct geographical boundary on the eastern side of the arid western plains. The hotspot area comprises of the following districts of Rajasthan: Sikar, Nagaur, Pali, Hanumangarh, Ganganagar, Jalore, Sirohi, Jodhpur, parts Jaisalmer and Bikaner, Udaipur, Dungarpur, Churu, and Jhunjhunun.

Agroclimate

The region has typical hot arid climate, characterised by hot summers and cool winters. The mean annual rainfall is less than 300 mm, which covers about 20 per cent of annual evapotranspiration. This results in large water deficit throughout the year reducing the growing period/ season to less than 90 days. The dominant landscape is represented

by gentle to very gentle slopes. The dominant soil profile is "Thar series" which is moderately calcareous and alkaline in reaction.

Floristic diversity

The region is not very rich in floristic diversity. However, there are a large number of plant species, which have developed adaptive strategies to face aridity. The Jodhpur-Bikaner arid region is the main component of the Thar Desert. The vegetation is dominatesd by stunted prickly shrubs and drought resistant perennial herbs. The trees are few and their distribution is scattered. The important trees are *Acacia senegal*, *A. jacquemontii*, *Prosopis cineraria*. The shrubs occurring in the sandy and gravelly areas are *Calligonium polygonoides*, *Calotropis procera*, *Capparis decidua*, *Clerodendron phlomidis*, *Maytenus emarginatus*. Some of the prominent herbaceous species are *Aerva javanica*, *Citrullus colocynthis*, *Farsetia hamiltonii*, *Indigofera argentea*. Some of the grass species which bind the sand dunes are *Cenchrus biflorus*, *Cymbopogon jawarancusa*, *Dactyloctenium aegypticum*, *D. scindicum*, *Lasiurus scindicus*, *Latipes senegalensis*, *Panicum antidotale*. The prominent species that grow in the saline areas are *Chenopodium album*, *Cressa cretica*, *Haloxylon salicornicum*, *Limeum indicum*, *Peganum harmala*, *Salsola baryosma*, *Suaeda fruticosa*, *Zygophyllum simplex*. The most characteristic lithophyte in the rocky Jaisalmer plateau, Barmer hills, Jalore hills, Jodhpur-Mandore plateau is *Euphorbia caducifolia*. The trees and shrubs growing in this area are *Acacia senegal*, *Anogeissus pendula*, *Capparis decidua*, *Commiphora wightii*, *Maytenus emarginatus.*

Agriculture and agrobiodiversity

The traditional agriculture is rain-fed dryland farming. The farmers grow drought resistant and short duration rainy season crops/varieties, such as pearl millet, sorghum, semi-arid legumes; while fodder crops are grown in non-saline areas. In the arid and semi-arid regions, pearl millet is grown along with *kharif* sorghum. In the arid regions of Jodhpur, *Kharif* crops are grown with the onset of rains during July (mean annual rainfall 380 mm) and the crops cultivated are pearl millet, green gram, cowpea, moth bean, guar, sesame. Some farmers prefer oilseed crops and pulses instead of pearl millet (Rathore *et al.*, 1991). The cropping systems and combination of crops usually adapted by

the farmers are as follows: pearl millet and cluster bean; mixed farming: pearl millet + moth bean, pearl millet + mung bean, cluster bean + sesame, castor + sesame, castor + moth bean, castor + sesame.

Crops and wild relatives

Cereals: Kharchia wheat: *Triticum aestivum* is drought and salinity tolerant; *Sorghum bicolour.* Millets*:* Ghant ghas (*Dactyloctenium scindicum*)*;* Raishan*: Digitaria cruciata;* Barnyard millet*: Echinochloa cruss-galli;* Sawank: *Echinochloa colonum;* Japanese barnyard millet*: Echinochoa frumentacea;* Finger millet*: Eleusine coracana*, *E. compressa*, *E. indica; Panicum miliare*, *P. psilopodium;* Pearl millet (*Pennisetum glaucum*); Foxtail millet: *Setaria italica*, *S. glauca*, *S. verticillata*.

Vegetables: Onion (*Allium cepa*), Lashun (*Allium sativum*); *Amaranthus caudatus*, *A. viridis*, *A. spinosus;* Chilli (*Capsicum annuum C. frutescens*); *Chenopodium album;* Water melon (*Citrullus lanatus*), Bitter Apple (*Citrullus colocynthis*), WR Cucumber: *Cucumis sativus*, *C. prophetrum;* Melon (*Cucumis melo* var. *agrestis*); Cluster bean/guar (*Cyamopsis tetragonolobus*), *Digera muricata*, Sponge gourd (*Luffa aegyptiaca*); Drumstick tree: *Moringa oleifera*, *M. concanensis*; Khejari, young pods (*Prosopis cineraria*); Sesame (*Sesamum indicum*); Cowpea (*Vigna unguiculata*), *Ziziphus nummularia*.

Fibre*:* Bikaneri nerma cotton variety: *Gossypium herbaceum; Agave americana*, *Crotalaria juncea*, *Hibiscus cannabinus*, *Linum usitatisimum*.

Dyes: Ratanjot: *Arnebia hispidissima; Cocculus hirsutus*, *Indigofera coerulea*, Harmal*: Peganum harmala*, *Wrightia tinctoria*.

Spices*:* Fennel (*Foeniculum vulgare*), *Commiphora wightii*.

Other economic species

Aloe barbadensis, *Azima tetracantha*, Lasoda (*Cordia myxa*), Khodhab (*Cadaba fruticosa*), Phok (*Calligonium polygonoides*), Ket (*Capparis decidua*, *Commiphora caudata*), *C. wightii*, Gum guaiacum (*Guaiacum officinale*), Kejeri (*Prosopis cineraria*), Mesquite (*P. juliflora*), Jojoba: *Simmondsia chinensis*, *Salvadora oleoides*, *Tecomella undulata*, *Withania coagulans*, *W. somnifera*.

Medicinal plants: *Abutilon indicum*, *Alhagi maurorum*, *Barleria prionitis*, *Boswellia serrata*, *Cassia auriculata*, *Calotropis procera*, *Citrullus colocynthis*,

Commiphora wightii, *Euphorbia caducifolia*, *Fagonia cretica*, *Pedalium murex*, *Peganum harmala*, *Phyllanthus fraternus*, *Psoralea corylifolia*, *Tephrosia purpurea*, *Tribulus terrestris*, *Ziziphus numularia*, *Zygophyllum simplex*.

Agroforestry species: *Acacia albida*, *A. nilotica*, *A. catechu*, *A. senegal*, *Albizia lebbeck*, *Prosopis cineraria*, *P. juliflora*, *Pithecellobium dulce.*

Fodder species:*Alhagi pseudalhagi*, *Crotalaria burhia*, *Cenchrus ciliaris*, *C. setigerus*, *Chrysopogon fulvus*, *Dichanthium annulatum*, *Dactylocytenium scindicum*, *Eleusine compressa*, *Lasiurus sindicus*, *Panicum antidotale*; *Pennisetum purpureum*, *Sorghum halepense.*

Life supporting species: *Balanites aegyptiaca, Calligonium polygonoides*, Kejeri (*Prosopis cineraria*), Mesquite (*P. juliflora*), *Tamarix aphylla*, *T. indica*.

Endemic species: *Abutilon bidentatum* var. *major*, *A. fruticosum* var. *chrysocarpa*, *Alysicarpus monilifer* var. *venosa*, *Barleria prionitis* subsp. *dicantha*, *Cenchrus rajasthanensis*, *Ceropegia odorata*, *Citrullus colocynthis*, *Cleome gynandra* var. *nana*, *Commiphora wightii*, *Cucumis prophetrum*, *Ipomoea cairica* var. *semineglabra*, *Pavonia arabica* var. *glutinosa*, *P. arabica*. var. *massuriensis*, *Salvadora persica*, *Tecomella undulata*, *Withania coagulans*, *Ziziphus truncata*, *Z. williamsii*.

Threatened species: *Abutilon bidentatum* var. *major*, *Abutilon fruticosum* var. *chrysocarpa*, *Anogeissus sericea* var. *nummularia*, *Cenchrus rajasthanensis*, *Commiphora wightii*, *Cucumis prophetrum*, *Indigofera coerulea* var. *monosperma*, *I. constricta*, *Tecomella undulata*, *Withania coagulans.*

Associated culture and tribes

The Arid western region is inhabited by Indo-Aryan and Dravidian races with dominant influence of the Indo-Aryan culture. There are many tribes, such as Bhil, Rabari, Minas, Garasias, Bhishinoi and Sahariyas. The Bhishnoi community is known for their dedication in conserving and protecting life supporting tree species especially *Khejari* tree (*Prosopis cineraria*). It is a well known ritual that among traditional families in Rajasthan eat Sama (*Echinochloa colonum*) during the day of fast usually on the "Ammavasi" day. This ritual has

helped the conservation of *Echinochloa colonum* as this has generated an institutionalized demand for Sama.

Technology and products

The region has evolved several practices for dryland farming. The extreme dry conditions and soil salinity have resulted in the evolution of genetic diversity in most crops for drought and salinity resistance. In pearl millet, extra-early (60 - 65 days) lines have been identified which are used globally (Gupta *et al.*, 2006). In bread wheat, the region is known for variability in spike maturity, spike density, tiller number, whereas in the case of durum wheat, there is rich variability for initial growth habit, spike emergence, plant height, grain yield, grain colour, etc. (Singh[3] *et al.*, 2006). For example, Kharchia local varieties of wheat are being used as source of salt tolerance and Hindi 62 for heat tolerance. They are extensively cultivated and used in breeding programme for drought and salinity tolerance. In barley, genetic variability landraces for adaptation to saline and alkaline conditions have been collected (Verma *et al.*, 2006). Pearl millet is one of the staple food of the region and has variability for shorter and narrow leaves, small or long spike and early maturity (Gupta *et al.*, 2006).

The region is known for variability in arid-legumes, such as cluster bean, moth bean, cowpea, horsegram, etc. In cluster bean, highest gum content (33.9%) and also highest and lowest protein contents (29.4 and 22.4%) have been recorded in collections from Rajasthan. In moth bean, the region provides useful variability for growth habit, branching pattern, leaf lobation, pod and seed colour, early maturity, grain yield and resistance to diseases. Varieties like PLM039, PLM055, and IC8551 have been developed by NBPGR, Regional Station, Jodhpur; variety Jadia Jwala has been developed from a local landrace from Bikaner (Dabas *et al.*, 2006). Variability for seed size, shape, colour and maturity period exists in pea, and variety RPG3 has been derived from a local landrace. The region is known for rich variability for number of seeds per pod in mung bean and for bold seededness in urd bean.

Among oilseeds, variability exists in mustard (*Brassica tournfortii*) and niger (*Guizotia abyssinica*). The variety Durgamani of *B. juncea* and

variety Karan Tara of Tara Mira (*Eruca sativa*) have been developed from local landraces of Ganganagar (Kumar *et al.*, 2004). Also, the region represents maximum variability in sesame and variety Pratap has been developed from a local landrace of Kota.

Among fibre crops, Bikaneri Nerma cotton, which is derived from American cotton (F414) and local Sanguineum desi cotton (G7) are nationally known and they are being used as source of drought tolerance and fibre quality.

The region represents a significant amount of genetic diversity for cucurbitaceous vegetables and fruits. The region is rich in diversity of water melon (*Citrullus lanatus*) and snap melon (*Cucumis melo* var. *momordica*) for drought hardiness and sweetness, better shelf life. In *Cucumis sativus*, specific variability has been recorded for small (tender) fruit size, drought tolerance and yield. Using this genetic trait, a number of varieties have been developed through selection from local landraces. i.e. varieties Durgapura Kesar and Durgapura Madhu in the case of water melon; varieties Akra Rajhans, Pusa Madhu in the case of musk melon; and varieties Pusa Do Mausmi in the case of *Momordica charantia* (Sirohi *et al.*, 2005).

Among fruit crops, the region is known for variability in Mandarin (*Citrus reticulata*) i.e. variety Kinnow mandarin; in Sweet orange (*Citrus sinensis*), there are good varieties as Mosumbi, Malta and Blood Red. In addition, the region is very rich in diversity for fruits well adapted to dry conditions. Some common species with important variability are cactus pear (*Opuntia ficus-indica*), ket (*Capparis decidua*), lasoda (*Cordia myxa*), which are eaten and used for preparations, like pickles etc. Indian *Jujube* (*Zizyphus Jujube*) is another important fruit with local cultivars, like Gola. Khejari (*Prosopis cineraria*), is a life supporting species in the desert having fruit diversity for traits like high cluster bearing, larger pod size and sweet taste etc. Phalsa (*Grewia subinaequalis*) is an ethnic arid fruit known for its local drinks and pomegranate (*Punica granatum*) having bigger fruit size and yield is widely popular through the varieties such as Jodhpur red, Jalore seedless (Vashishtha *et al.*, 2005).

There is rich genetic diversity in seed spices, such as coriander, cumin and fennel, and several varieties have been developed from

local landraces/cultivars. Some of the varieties developed from the local landraces are: in coriander, Rcr41, Rcr435, Rcr436 through recurrent selection; Rcr 684 through mutation in Rcr20; in cumin, variety RZ19 through recurrent selection in UC-19; in fennel, variety RF101 through recurrent selection from a local germplasm; in fenugreek, variety RMt1 through pure line selection in Nagpur local and RMt 303 and through mutation in RMt 1 (Ravindran *et al.*, 2005).

There are several common practices followed in the region for sustainability of agriculture. Through planting of multipurpose tree khejari (*Prosopis cineraria*) productivity and environmental sustainability is being achieved. In mixed cropping, water melon (*Citrullus lanatus*) is cultivated along with pearl millet which ensures availability of diverse food crops. The tribal communities of the region follow an agro-pastoral life leading to shifiting habitations as per the availability of resources from the fragile landscape. The communities rear livestock responding to the vagaries of nature. Marwar teak (*Tecomella undulata*) is used for making carved furniture and the species is under threat because of over-exploitation. Bishnoi community from Jodhpur region is legendarily known for protecting the multipurpose species such as khejari which provides food, fuel and shelter to the community.

7.8 Malwa Plateau and Central Highlands Agrobiodiversity Region

Location and extent

The Malwa plateau and central highlands bordering the semi-arid zone of eastern Rajasthan on the western side, the fertile Indo-gangetic plains on the northern side, Maikala range on the eastern side and Satpura hills on the southern side is a contiguous agrobiodiversity region. The Malwa plateau,Vindhyan ranges of the Central Highlands form the northern part of the peninsular Indian plate.The Malwa plateau and central highlands agrobiodiversity region includes the Malwa plateau, central highlands, the Mewar plateau and semi-arid south-eastern Rajasthan. The hotspot area comprises the following districts of Shadol; Raisen, Bhopal, Sehore, Shajapur,

Indore, Ujjain, Mandasaur, Rajgarh, Hoshangabad, Narsinghpur, Jabalpur, Mandla, Umaria and the districts of Mewar plateau in south eastern Rajasthan.

Agroclimate

The agroclimate of the area is characterised by hot summer and mild winters. The region receives a mean annual rainfall of 1000 - 1500 mm of which 60-70 per cent is received from June to September in most of the years. The annual rainfall covers about 80 per cent of the mean annual potential evopo- transpiration. Generally, the post-rainy season remains dry. The distinct dry period is from March to June. The growing period as per the availability of the moisture varies from 150 - 180 days in a year. The landscape of the region is represented by gentle to moderate slopes. The soil is calcareous, slightly alkaline and has shrinking properties on wetting and expansion properties on drying. The region consists mostly of red soil, black soil and clayey soil.

Floristic diversity

This region is rich in floristic diversity especially in the species assemblages of tropical moist deciduous and tropial dry deciduous forests. The area comprises Malwa Plateau, Central Highlands of Madhya Pradesh. The natural vegetation is represented by tropical dry deciduous forests, which consists of dhak, teak, mahua, chiraungi, khardai, dhau, khair, and scrubs. The Malwa Plateau is dominated by *Adina cordifolia*, *Bauhinia racemosa*, *Dalbergia latifolia*, *Cassia auriculata*, *Holoptelea integrifolia*, *Lagerstroemia parviflora*, *Madhuca indica*, *Phyllanthus emblica*, *Terminalia arjuna*. The tropical wet deciduous forests have the following dominant species: *Buchnania lanzan*, *Careya arborea*, *Cassia fistula*, *Dalbergia paniculata*, *Dillenia pentagyna*, *Garuga pinnata*, *Haldinia cordifolia*, *Grewia tiliaefolia*, *Lagerstroemia parviflora*, *Pterocarpus marsupium*, *Terminala alata*, *T. bellerica*, *T chebula*, *Tectona grandis.* The tropical dry deciduous forest of Central Highlands has the following tree representation: *Azadirachta indica*, *Anogeissus latifolia*, *Butea monosperma*, *Boswella serrata*, *Cochlospermum religiosum*, *Cordia obliqua*, *Diospyros melanoxylon*, *Hardwickia binata*, *Lagerstroemia parviflora*, *Phyllanthus emblica*, *Shorea robusta*, *Soymidia febrifuga*, *Tectona*

grandis. The green revolution has brought more land under agriculture causing reduction of the forest area.

Agriculture and agrobiodiversity

The rainfed farming is the common agriculture practice in the region. During the rainy season, *kharif* crops such as sorghum and pigeonpea are cultivated. In *rabi* season, farmers commonly grow wheat and chickpea. The prosperous farmers even irrigate their wheat crops four times, while the marginal farmers undertake protective irrigation at the time of flowering. In the Malwa region, wherever rainfall is marginal, *kharif* sorghum is cultivated, while wheat and fodder grasses are also grown. The most important crops are rice, wheat, sorghum, maize, ground nut, soybean and grain legumes like peas, beans, lentils. The rice is grown in the eastern region where there is more rainfall, while wheat and sorghum are grown in the western region. In eastern Rajasthan, maize is grown as an exclusive crop in some areas and while in other areas small millets, pulses, ground nut, linseed and wheat (*rabi*) are cultivated. In the eastern Rajasthan and western Madhya Pradesh and Malwa region, sorghum is replaced by maize and barley. In the cotton growing belt of south western Madhya Pradesh (Khandwa and Jhabua), alternate crops such as sorghum, ground nut and small millets are also cultivated. The region also has traditional cultivation of soybean, an introduced crop. Other crops under cultivation include linseed, sesame, sugarcane, cotton, as well as minor millets. The region (near eastern Rajasthan and Marosona near Katwa) is the largest producer of opium. Other common *kharif* crops cultivated in the area are pearl millet, ground nut, pulses, etc. while common *rabi* crops are sorghum, safflower, sunflower, pigeon pea, etc. In some of the areas of Madhya Pradesh having black cotton soil, the land is left fallow during rainy season and wheat is grown after the rainy season. In non-irrigated areas especially northern districts, wheat plus barley and wheat plus gram are the combination crops. The cropping patterns as per soil profiles are: Vertisols and related black soil: Indore dry land region: Soybean wheat; soybean/sorghum/maize; Safflower/chickpea; Rewa dry land region: Rice-chickpea/lentil/wheat; Ground nut/sorghum-chickpea; Black gram-wheat; Green gram- safflower (Rathore *et al.*, 1991).

Crops and wild relatives

Cereals: Rice: *Oryza sativa*, *O. rufipogon*; rice varieties: *Anupama*, *Bala*, *Cauvery*, *Ratna*, *Kranti*, *Kalinga*, *Jaya*, *Vijaya*, *Pragati*, *Jagiriti*, *Mahsuri*, *Dubraj* (*scented variety*), *Kubrimohar;* Wheat (*Triticum aestivum*: wheat varieties: *Kalyansona*, *Sonalika*, *Sonora*, *Jayaraj*, *Sharbati*, *Shera*, *Meghadoot*, *Mukta*, *Narbada*. Maize (Zea mays), *Sorghum bicolor*, *S. cernuum* var. *yemense*, *S. deccanense*, *S. halepense*, *S. nitidum*.

Millets: *Echinochloa crus-galli*, Sanwa (*E. frumentacea*), Finger millet (*Eleusine coracana*), *E. indica*, Kodo millet (*Paspalum scrobiculatum*), Proso millet (*Panicum miliare*), Pearlmillet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*),

Vegetables: Okra & WR: *Abelmoschus esculentus*, *A. pungens*, *A. tetraphyllus*, *A. tuberculatus;* Amaranth: *Amaranthus hybridus*, *A. spinosus*, *A. tricolor*, *A. viridis;* *Chenopodium album;* Musk melon: *Cucumis melo* var. *culta;* WR melon: *C. prophetarum;* Musk melon: *Cucumis callosus*, *C. setosus;* WR Cucumber: *C. hardwickii;* Water melon: *Citrullus lanatus*, *C. colocynthis*, Melon (*Cucumis melo* var. *agrestis*); Cluster bean/guar (*Cyamopsis tetragonolobus*), *Digera muricata*, Hyacinth bean: *Lablab purpureus;* Sponge gourd (*Luffa aegyptiaca*); Drumstick: *Moringa oleifera*, *M. concanensis*, Khejari, young pods (*Prosopis cineraria*);

Legumes: *Alysicarpus monilifer*; Pigeon pea (*Cajanus cajan*), *C. cajanifolius*, *C. scarabaeoides*, *C. sericeus*, Chickpea (*Cicer arietinum*), Soybean (*Glycine max*); Horsegram (*Macrotyloma uniflorum*), *Macroptilium atropurpureum;* Garden pea (*Pisum sativum*); WR Fenugreek: *Trigonella balanse* ,*T. occulta;* Moth bean: *Vigna aconitifolia*, WR Vigna: *Vigna dalzelliana*, *V. hainiana;* Black gram (*Vigna mungo*), *V. mungo* var. *silvestris*, WR Green gram: *V. radiata* var. *sublobata*, *V. trilobata;* Cowpea (*Vigna unguiculata*).

Oilseeds**:** Ground nut (*Arachis hypogaea*); Linseed *Linum usitatissimum*, Mustard (*Brassica juncea*), Niger (*Guizotia abyssinica*), Safflower (*Carthamus tinctorius*, WR Safflower: *C. oxycantha*), Sesame (*Sesamum indicum*). Sugarcane**:** *Saccharum officinarum*, *S. spontaneum*. Spices: WR Kala zira (*Carum villosum*), Coriander (*Coriandrum sativum*), Cumin (*Cuminum cyminum*), Fennel (*Foeniculum vulgare*).

Other economic plants

Fruits: *Aegle marmelos*, *Buchnania lanzan*, *Carissa carandas*, *Cordia obliqua*, *Dillenia indica*, *Mangifera indica*, *Phoenix acaulis*, *P.sylvestris*, *Spondias pinnata*, *Syzygium cuminii*, *Tamarindus indica*, *Ziziphus maurtiana*, *Z nummularia*, *Z. rugosa*.

Pot herb: *Basella alba*, *Digera muricata*, *Talinum portulacifolium*, *Trigonella foenum-graceum*.

Gums, Resins & Tanins: *Acacia nilotica*, *A.senegal*, *A. mollis*, *Boswellia serrata*, *Cassia alata*, *C auriculata*, *C. didymobotrya*, *Commiphora wightii*, *Prosopis cineraria*, *P. juliflora*.

Fibres: *Agave americana*, Jute WR *Corchorus fascicularis*, *C. tridens*, Cotton, Tula (*Gossypium arboreum*), Levant cotton, cultivated (*Gossypium herbaceum*), *Hibiscus cannabinus*, *H. radiatus*, *H. sabdariffa*.

Dyes: *Acacia catechu*, *Butea monosperma*, *Indigofera tinctoria*,*Lawsonia inermis*, *Mallotus philippinensis*, *Nyctanthus arbortristis*, *Pterocarpus marsupium*,*Toona ciliata*,*Woodfordia fruticosa*,*Wrightia tinctoria*.Narcotics: *Papaver somniferum*.

Fodder: *Cenchrus ciliaris*, *C. setigerus*, *Chrysopogon fulvus*, *Ficus glomerta*, *F. hispida*, *F. racemosa*, *F. virens*, Subabul (*Leucaena leucocephala*), *Panicum maximum*, *P. miliaceum*, *P. paludosum*, *Peninisetum pedicellatum*, *Sesbania gandiflora*, *Stylosanthes humilis.*

Medicinal plants: *Alstonia scholaris*, *Acorus calamus*, *Balanites aegyptiaca*, *Baliospermum montanum*, *Celastrus paniculatus*, *Embelia tsjeriam-cottam*, *Helictres isora*, *Holarrhena pubescens*, *Plumbago zeylanica*, *Psoralea corylifolia*, *Strychnos nux-vomica*, *Terminalia arjuna*, *T. bellerica*, *T. chebula*, *Vitex negundo*, *Woodfordia fruticosa*.

Timber: *Anogeissus latifolia*,*A.pendula*, *Diospyros melanoxylon*, *Dalbergia latifolia*, *D. sissoo*, *Hardwickia binata*, *Pterocarpus marsupium*, *Shorea robusta*, *Tectona grandis*, *Terminalia elliptia*. Multipurpose tree species: *Acacia arabica*, *Acacia catechu*, *Acacia nilotica*, *Diospyros melanoxylon*, *Dendrocalamus strictus*, *Hardwickia binata*. *Madhuca longifolia*, *Pongamia pinnata*, *Schleichera oleosa*.

Endemic species

Albizia kalkora, *Andropogon pumilus*, *Dichanthium tuberculatum*, *Indigofera glandulosa* var. *sykesii*, *Iseilema hubbardii*, *Sorghum deccanense.*

Threatened species

Cajanus sericeus, *Carum villosum*, *Indigofera deccanensis*, *Nogra filicaulis.*

Associated culture and tribes

The associated tribes are Barda, Bhim, Bhumiya, Bhil Mina, Bavacha, Jat, Bangri, and Sahariya. The Meena community in Madhya Pradesh and Rajasthan are largely associated with agriculture and they belong to land owning class; while Sahariyas' have marginal agriculture income and they usually work in the forest areas for collecting non timber products, honey, edible gums, collection of katha, chronji and tapping of Salai tree.

Technology and products

The region experiences scarcity of water due to irregular rains. Recently, the development of irrigated agriculture and livestock farming have improved the economy of the area. Short spells of heavy downpour causing high levels of soil erosion, etc., has led to the development of traditional water harvesting, mostly in the form of small tanks and reservoirs. The irrigation facilities available in the region are as follows: (i) Reservoir, primary surface tanks and ponds, (ii) Inundation irrigation systems and (iii) *In situ* storage facility. In the eastern Madhya Pradesh area where there are heavy clay soil and good rainfall, ridge and furrow system is developed by the farmers for facilitating proper drainage. It is noted that the wild relative of Okra (*Abelmoschus tuberculatus*) has been used as a breeding material for transferring genes for higher yield in the cultivated species. (Pal *et al.*, 1952).

The region is known for the cultivation of durum wheat which has rich genetic diversity for spike emergence, plant height, awn length, spike: awn ratio, high grain weight, tiller number, grain yield, grain shrivelling, drought tolerance, good chapatti making dough and dahlia quality. In the region, there are two types of durum wheat, *Bansi*

with yellow awn and *Baxi* with black awn (Singh[3] *et al.*, 2006). In sorghum, the landrace Chardwadi bhilkhari (IS4261) from Sehore, is a source of shoot fly resistance. In finger millet, accession JNR852 has high leaf area, high dry matter and moderate to high photosynthetic efficiency.

The region is having a rich genepool of desirable traits in grain legumes, particularly in the case of indigenous crops, like pigeonpea, where a landrace ICP7035 maintained by the local communities has resistance against wilt and sterility mosaic virus (SMV) and has been globally used as a source of multiple resistance. Varieties ICP 7018 and ICP 7035 are sources of short maturity duration, whereas ICP 6997 is a source of resistance to SMV and varieties, Hunt (Australia) and Jagriti have high grain yield (Remanandan *et al.*, 1997). The landrace ICP 6393, which originated from this region, has the parentage of variety Prgati (ICPL 87). There is a rich diversity for seed size, shape, colour and maturity time in lentil and pea. Lentil varieties i.e. JL-3 and JLS1 (Jawahar lentil) and pea variety JP179 have been derived from local landraces of Madhya Pradesh (Singh[2] *et al.*, 2006). In cluster bean, the region offers variability for early maturity, determinate habit, diseases resistance, green and fodder yield. In mung bean, the region has variability for bold seededness, whereas in urad bean for plant morphotype.

There are number of varieties in oilseed crop Sesame i.e. N32, G35, G-5 which are developed from local landraces from Gwalior. Among vegetable crops, the region has recorded significant variability for *Solanum melongena* in fruit shape, size and colour. Similarly, high variability has been recorded in *Capsicum* for fruit colour; shape, size and pungency (Kalloo *et al.*, 2005). The region has traditional varieties in mango, such as Alphanso, Bombai, Langra, Sunderja. The native fruits Bael (*Aegle marmelos*) and Chironji (*Buchnania lanzen*) have large diversity for characters panicle length, fruit size and quality of kernel.

7.9 Kathiawar Agrobiodiversity Region

Location and extent

The Kathiawar region is adjacent to the Gulfs of Kachchh and Kambhaat and it includes the Kathiawar Peninsula and the semi- arid

districts falling under Abu hills in Rajasthan. The Kachchh region is a saline desert having sandy soil with high salinity and gravely limestones. The Rann of Kutch is mainly a dry saline bed during summer and winter months. However, during tidal sea intrusions, the Rann becomes marshy. The hotspot area includes the following districts of Gujarat: Ahemadabad, Surendranagar, Jamnagar, Rajkot, Porbandar, Junagadh, Amreli, Bhavnagar, Bharuch, Surat, Navsari, Valsad, Banaskantha, and Anand.

Agroclimate

The climate of the area is characterised by hot and dry summers and mild winters. The annual rainfall ranges from 600 – 900 mm. covering 40-50 per cent of annual potential evapotranspiration. The moisture availability i.e. growing period ranges from 90 - 150 days in a year. The landscape has a gentle slope and the soil consists of loamy to clayey and deep black soils. The soil is slightly alkaline, and calcareous, and shows typical swelling and shrinking properties.

Floristic diversity

The natural vegetation of the region comprises dry deciduous forests and scrub forests, while mangroves and halophytic vegetation occur along western coasts of Kachchh and Kathiawar peninsula. The dry deciduous forests seen in the Rajkot region of Kathiawar consists of *Anogeissus latifolia*, *Butea monosperma*, *Diospyros melanoxylon*, *Boswellia serrata*, *Terminalia crenulata*. The scrub forests in North Gujarat consists of *Acacia senegal*, *Acacia farnesiana*, *Dichrostachys cinerea*, *Commiphora wightii*, *Prosopis cineraria*, *Salvadora oleoides*. The important species of mangroves are *Avicennia marina*, *A. officinalis*, *Aegiceras corniculata*, *Bruguiera gymnorhiza*, *Ceriops tagal*, *Rhizophora conjugata*, *R. mucronata*. The halophytic vegetation consists of *Alhagi pseudalhagi*, *Atriplex stocksii*, *Cressa cretica*, *Haloxylon salicornum*, *Salsola barysoma*, *Sesuvium sesuvoides*, *Suaeda fruticosa*, *S. maritima*, *Salicornia brachiata*. The sand dunes near the coast are covered with *Ipomaea pes-caprae*, *Indigofera cordifolia*, *Spinifex littoreus*, *Limonum stocksii* and *Zygophyllum simplex*.

Agriculture and agrobiodiversity

The dryland farming is the common practice followed by the farmers in this region. Farming is the main occupation of the people and despite a rugged topography and unfavourable environment it is practised with ingenuity contributing to the economy of the state. Where there is low rainfall, pearl millet is being cultivated along with cotton, ground nut and pulses. During the rainy season, the crops cultivated are sorghum, pearl millet, ground nut and castor. While in non-saline areas, sorghum and pulses are grown. In dry areas, the cropping pattern is castor + pearl millet and castor + pearl millet + chickpea. However, the cropping pattern is dominated by cash crops like cotton and ground nut. Gujarat is one of the highest cotton and ground nut producing states of India. Other crops being cultivated are tobacco, cumin, sugarcane, sorghum, pearl millet, maize, rice, wheat, pulses like pigeonpea, chickpea, ground nut and horticultural crops like mango, jamun, banana, guava, isabgol, etc. The region is rich in medicinal plants and they are being used in the development of herbal ayurvedic medicines on the basis of indigenous knowledge.

Crops and wild relatives

Cereals: Barley (*Hordeum vulgare*); Rice (*Oryza sativa*) *O. nivara:* rice varieties: Sathi, Kada, Kolhapur scented, Zinya, Jirsal, Kamod, Pankhari; Wheat (*Triticum aestivum*, *T. durum*): wheat varieties: Kalyansona, Sonalika, Shera, Raj 911*; T. durum*; Sorghum (*Sorghum bicolor*), Maize (Zea mays). Millets: Pearl millet (*Pennisetum glaucum*), Cheena or Proso millet (*Panicum miliaeceum*), Foxtail millet (*Setaria italica*).

Legumes: Chickpea (*Cicer arietinum*), Pigeonpea (*Cajanus cajan*), Cluster bean (*Cyamopsis tetragonolobus*), Sweet pea (*Lathyrus odoratus*), Garden pea (*Pisum sativum*), Moth bean (*Vigna aconitifolia*), *V. khandalensis*, Black gram (*V. mungo*), Green gram (*V. radiata*), Cowpea (*V. unguiculata*).

Vegetables: Amaranth: *Amaranthus tricolour*, *A. viridis*, Mustard (*Brassica juncea*), *Chenopodium album*, Water melon: *Citrullus lanatus;* WR Bitter Apple*: Citrullus colocynthis; Ivy* gourd: (*Coccinia indica*, *syn. C. grandis*)*; Musk* melon*: Cucumis melo*, WR melon*: Cucumis prophetarum;* Bottle

gourd (*Lagenaria siceraria*), Bitter gourd (*Momordica charantia*), *M. balsamina*, *M. dioica; Moringa oleifera;* Brinjal*: Solanum melongena*, *S. nigrum*, *S. purpureilineatum*, Snake gourd*: Trichosanthes cucumeriana* var. *cucumeriana*, *T. dioica; WR* Fenugreek*: Trigonella foenum- graceum*, *T. glabra* subsp. *uncata, T. occulta*, .

Edible oilseeds: Ground nut (*Arachis hypogaea*), Mustard: *Brassica napus*, *B. tournefortii*, *Eruca sativa*, Niger: *Guizotia abyssinica*, Sesame (*Sesamum indicum*), *S. alatum*. Spices*: Anethum graveolens*, Cumin (*Cuminum cyminum*), Coriander (*Coriandrum sativum*), Fennel: (*Foeniculum vulgare*), Psyllium (*Plantago ovata*). Narcotics: Tobacco (*Nicotiana tabacum*). Sugarcane**:** *Saccharum officinarum*, *S. benghalense.*

Other economic plants

Fruits: Ket: (*Capparis decidua*), Orange (*Citrus sinensis*), Phalsa, (*Grewia asiatica*, *G. bicolor*, *G. flavescens*), Wood Apple (*Limonia acidissima*), Mango (*Mangifera indica*), *Phyllanthus emblica*, Guava (*Psidium guajava*), *Salvadora oleoides*, *S. persica*, *Jamun* (*Syzygium cuminii*), Ber: *Ziziphus mauritiana*, *Z. nummularia.*

Fibre: *Corchorus depressus*, *C. olitorius*, *Corchorus trilocularis*, C. *urticifolius*, Cotton, Tula (*Gossypium arboreum*), Levant cotton, cultivated (*Gossypium herbaceum*), American cotton, cultivated (*Gossypium hirsutum*).

Gum and resin yielding plants: *Acacia senegal*, *A. nilotica*, *Alhagi pseudalhagi*, *Boswellia serrata*, *Commiphora wightii*, *Garuga pinnata*, *Prosopis juliflora*, *Pterocarpus marsupium* var. *acuminatus*, *Sterculia urens.*

Dyes: Indigo WR *Indigofera tinctoria*, *I. coerulea v*ar. *monosperma*.

Fodder*: Aleuropius logopoides, Alhagi pseudalhagi*, *Alhagi maurorum*, *Atriplex stocksii*, *Cenchrus biflorus*, *C. ciliaris*, *Chloris villosa*, *Chrysopogon fulvus*, *Cynodon dactylon*, *Dichanthium annulatum*, *Dactyloctenium aegypticum*, *D. scindicum*, *Eleusine compressa*, *Eragrostis ciliaris*, *E. minor*, *Ficus benghalensis*, *F. racemosa*, *Heteropogon compressus*, *Indigofera oblongifolia*, *Leucaena leucocephala*, *Medicago sativa*, *Panicum psilopodium P. turgidum*, *Panicum antidotale*, *Peninisetum pedicellatum*, *Sorghum halepense.*

Timber*: Acacia chundra*, *A. nilotica* subsp. *indica*, *A. senegal*, *Albizzia lebbeck*, *Anogeissus latifolia*, *Dalbergia latifolia*, *D. sissoo*, *Pterocarpus marsupium*, *Shorea robusta*, *Terminalia arjuna*, *T. bellerica*.

Volatile oil: *Cymbopogon martinii*, *C. citratus*, *Vetiveria zizanoides.*

Multipurose species: *Azadirachta indica*, *Butea monosperma*, *Bambusa arundianacea*, *Diospyros melanoxylon*, *Madhuca indica*, *Phoenix sylvestris*, *Prosopis cineraria*, *Sesbania concolor*, *S. sesban*, *Schleichera oleosa*.

Life supporting species*: Balanites aegyptiaca*, *Prosopis cineraria*, *Salicornia brachiata*, *Suaeda nudiflora, Tamarix aphylla*, *T. kutchensis*

Endemic species: *Ceropegia odorata*, *Clitoria ternatea* var. *pilosula Cyperus dwarakensis*, *Dipcadi ursulae* var. *longiracemosa*, *Helichrysum cutchicum*, *Indigofera coerulea* var. *monosperma*, *Solanum purpureilineatum*, *Tamarix kutchensis*, *Tephrosia jamnagarensis*, *Viola cinerea* var. *stocksii* forma *kathiwarensis*, *Ziziphus williamsii*.

Threatened species: *Cajanus sericeus*, *Helichrysum cutchicum*.

Associated culture and tribes

The region is inhabitated by the Indo-Aryans and Sidhi tribal descendants. Some of the associated tribes are Barda, Bhil, Bavacha, Dhodoa, Gond, Koli, Paradhi, Vafhri, Kathodi, Siddis, Kolgha, Kotwalia, Padhar. The Kotwalias tribe of South Gujarat generally includes landless people who primarily depend on bamboo basket making for their livelihood.Their products include split bamboo mats (*Palas*), threshing trays (*Topla*), baskets (*Supra*) and Kathiawar wooden toys.The Dhodia tribes worship Goddess of food called Kanasari and they are predominantly farmers.

Technology and products

Farmers develop innovative soil moisture retention techniques. i.e. permanent set and furrow systems have been practised in Saurashtra where the land is dry and soil is light and having low rainfall. This system is useful for ground nut where the moisture is retained in the furrows; while ground nut crop is being cultivated on the slightly raised beds. Similar physical arrangements with characteristic

variations in different kinds of agroecological conditions provide low technology methods for the retention of soil moisture (Gupta, 1996).

The diverse agroclimate has generated good amount of genetic variability in major crops. In addition to bread wheat, the region is known for durum wheat. In the case of bread wheat, the region is known for variability in traits like leaf colour at fifth leaf stage, plant height, grain yield, tiller number, grain uniformity, grain shriveling, etc., whereas in the case of durum wheat for spike emergence, spike maturity, spike length, awn length, spike: awn ratio, spike density, tiller number, etc. (Singh[3] *et al.*, 2006). The pearl millet has rich diversity for useful and desired traits. i.e. landraces having long spike and early maturity. Sorghum landrace IS8315 from the region is a source of stem borer resistance, while Gotri (IS4825) from Baroda is a source for shoot fly resistance. The Kathiwar region has rich diverity in arid legume crops. There is a considerable variability in mothbean and several useful traits in the genepool of moth bean, namely, growth habit, branching pattern, leaf lobation, pod and seed colour, early maturity, grain yield and resistance to diseases are recorded: GHU Moth 1 (Baleshwar) is a selection from a local landrace (Dabas *et al.*, 2006).Variability has been recorded for mung bean for the number of seeds per pod. The region has good plant morphotypes in urad bean. Among oilseeds, rich variability has been observed in the Indian mustard (*Brassica juncea*).Varieties like Patan mustard is a selection from a landrace from Patan. Gujarat mustard is a selection from a landrace of Vedancha. Similarly, in *Brassica napus* var. *yellow sarson*, Patan sarson-2 is a selection from a landrace from Patan (Kumar *et al.*, 2004). For ground nut, the region is known for high variability and several varieties, such as Girnar, Somnath, J-11, MH1 (from Faizpur 1-5) and MH2 (from Gujarat dwarf mutant) and DSG1 (from Murdur local) have been developed through selection from local landraces (Bandyopadhyay *et al.*, 2004). Similarly, sesame, varieties, Parval, Murg 1 and Patan 64 have been selected from local landrace of Gujarat. In niger, the quality landraces Gujarat 1 and PCR317 are selections from local landraces.

Among horticultural crops especially in vegetables the region has recorded significant variability in chilli. In musk melon varieties have been developed through selection from local landraces, like Gujarat musk melon 1 and 2 from landraces from Sabarkantha and Nagpur respectively (Sirohi *et al.*, 2005).

The region is well known in having traditional varieties of mango, such as Alphanso, Kesar, Rajapuri, Vanraj. Besides, the region is very rich in arid fruits, such as Indian cherry (*Cordia myxa*), where a long fruited local cultivar Paras is well known. There is high variability in custard apple (*Annona squamosa*) i.e. Sel-9 having the highest fruit weight (154 g). The semi-arid fruits with rich variability are seen in Ber (*Zizyphus mauritiana*) and WR Phalsa *Grewia subinaequalis* (Vashishtha *et al.*, 2005).

Among spices, the region has rich diversity in turmeric, coriander, cumin, fennel and fenugreek. i.e., Turmeric var. Uganda is developed through clonal selection from local germplasm. In coriander, Guj Co1 is a selection from local germplasm, Guj Cor2 is a reselection from Co2; in cumin, MC43 is a selection from a local, Gujarat cumin 1, while selection Gujarat cumin 2, is a selection from UC-19; in fennel, PF-35 is local selection, whereas Gujarat Fennel 1 and 2 are pure line selections from local germplasm; in fenugreek, Gujarat Methi 1 is a pure line selection from J. Fenu 102 (Ravindran *et al.*, 2005).

7.10 Bundelkhand Agrobiodiversity Region

Location and extent

The Bundelkhand agrobiodiversity region includes Bhamder plateau and Kaimur hills. The Bundelkhand Gneiss rocks are one of the oldest rocks in India. The soil profile of the region shows the footprints of its geological history due to continental drift and the subduction of the peninsular Indian plate. The hotspot area includes the districts of Jhansi, Banda, Chitrakoot, Hamirpur, Jalaun and Lalitpur in UttarPradesh and Damoha, Datia, Panna, Sagar, Tikamagarh, Chattarpur, Rewa, Sidhi and Satna in Madhya Pradesh.

Carissa carandas- an important fruit genetic resource of India

Phoenix acaulis-a wild relative of Date Palm found in foot hills of Western & Eastern Himalayas and Peninsular India

Agroclimate

The Bundelkhand region is a hot semi-arid eco-region with 930 mm of annual rainfall from late June to September and it lies between the fertile Gangetic plains and the Central Highlands of Madhya Pradesh. The presence of ferruginous red soil, mixed red and black soil, medium black soil indicates the geological history. Usually, *Kharif* crops are grown on red soils and *rabi* crops are cultivated on black soils. Generally monocropping is practised, while double cropping is possible in black soil with facilities of irrigation. The major portion of the region especially in Bundelkhand region faces ecological degradation, loss of biodiversity due to soil erosion and deforestation. Soil erosion is the most common malady of the area. Whle water stagnation is a menace during rainy season.

Floristic diversity

The tropical dry deciduous forest of Central Highlands has the following tree representations: *Aegle marmelos*, *Anogeissus latifolia*, *Boswellia serrata*, *Butea monosperma*, *Cordia obliqua*, *Cochlospermum religiosum*, *Diospyros melanoxylon*, *Hardwickia binata*, *Pterocarpus marsupium*, *Lagerstoemia parviflora*, *Phyllanthus emblica*, *Pterocarpus marsupium*, *Soymidia febrifuga*, *Tectona grandis.* Some of the common shrubs are *Alangium salvifolium*, *Casearia elliptica*, *Capparis zeylancia*, *Flacourtia indica*, *Holarrhena antidysentrica*, *Kirganellia reticulata*, *Woodfordia floribunda*. The herbaceous species genetic resources value are*: Coccinia indica*, *Momordica dioica*, *Pueraria tuberosa*, *Ziziphus oenoplia*.

Agriculture and agrobiodiversity

Traditionally, the farming is rainfed. The area is mainly monocropped. However, double cropping is feasible in black soil. The crops grown are sorghum, pegionpea, ground nut during *kharif* season, green gram during normal monsoon period and early maturing varieties of sorghum, soybean and pearl millet during delayed monsoon season. Barley, gram, mustard and safflower are the suitable crops for *rabi* season. In black soil, following crops are cultivated: sorghum,

cowpea, black gram, green gram or fodder sorghum crop. The crop combination for semi -arid region is as follows: Cowpea /blackgram, Safflower/chickpea, Soybean –mustard / safflower. Watermelon, musk melon and vegetables are raised along dried river beds which is called "Zaid".

Crops and wild relatives

Cereals: Wheat (*Triticum aestivum*): wheat varieties: *Kalyansona*, *Sonalika*, *Sonora*, *Jayaraj*, *Sharbati*, *Shera*, *Meghadoot*, Maize (*Zea mays*); *Sorghum bicolor*, *S. cernuum* var. *yemense*, *S. halepense*, *S. nitidum*.

Millets: Barnyard millet (*Echinochloa crus-galli*), Sawa (*Echinochloa frumentacea*), Finger millet (*Eleusine coracana*), *E. indica*, Kodo millet (*Paspalum scrobiculatum*), Proso millet (*Panicum miliare*), Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*).

Vegetables: Okra WR: *Abelmoschus manihot* subsp. *tetraphyllus* var. *pungens*, *A. manihot* subsp. *tetraphyllus* var. *tetraphyllus*, *A. tuberculatus;* Amaranth: *Amaranthus hybridus*, *A. spinosus*, *A. tricolor*, *A. viridis*, *Chenopodium album*, Musk melon (*Cucumis melo* var. *melo*); WR melon: *Cucumis prophetarum;* Musk melon: *Cucumis callosus*, *C. setosus;* WR Cucumber: *Cucumis hardwickii;* Cucumber: *Cucumis sativus;* Squash crook-necked: *Cucurbita moschata;* Winter Squash: *Cucurbita maxima;* Pumpkin: *Cucurbita pepo; Water* melon (*Citrullus lanatus*), Bottle gourd (*Lagenaria siceraria*), Bitter gourd (*Momordica charantia*), *M. balsamina*, *M. dioica; Moringa oleifera*, *Trichosanthes dioica*, *Trigonella occulta*. Pot herb: *Digera muricata*.

Legumes: Pigeon pea: *Cajanus cajan*, C. *scarabaeoides*, C. *sericeus*, Ground nut (*Arachis hypogaea*), Chickpea (*Cicer arietinum*), Soybean (*Glycine max*), Sweet pea (*Lathyrus odoratus*), Garden pea (*Pisum sativum*), *Vigna aconitifolia*, Black gram (*Vigna mungo*), *V. radiata* var. *sublobata*, *V. trilobata*, Cowpea (*Vigna unguiculata*).

Oilseeds: Ground nut (*Arachis hypogaea*), Mustard (*Brassica rapa* subsp. *campestris*), Niger (*Guizotia abyssinica*), Linseed (*Linum usitatissimum*), Safflower (*Carthamus tinctorius*), Sesame (*Sesamum indicum*), *Sesamum laciniatum*. Sugarcane: *Saccharum officinarum*, *S. spontaneum*.

Other economic plants

Gums & resins: *Acacia nilotica*, *A. senegal*, *A. mollis*, *Boswellia serrata*, *Commiphora wightii*, *Prosopis cineraria*, *P. juliflora*. Dyes: Indigo WR *Indigofera deccanesis*, *I. tinctoria*.

Fodder: *Alysicarpus monilifer*, *Chrysopogon fulvus*, *Pennisetum pedicellatum*, Subabul (*Leucaena leucocephala*), *Sorghum halepense.*

Medicinal plants: *Alstonia scholaris*, *Acorus calamus*, *Balanites aegyptiaca Baliospermum montanum*, *Celastrus paniculatus*, *Embelia tsjeriam-cottam Helictres isora*, *Holarrhena antidysentrica*, *Plumbago zeylanica*, *Psoralea corylifolia*, *Strychnos nux-vomica*, *Terminalia arjuna*, *T. bellerica*, *T. chebula*, *Vitex negundo*, *Woodfordia fruticosa*. Multipurpose species: Dhak (*Butea monosperma*), Mahua (*Madhuca indica*), Chironji (*Buchnania lanzan*), *Imperata cylindrica*.

Timber: *Anogeissus latifolia*, *A. pendula*, *Diospyros melanoxylon*, *Dalbergia sissoo*, *Pterocarpus marsupium*, *Shorea robusta*, *Tectona grandis.*

Endemic species: There are no endemic species of agro-biodiversity importance.

Threatened species There are no threatened species in this region

Associated culture and tribes

The associated tribes are Gonds and Bhrias who depend on agriculture and they practise generally shifting cultivation.

Technology and products

The Bundelkhand region was densely forested until the beginning of 19th century. After the turn of the century, rising demands for food and fuel led to agricultural expansion. Post independence population growth and the emergence of green revolution brought even larger tracts of land under the plough and further increased wood-based energy needs. These factors, combined with poor land management and government approved commercial logging, have drastically reduced forested area in the region causing degradation of land and environment. Today, only small patches of dry scrub and thorn forests comprising mainly

of dhak, teak, mahua, chironji, khardai, dhau, khair are the only remnant forests existing in the region.

The region is rich in genetic diversity of grain legumes. Variability for seed size, shape, colour and maturity time in lentil has led to the development of varieties like K75 (Malika), which in turn has been derived from local landraces. Variability in seed size has resulted in the evolution of bold seeded varieties in Lentil. There are bold seeded types in mung bean and good morpho types in urad bean known in the region. Among oilseeds, the region has significant variability in castor which has dark red, white rose mahogany and sulphur white coloured capsule; there are also wide variations in seed colour and shape. The castor plants grow tall up to 3 m with large leaves having >50 cm diameter. Such types have been successfully used in rearing silk worm (Anjani *et al*, 2004). Variations have also been recorded in sesame; variety type 3 has been developed through selection from a landrace from Hamirpur.

In vegetables, the region is known for variability in solanaceous crops like *Solanum melongena*; landraces such as Bundelkhand Desi with tolerance to drought are known nationally (Kalloo *et al*., 2005). The region has rich diversity of Bael (*Aegle marmelos*) and has popular traditional varieties like Kagzi Etawah.

Since rainfall is irregular there is scarcity of water. This has led to the development of irrigated agriculture and livestock farming. However, there are also short spells of heavy downpour causing inundation leading to soil erosion, etc. In order to mitigate water shortage, traditional water harvesting is followed, mostly in the form of small reservoirs which would help the recharging of ground water resource. There are three types of traditional irrigation systems: i) reservoir, primary surface tanks and ponds; ii) inundation irrigation system; and iii) *in situ* storage facility.

7. 11 Upper Gangetic Plains Agrobiodiversity Region

Location and extent

The Upper Gangetic Plains agrobiodiversity hotspot falls between the Himalaya in the north and the hill plateau in the south and comprises the major portion of upper Uttar Pradesh and watered

and irrigated by the important river network of Yamuna, Ganga, Gomati and Sarayu with their tributaries extending from south of the Shiwalik Range. The hotspot area includes the districts of Hardoi, Sitapur, Barabanki, Lucknow, Unnao, Rae Bareilly, Kanpur, Kannuj of Central Uttar Pradesh and the districts of Maharajganj, Sidharatnagar, Kushinagar, Deoaria, Sant Kabir Nagar, Gorakhpur, Basti of Northeastern Uttar Pradesh.

Agroclimate

The region is characterised as hot sub-humid eco-region with alluvium-derived soil. The climate of the region is characterised by hot to warm summers and cool winters. It receives a mean annual rainfall of 1000 -1200 mm, of which 70 per cent is received during the summer monsoon season extending from July to September. The rainfall covers 70 per cent of the evapotranspiration and the availability of moisture extends from 150 to180 days which is the growing season of crops. The region has dry period from February to June. The soil profile of the region is generally deep loamy and alluvial. The dominant landscape of the northern plains is a gentle slope. The area adjacent to the foot hills of western Himalayas called *Tarai* zone is dominated by the landscape with moderate to gentle slopes. The soil is rich in organic matter and moisture availability is medium to high.

Floristic diversity

The major natural vegetation in the region is tropical dry deciduous forests occurring in patches. The dominant tree species in this region are: Khair (*Acacia catechu*), Bael (*Aegle marmelos*), Siris (*Albizia lebbeck*), Dhawa (*Anogeissus latifolia*), Palas (*Butea monosperma*), Amaltas (*Cassia fistula*), Sheesham (*Dalbergia sissoo*), Bargad (*Ficus benghalensis*), Peepul (*Ficus religiosa*), Haldu (*Haldinia cordifolia*), Jamun (*Syzygium cuminii*), Sal (*Shorea robusta*), Bahaera (*Terminalia bellerica*). The western part of the Gangetic plains has representative species such as *Balanites aegyptica*, *Boswellia serrata*, *Lannea coromandelica*, *Prosopis cineraria*, *Anogeissus pendula*. The gangetic plains is characterised by having tall grasses belonging to the genera *Cymbopogon*, *Phragmites*, *Saccharum* and *Vetiveria*. The important grass species are Kilikanal (*Arundo*

donax), (*Chrysopogon fulvus*), Jarakush (*Cymbopogon martini*), Kush (*Desmostachya bipinnata*), Bhalai (*Imperata cylindrica*), Narkul (*Phragmites karka*), Kans (*Saccharum spontaneum*, *S. narenga*), Khuskhus (*Vetiveria zizanoides*).

Agriculture and agrobiodiversity

The traditional farming practice comprises both rainfed and irrigated agriculture. The common crops grown in the area are rice, maize, and pigeon pea during the rainy (*kharif*) season and wheat, chickpea, rapeseed, mustard and vegetables during cold (*rabi*) season. Sugarcane is cultivated as a post *rabi* crop during the months of February-March in the Upper gangetic plains. The cropping patterns are chiefly sugarcane, vegetables, rice, potato and wheat. Rice is mainly cultivated in the eastern districts of Upper Gangetic plains and the alternate crops are pulses, sugarcane, ground nut and jowar. *Rabi* wheat- gram based cropping patterns are in the areas of north western districts of Uttar Pradesh and Haryana districts. The network of canals in Punjab, Haryana and north western districts of Uttar Pradesh support irrigated wheat crops. The alternative important crops are maize, sugarcane and ground nut. The largest area of *kharif* maize is in Uttar Pradesh and the alternate crops in maize areas are rice in *kharif* and wheat in *rabi*. However, in some areas, ground nut, sugarcane, ragi and pulses are the alternate crops.

Crops and wild relatives

Cereals: *Oryza sativa*, rice varieties: *Jaya*, *Basmati*, *Palman Jhona*, *Bala*, *Cauvery*, *Saket*, *Sarjoo*, *Chakia*, *Maduka*, *Oryza rufipogon* Maize (*Zea mays*), Sorghum (*Sorghum bicolor*), Wheat (*Triticum aestivum*). Millets: Kodo millet (*Paspalum scrobiculatum*), Proso millet (*Panicum miliaeceum*), Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*). Pseudocereals: Amaranth (*Amaranthus hypocondriacus*), Buckwheat (*Fagopyrum emarginatum*).

Vegetables: Okra (*Abelmoschus esculentus*), *A. manihot*, Onion (*Allium cepa*), *A. ascalonicum*, Lasun (*A. sativum*), *A. wallichii*, *A. stracheyi*, Ras Dhana (*Amaranthus caudatus*), Lal sag (*A. gangeticus*), Chaulai (*A. paniculatus*), *A. polygamus*, Satawar (*Asparagus racemosus*), *A. curillus*, *A. sarmentosus*, Ash gourd (*Benincasa hispida*); *Beta vulgaris* subsp. *maritima*;

Cauliflower: *Brassica oleracea* var. *botrytis*; Brussels sprouts: *B. oleracea* var. *gemmifera;* Cabbage: *B. oleracea* var. *capitata*, Knol Khol: *B. oleracea* var. *gongylodes*; Rapeseed (*B. napus*), Rai seed (*B. juncea* subsp. *integrifolia*), Black Mustard, Benarasi Rai (*B. nigra*); Lal mirch (*Capsicum frutescens*), Chenopod (*Chenopodium murale*); Round gourd (*Citrullus fistulosus*); Pumpkin (*Cucumis pepo*), Cucumber (*Cucumis sativus*), *C. hardwickii*, Mitha kumra (*Cucurbita maxima*); Latmhuria (*Digera muricata*, pot herb), Faridbutti, used as pot herb (*Farsetia hamiltonii*, *F. jacquemontii*); Garden lettuce (*Lactuca sativa*); *Ipomoea aquatica;* Ridge gourd WR *Luffa acutangula*, *L. hermaphrodita*, Sponge gourd (*Luffa aegyptiaca*), *L. echinata;* Bitter Gourd: *Momordica charantia*, *M. balsamina*, Fenugreek WR. *Trigonella foenum-graceum*, *T. balanse*, *T . obcordata*, *T. Occulta;* Water chestnut (*Trapa natans* var. *bispinosa*).

Legumes: Pigeon pea (*Cajanus cajan*), *Cajanus scarabaeoides*, Chickpea (*Cicer arietinum*), Lablab Bean: *Lablab purpureus* subsp. *benghalensis*, Lentil (*Lens culinaris*), Sweet pea (*Lathyrus odoratus*), Garden pea (*Pisum sativum*), Black gram (*Vigna mungo*), *V. prainiana*, Mung bean (*Vigna radiata*), *Vigna radiata* var. *sublobata*. Tubers: *Dioscorea bulbifera*, *D. deltoidea D. kalkapershadii*, Sweet Potato: *Ipomoea batatas*, Potato*: Solanum tuberosum*.

Spices*:* Turmeric WR *: Curcuma ferruginea*, *C. leucorhiza*, *Murraya koengii*.

Edible oils: *Brassica juncea*, *B. quadrivalvis*, *B. tournefortii*, Safflower (*Carthamus tinctorius*), *C. oxycanthus;* Taramira : *Eruca sativa*,

Sugarcane: *Saccharum officinarum*. *S. ravennae*, *S. longisetosum*, *S. narenga*, *S spontaneum*, *S. williamsii*. Fibres**:** Cotton Tula (*Gossypium arboreum*), Levant cotton (*G. herbaceum*).

Other economic plants

Fruits: Bael (*Aegle marmelos*), Phalwara (*Aiasandra butyracea*), *Ampelocissus latifolia*, Karaunda (*Carissa carandas*), Kinnow (*Citrus deliciosa*), Karna Orange (*Citrus karna*), Grape fruit (*Citrus paradisii*), Sweet orange (*Citrus sinensis*), *Celtis australis*, Sansaru (*Debregeasia hypoleuca*), Kondai (*Flacourtia sepiaria*), Salpan (*Flemingia chappar*), *Ficus carica*, *F. palmata;* Wood Apple (*Limonia acidissima*), Litchi (*Litchi chinensis*), Mango (*Mangifera indica*), *Myrica esculenta*, Indian gooseberry (*Phyllanthus emblica*), *Perilla ocimoides*, Guava (*Psidium*

guajava), Pomegranate (*Punica granatum*), Jamun (*Syzygium cuminii*), Ber WR (*Ziziphus oenoplia*).

Medicinal Plants*: Acorus calamus*, *Adhatoda zeylanica*, *Aegle marmelos*, *Andrographis paniculata*, *Cymbopogon martini*, *Gloriosa superba*, *Lactuca remotiflora*, *Mucuna deeringiana*, *Plumbago zeylanica*, *Psoralea corylifolia*, *Ricinus communis*, *Rubia manjith*, *Sesbania cannabina Terminalia bellerica*, *Withania somnifera*.

Fodder*: Eragrostis gangetica*, *E. pilosa*, *E. tenella*, *E. unioloides*, *Grewia optiva*, *Ficus auriculata*, *F. palmata*, *F. racemosa*, *F. semicordata*, *Indopiptadenia oudhensis*, *Lathyrus aphaca*, *Leucaena leucocephala*, *Medicago lupulina*, *M. polymorpha*, *M. sativa*, *Panicum atrosanguineum*, *P. maximum*, *Sesbania sesban*.

Fibres: *Crotalaria tetragona*, *Hibiscus surattensis.*

Multipurpose species*: Acacia catechu*, *A. mollis*, *Albizia lebbeck*, *Butea monosperma*, *Buchanania lanzan*, *Madhuca longifolia*, *Phoenix robusta*, *P. paludosa*, *Pongamia pinnata*, *Thysanolaena maxima* (*brooms*).

Dyes: Indigo *: Indigofera tinctoria*, *I. coerulea* var. *coerulea*, *I. gangetica*, *I. Thothathrii*.

Timber*: Anogeissus latifolia*, *Dalbergia sisoo*, *Toona ciliata*, *Shorea robusta*.

Endemic species: *Derris scandens* var. *saharunpurensis*, *Indigofera gangetica*, *I. thothathri*, *Indopeptadenia oudhensis*.

Threatend species: *Albizia thompsonii*, *Carum villosum*, *Cymbopogon osmastoni*, *Indopeptadenia oudhensis*

Associated culture and tribes

There are small pockets of tribal communities such as Bhil, Bhishinoi, Rabari and Minas. Bhishnoi community is known for the conservation and protection of *Khejari* tree. Some of the associated tribes are Barda, Bavacha, Gond, Koli, Paradhi, Vafhri. Kathodi, Siddis, Kolgha, Kotwalia, Padhar in southern Gangetic plains adjoining to Malwa plateau and Bundelkhand region.

Technology and products

The fertile Indo- Gangetic plains with plenty of water resources from ancient times has become the centre of cultivated species and the recepient of introduced crop diversity from Central Asia and Africa especially cereals, legumes, vegetables and oilseeds. The crop species through adaptations and through selections over the millennia evolved to form new varieties and cultivars adapted to different agro-ecological and edaphic zones of the Indo-gangetic plains. In the Hemval Ghati of Uttar Pradesh, among the Himalayan foothills, some farmers under the banner of the *Beej Bachao Andolan* (Save the Seeds Movement) spearheaded a movement for the conservation of native varieties and cultivars (Jardhari *et al.*, 1995). Though the area has largely taken to HYV paddy cultivation, it is reported that the *Beej Baachao Andolan* encouraged farmers to grow indigenous varieties in small plots adjacent to the plot growing commercial high yielding varieties. As the region has fertile indo-gangetic alluvial soils, irrigated by a net work of canals, it has been a granary of cereals, pulses and edible oilseds from ancient times. Several crop species, particularly grain legumes, oilseeds introduced from Africa and central Asia got adapted to the region and spread further generating a great amount of genetic diversity. In rice, the region is known for variability for drought, deep-water floating rice, scented rice, etc. Some of the valuable traditional varieties evolved with aroma are 'Kala Namak' variety of rice with resistance to soil salinity. In barley, genetic variability for saline and alkaline tolerance has been reported (Verma *et al.*, 2006).

In pigeon pea significant variability has been observed and landraces such as ICP7626 with resistance to wilt have been collected and used in the development of variety Maruti (Remanandan *et al.*, 1997). In cluster bean, the region offers variability for early maturity, determinate habit, diseases resistance, and fodder yield. There is rich variability in cow pea for growth habit, flower colour, colouration of plants, including pod and seed, and their size. In moth bean, Type 1 has been developed from a landrace from Meerut.

Among oilseeds, the region has recorded significant variability in *Brassica napus*, with early and dwarf toria and yellow sarson.

Consequent of this variability, several varieties have been developed from local landraces: for example *Brassica juncea*, T-11 from a landrace of Kanpur; the Shekhar and Laha 101 were developed from landraces of Etawah, Pusa Kisan from Agra landrace and Varuna from Varanasi landrace. In *Brassica napus* var. *toria*, T-9 and T-36 were developed from landraces of Etawah, whereas *B. napus* var. yellow sarson, T-10 came from Kanpur, T-151 from Aligarh, YST151 from Barabanki, T-42 from Basti, T-48 from Etawah. The eastern Uttar Pradesh is also known for tall, robust toria (*Brassica napus*) types with multi-locular capsule. In safflower, Type 65 is a selection from a local landrace of the region (Kumar *et al.*, 2004).

The Indo-Gangetic alluviul plains has been recognised as a major centre of origin and diversity for Asiatic cotton (*Gossypium arboreum*). It is reported that *G. arboreum* race *indicum* is similar to *G. herbaceum* race *acerifolium* and *wightianum* with significant variability (Singh, 2004).

The region is also known for the significant genetic diversity in *Saccharum spontaneum* which is a wild relative of sugarcane, for desirable features, like disease resistance, insect - pests resistance, drought and salinity tolerance and water logging resistance, which are of high breeding value.

In continuation of variability present in sub-Himalayan region, there is genetic diversity for vegetable crops. Brinjal (*Solanum melongena*) has significant variability and the local well known landraces are Ramnagar Baingan; similarly in chilli, there is significant variability in fruit shape, size and colour (Kalloo *et al.*, 2005). There is andro-monoecious type in Bottle gourd (*Lagenaria siceraria*) from Faizabad and Shahjahanpur; there are also downy mildew and root rot wilt complex resistance types in Squash melon (*Praecitrullus fistulosus*). In several crops, varieties have been developed through selection from local landraces, for example, in musk melon, Akrajeet from UP local, Lucknow safed from Lucknow local; in Cucumber (*Cucumis sativus*), Kalyanpur green was developed from local cultivars; in Sponge gourd (*Luffa aegyptiaca*), Kalyanpur Hari Chikni was developed from local landrace; in Ridge gourd (*Luffa acutangula*), Pusa Nasdar originated

from Neemuch local; in Bitter gourd, (*Momordica charantia*), Kalyanpur Barahmasi, and Pusa Videsh were developed from Hapur local (Sirohi *et al.*, 2005). In potato, Agra-red was derived from local Desi type (Shekhawat *et al.*, 2005), whereas in onion, Pusa Madhawi was developed from Muzaffernagar local and Kalyanpur red round from Kanpur local (Pandey *et al*, 2005).

The region represents rich genetic diversity in case of tropical and semi- arid fruits. The region has traditional varieties in mango, such as Bombay green, Dashehari, Fazli, Langra, Safeda Lucknow, Smarbehisht, Chausa; in Guava, there are several traditional varieties, such as Lucknow Safed, Allahbad Safed, Banarasi Chittidar, Baruipur; in lemon, (*Citrus limon*), Baramasia, Pant lemon, Gandhraj are well known (Karihaloo *et al.*, 2005); in Indian gooseberry (*Phyllanthus emblica*), the varieties banarasi, Hathojhoool, Basanti Red, Desi and Chakaiya are developed; in Ber (*Zizyphus mauritiana*) several forma are available in Western Uttar Pradesh; in Jamun (*Syzygium cumini*), considerable variability for fruit size, shape, pulp colour, TCS, acidity and earliness has been recorded, though no pure line is established; similarly rich variability has been recorded in Phalsa (*Grewia subinaequalis*) (Vashishtha *et al.*, 2005).

In mixed cropping, planting of Snap melon (*Cucumis melo* var. *momordica*) or Cucumber (*Cucumis sativus*) mixed with maize is followed in order to ensure availability of diverse food crops. The region is also known for several cultural practices for the control of pests and diseases using natural products like Neem cake/leaves/ powder mixed with cow-dung ash in order to control powdery mildew disease.

7. 12 Lower Gangetic Plains Agrobiodiversity Region

Location and extent

The Lower Gangetic Plains agrobiodiversity hotspot comprises Eastern Gangetic plains covering mostly north and northeastern part of Bihar, including central foothills of the Himalayas; the alluvial flat plains which is a hot and sub-humid eco-region, is mainly irrigated by the Ganges and its tributaries-Kosi, Sone and Gandak; and the

districts in Bihar (which are flat plains) adjacent to the Ganges, Kosi- Sone- Gandak riverine systems, e.g., the Paschim Champaran, Purbi Champaran, Gopalganj, Siwan, Sitamarhi, Muzaffarpur, Sasaram, Buxar, Bhjojpur, Patna, Bhabua, Rohtas, Jahanabad, Vaishali, Samastipur, Darbangha, Madhubani, Sheohar, and Madhupura.

Agroclimate

The climate of the region is characterised by hot summers and cool winters. The area receives an annual rainfall of 1400 - 1600 mm, ensuring the availability of moisture for most part of the year and extending the growing period from 180 to 210 days. The area has short dry period from February to May resulting in drying of soil moisture. The mean soil temperature is about 22^0C. The landscape in the area is represented by alluvial soil. The soil is calcareous and moderately alkaline in nature.

Floristic diversity

The natural vegetation of the Eastern Lower Gangetic Plains comprises grasslands, swampy vegetation and remanants of tropical moist deciduous and dry deciduous forests. The prominent trees are *Aegle marmelos*, *Diospyros melanoxylon*, *Madhuca longifolia*, *Spondias pinnata*, *Syzygium cuminii*, *Terminalia arjuna*, *T. bellerica*. The grasslands have the following salient species: *Coix aquatica*, *Phragmites karka*, *Saccharum procerum*, *S. bengalense*, *S. narenga*, *Vetiveria zizanoides.*

Agriculture and agrobiodiversity

Agriculture here is mainly rainfed. Rice and Maize are the major cultivated crops during rainy (*kharif*) season. Wheat and sugarcane are the alternate important crops cultivated in irrigated and rainfed conditions. The main *rabi* crop is wheat in the northern districts of Bihar and the alternate crops in the *kharif* are rice, maize and sugarcane. Sugarcane is cultivated as a post *rabi* crop from March onwards. The cropping system is rice-maize during rainy season and wheat-sugarcane with or without irrigation during winter season. The combination of cropping patterns is rice - chickpea, rice – mustard, rice – lentil, pulses- rabi maize, sugarcane – pigeon pea.

Crops and wild relatives

Cereals: *Oryza sativa*: rice varieties: *Padma*, *Narsing*, *Vishnu*, *Prahalad*, *Kanchan*, *Ratna*, *Bala*, *Cauvery*, *Kiran*, *Seeta*, *jaya*, *Masuri*, *Jassaria*, *Tulsimanjari;* Sorghum (*Sorghum bicolor*), Maize (*Zea mays*); Barley (*Hordeum vulgare*); Wheat (*Triticum aestivum*) varieties: Sonalika, Kalyansona, Janak.

Millets: Finger millet (*Eleusine coracana*), Proso millet (*Panicum milliare*). Kodo millet (*Paspalum scrobiculatum*), Foxtail millet (*Setaria italica*).

Pseudocereals: Buckwheat (*Fagopyrum emarginatum*), Amaranth (*Amaranthus hypocondriacus*).

Legumes: Chickpea (*Cicer arietinum*), Pigeon pea (*Cajanus cajan*), Lentil (*Lens culinaris*), Lablab bean (*Lablab purpureus* subsp. *benghalensis*), Soybean (*Glycine max*), *Black* gram (*Vigna mungo*), Green gram: *Vigna radiata*, *V. radiata* var. *sublobata; Rice* bean (*V. umbellata*), Cowpea (*V. unguiculata*).

Vegetables: Okra (*Abelmoschus esculentus*, *A. manihot*); Amaranth: *Amaranthus gangeticus*, *A. paniculatus*, Cauliflower: *Brassica oleracea* var. *botrytis*; Brussels sprouts: B. *oleracea* var. *gemmifera;* Cabbage: B. *oleracea* var. *capitata;* Knol Khol: *B. oleracea* var. *gongylodes*; Turnip (*B. rapa*); Ashgourd (*Benincasa hispida*); Chilli (*Capsicum annuum*), Ivy gourd (*Coccinia indica*), Cucumber (*Cucumis sativus*), Pumpkin (*Cucurbita pepo*), Soh-phlang, edible tubers (*Flemingia procumbens*, *F. strobilifera*), Garden Lettuce (*Lactuca sativa*), *L. remotiflora*, Ridge Gourd (*Luffa hermaphrodita*), Sponge Gourd (*Luffa aegyptiaca*), *L. echinata*, Small bittergourd (*Momordica dioica*), *M. balsamina*, *M. subangulata* var. *renigera;* Brinjal: *Solanum melongena*, *S. incanum*, *S. indicum*, Fenugreek WR. *Trigonella foenum-graceum*, *T. balanse*, *T. obcordata*, *T. occulta;* Water chestnut (*Trapa natans* var. *bispinosa*).

Tubers: Soh-phlang, edible tubers (*Flemingia procumbens*, *F. strobilifera*), Yam bean: *Pachyrhizus tuberosus;* Potato (*Solanum tuberosum*), Yam: *Dioscorea kalkapershadii*.

Sugarcane: *Saccharum officinarum*, *S. barberi*, *S. bengalense S. longisetosum*, *S. narenga*, *S. ravennae*, *S spontaneum*, *S. williamsii*, *Saccharum arundinaceum*.

Spices: *Carum villosum*, *Curcuma ferruginea*, *C. leucorhiza*, *C. rubescens.*

Oilseeds: Taramira (*Eruca sativa*), *Mustard*: *Brassica juncea*, *B. quadrivalvis*, *B. tournefortii*, Black Mustard (*Brassica nigra*), Safflower (*Carthamus tinctorius*), Wild safflower (*Carthamus oxycanthus*), Linseed (*Linum usitatissimum*).

Fodder: *Eragrostis gangetica*, *E. pilosa*, *E. tenella*, *E. unioloides; Grewia optiva*, *Ficus auriculata*, *F. benghalensis*, *F. racemosa*, *F. semicordata;* Iseilema *holei*, *Lathyrus aphaca*, *Leucaena leucocephala; Medicago lupulina*, *M. polymorpha*, *M. sativa; Panicum atrosanguineum*, *P. maximum; Pennisetum pedicellatum*, *P. polystachyon*, *P. purpureum; Sesbania sesban*.

Other economic plants

Fruits: Bael tree (*Aegle marmelos*), Grape fruit cultivated (*Citrus paradisii*), Lasora (*Cordia myxa*), Indian gooseberry (*Phyllanthus emblica*), Wood Apple (*Limonia acidissima*), Fig (*Ficus carica*), Litchi: (*Litchi chinensis*), Mango (*Mangifera indica*), Pomegranate (*Punica granatum*), *Phoenix paludosa*, *P. robusta*, Wild jamun (*Syzygium cuminii*), *Ziziphus oenoplia*.

Medicinal plants: *Alangium salvifolium*, *Buchanania lanzan*, *Celastrus paniculatus*, *Clausena excavata*, *Lactuca remotiflora*, *L. runcinata*, *Mucuna pruriens* var. *utilis*, *Oroxylum indicum*, *Plumbago zeylanica*, *Soymida febrifuga*, *Trichosanthus tricuspidata*.

Dyes: Indigo (*Indigofera tinctoria*).

Multipurpose species: *Butea monosperma*, *Bursera serrata*, Phalsa (*Grewia asiatica*), *Haldinia cordifolia*, *Madhuca longifolia*, *Schleichera oleosa*, *Terminalia elliptica*, *T. arjuna*, *T. bellerica*.

Endemic species: *Albizia thompsonii* var. *galbana*, *Carum villosum*, *Chrysopogon hamiltonii*, *Dendrocalamus strictus* var. *sericeus*, *Dimeria ornithipoda* var. *gracilima*, *Iseilema holei*, *Leucas helectrifolia*, *Lohopogon kingii*, *Sophora bakeri*.

Threatened species: *Albizia thompsonii* var. *galbanum*, *Carum villosum*, *Carex myosurus* var. *oraestans*, *Ligusticum albo-alatum*.

Associated cultures and tribes

Austrics and Adivasis have contributed to the development of farming. The predominant tribes are Ahirs, Rajis, Buxa, etc.

Technology and products

The region is one of the centres of genetic diversity of major crop species such as rice, pigeon pea, oilseeds, sugarcane, jute, vegetable crops especially solanaceous and cucurbitaceous crops, fruits, such as mango, litchi, banana, bael. There are a large number of rice cultivars having traits for submergence tolerance, deep-water floating rice, scented rice, etc. In barley, genetic variabilities for salinity and alkaline conditions have been collected (Verma *et al.*, 2006). Similarly, in pigeon pea variability has been observed in long duration types. It is reported that landraces such as ICP11384 with resistance to sterility mosaic have been collected from foothills of Himalayan region. Mung bean variety with many seeded pods are also known from the region. In cow pea, there is a rich variability for growth habit, flower colour, colouration of plants, including pod and seed, and their size.

Among oilseeds, significant variability has been recorded in Toria (*Brassica napus*) for early and dwarf types such as var. toria and yellow sarson. In var. toria, BR-23 is derived from a landrace of Purnia. In Rai (*Brassica juncea*) several varieties have been developed from local landraces, such as BR-40 from Bihar local and BR-13 from a landrace from Purnia (Kumar *et al.*, 2004). In castor, the region is known for tall types of more than 3 m height with large leaves of more than 50 cm in diameter, which are suitable for rearing of silk-worm. In Sesame, Kanke white has been derived from a local landrace.

In continuation of upper Gangetic plain, this part of Indo-Gangetic alluvium is considered as one of the centres of origin and diversity for Asiatic cotton (*Gossypium arboreum*). It is seen that *G. arboreum* race *indicum* is similar to *G. herbaceum* race *acerifolium* and *wightianum*, with significant variability. In sugarcane, the region is known for significant genetic diversity in *Saccharum spontaneum* for desirable traits, like resistance to diseases and insect pests, drought, salinity and water logging tolerance which are of good breeding value. There is a wide variability in jute (*Corchorus capsularis*) and several varieties have been developed through selection from local landraces from Bihar.

In Brinjal (*Solanum melongena*), chilli (Kalloo *et al.*, 2005) and other cucurbitaceous crops like *Luffa*, *Momordica*, *Trichosanthes*, *Lageneria* etc., varieties have been developed using local landraces. Some of the varieties developed are as follows: in Bottle gourd (*Lageneria siceraria*) variety Rajendra Chamatkar; in Ridged gourd (*Luffa acutangula*) variety Satputia; in Sponge gourd (*Luffa aegyptiaca*), varieties Pusa Chikni, Pusa Supriya; in Pointed gourd (*Trichosanthes dioica*), varieties Rajender Parwal and Rajender Parwal 1 through selection from Bhagalpur local (Sirohi *et al.*, 2005). For Okra, the region presents maximum variability in fruit and plant morphotypes along with the wild realtive *Abelmoschus crinitus*. Variety Agrifound white (G41) has been developed in garlic from a collection from Bihar Sharif of Nalanda district.

The region is known for the rich variability for several tropical fruits, such as mango, litchi, bael and banana. The common varieties of mangoes are Bathua, Bombai, Himsagar, Kishen Bhog, Sukul; Litchi has the following well known varieties: North Muzaffurpur, Darbhanga are known for varieties like Bedana, Calcuttia, Purbi, Kasba, Desi, early Bedana, etc. Bael fruit has the varieties such as Ojha, Azamati, Khamaria, Sewan large with unique characteristics. Banana is known for traditional varieties, like Dwarf Cavendish, Poovan, and Rasthali; *Carissa carundas* has variability for fruit and plant type.

In spices, the region is known for genetic variability in ginger and turmeric; in ginger, 'Rajendra Sonia' has been derived from a local collection. In case of seed spices, the fenugreek variety 'Rajendra Kranti' is a pure line selection from a local collection of Raghunathpur. Betel vine is also cultivated as a commercial crop.

A unique irrigation system called '*ahar*', which is a combination of tank/inundation irrigation systems often built in series have also been developed as a traditional irrigation system.

7.13 Gangetic Delta Agrobiodiversity Region

Location and extent

The Gangetic Delta agrobiodiversity region broadly includes the deltaic North and South 24-Parganas districts, but also the districts

of Hoogly, Howrah, Nadia, Bardhaman, Birbhum and Murshidabad which flank on both sides of the river Hoogly flowing into the Bay of Bengal. The deltaic ecosystem "Sunderbans" which straddles West Bengal and Bangladesh, is the third largest mangrove formatiom in the world. The hotspot areas are the districts of South 24 Parganas, North 24 Parganas, Howrah, Hoogly, Nadia, Bardhaman, Birbhum and Murshidabad.

Agroclimate

The climate of the region is characterised by the hot summers and mild winters. The region receives high rainfall both during summer and winter seasons, ranging from 1000 – 2000 mm. The precipitation satisfies 80 per cent of the water requirement. The region experiences water stress from March to May. The moisture availability period and growing seasons range from 150-210 days. The Gangetic delta has fertile alluvial plains. The soil is mostly clayey in texture.

Floristic diversity

The area is very rich in floristic diversity, particularly in the swampy mangrove forests. The natural vegetation is littoral swamp forests called Sunderban's Mangroves. The name is derived from the Sundari tree, the local Bengali name given to the mangrove species *Heritiera fomes.* The mangrove vegetation is dominated by *Rhizophora mucronata*, *R. apiculata*, *Kandelia candel*, *Aegiceras corniculatum*, *Brugiuera gymnorrhiza*, *Xylocarpus granatum*, *Avicennia officinalis*. The associated trees are: *Ceriops decandra*, *Excoecaria agallocha*, *Heritiera fomes*, *Phoenix paludosa*. Some of the common trees occurring in the plains are *Butea monosperma*, *Haldinia cordifolia*, *Mangifera indica*, *Madhuca indica*, *Shorea robusta*, *Terminalia arjuna*, *T. chebula.*

Agriculture and agrobiodiversity

The rainfed agriculture is the traditional farming system. However, in some pockets wherever irrigation facilities are available, irrigated farming is also practised. The main crop cultivated is rice both in *kharif* and *rabi* seasons. Jute is also cultivated as an additional crop in the areas prone to flooding. Some of the horticultural and supplementary crops grown in the plains are aroids, banana, coconut,

cucurbits, mango, papaya. The cropping system consists of following pattern of crops: rice – wheat, rice – potato, sesame – ground nut-sunflower, jute – rice – sunflower, jute-mustard.

Crops and wild relatives

Cereals: *Oryza sativa*, rice varieties: *Jaya*, *Jayanthi*, *Ratna*, *Krishna*, *Cauvery*, *Supriya*, flood tolerant varieties*: Jalaplabhan*, *Jaldhi;* salt tolerant varieties*: Nona Bokra*, *Rupsali;* Scented varieties: *Gopal bhog*, *Govind bhog*, *Kammini bhog*, *Randhunipagal*, *Seeta bhog*, *Kataribhog;* Disease resistant varieties: *Jaya*, *Rasi*, *Vani*, *Surekha*, *Sonamukhi*, *Lal Basmati; Oryza rufipogon*, *Porteresia coarctata*, Sorghum (*Sorghum bicolor*,) Maize (*Zea mays*), Wheat (*Triticum aestivum*).

Millets and pseudocereals*:* Amaranth (*Amaranthus hypocondriacus*), *Coix agrestis*, *Coix aquatica*, *Echinochloa frumentacea*, *Paspalum scrobuculatum*, Foxtail millet (*Setaria italica*).

Vegetables: Okra (*Abelmoschus esculentus*, *A. manihot*)*;* Amaranth *Amaranthus tricolor*, *A. caudatus*, *A. gangeticus*, *A. paniculatus;* Ash gourd (*Benincasa hispida*)*; Basella alba*, *B. rubra; Pomelo* (*Citrus maxima*); Pumpkin (*Cucurbita pepo*); Kundri (*Coccinia indica*)*;* Musk melon (*Cucumis melo*); Cucumber (*C. sativus*)*;* Lablab bean (*Lablab purpureus* subsp. *Benghalensis*)*;* Ridge gourd (*Luffa acutangula*), Sponge gourd (*Luffa aegyptiaca*), Bittergourd (*Momordica charantia*), *M. cochinchinensis*, Small Bittergourd (*Momordica dioica*)*;* Winged bean (*Psophocarpus tetragonolobus*)*; Solanum incanum*, *S. lasiocarpum*. Fruits: Bael tree (*Aegle marmelos*), Sapota (Manilkara sapota), Mango (*Mangifera indica*), Banana (*Musa balbisiana*, *M. sapientum*), Guava (*Psidium guajava*), Wild jamun (*Syzygium cuminii*).

Grain Legumes: Chickpea (*Cicer arietinum*), Pigeon pea (*Cajanus cajan*), Green gram (*Vigna radiata*).

Tubers*:* Elephant-foot yam*: Amorphophallus bulbifer*, *A. paeoniifolius* var. *campanulatus*, *A. sylvaticus;* Taro*: Colocasia esculenta*, *C. fallax;* East Indian arrow root (*Curcuma angustifolia*), *C. caesia;* Mango ginger: *Curcuma amada;* WR Turmeric: *Curcuma aromatica*, *C. ferruginea C. zedoaria;* Yam*: Dioscorea esculenta*, *D. pentaphylla*, *D. puber; Yam* bean (*Pachyrhizus erosus*), *P. tuberosus;* Potato (*Solanum tuberosum*).

Edible oils: Mustard (*Brassica rapa* subsp. *campestris*), *B. tournefortii*, Wild safflower (*Carthamus oxycanthus*), Sunflower: *Helianthus annuus*, *H. tuberosus*, *Sesamum indicum*.

Sugarcane & WR: (*Saccharum officinarum*), *S. spontaneum*.

Fibres: Jute (*Corchorus capsularis*, *C. olitorius*), *C. trilocularis.*

Other economic plants

Fruits: Palmyra: *Borassus flabellifer*; Karonda (*Carissa carandas*), Indian cherry (*Cordia myxa*), Phalsa (*Grewia asiatica*); Wood apple: *Limonia acidissima;* Indian gooseberry (*Phyllanthus emblica*), Pomegranate (*Punica granatum)*, *Phoenix paludosa*, *P. robusta*.

Fodder: *Artocarpus lakoocha*, *Echinochloa colona*,, *Ficus benghalensis*, *F. religiosa*, *Imperata cylindrica*, *Paspalidium flavidum, Vigna unguiculata*.

Spices: *Enhydra fluctuans*, *Eryngium foetidum;* Betel (*Piper betel*).

Timber: *Pterocarpus marsupium*, Sal (*Shorea robusta*), Teak (*Tectona grandis*).

Multipurpose species: *Bauhinia vahlii*, *Dendrocalamus strictus*, *Madhuca longifolia*, *Phoenix paludosa*, *P. sylvestris*, *Nypa fruticans*, *Sesbania aegyptiaca*.

Endemic species: Nil.

Threatened species: Nil.

Associated culture and tribes

The region is inhabited by Indo-Aryans, Indo- Mongolides and Austrics races. The common tribes are Munda, Oraon, Parhiya, Santals, Sauri Paharia, Lodha, Birhor, and Tota.

Technology and products

There is rich genetic diversity in important crops like rice, Boro rice varieties and submergence tolerant varieties: Jalaplabhan, Jaldhi and salt tolerant varieties, Nona Bokra, Rupsali; These varieties have been extensively used in breeding programmes for development of new rice varieties suited to these areas.

The specific agro-ecology of excessive water during rainy season and ingress of salinity have generated genetic diversity in important crops like rice. The important and desirable traits for rice are submergence tolerance, salinity tolerance, and deep water floating rice, which occur in the districts of Medinipur, Birbhum, Hoogly, Howrah and 24-Parganas (Siddiq *et al.*, 2006). This has resulted in the production of series of varieties, like Boro rice for winter cultivation in rainfed swampy areas, and submergence tolerant rice varieties that have been extensively used in breeding programme for development of aromatic rice varieties suited to these areas. Among oilseeds, significant variability has been recorded in yellow sarson, where dwarf and early types with pendulous siliqua have been collected, particularly from Indo-Bangladesh border areas.

There are several commonly known landraces, such as Jatai rai, Desi rai, Maghi rai, etc. From local landraces several varieties have been derived through selection breeding, i.e. in *Brassica juncea*, Seeta from a landrace of Purva Medinipur; in *B. napus* var. toria, Agrani from a local collection; and in the case of *B. napus* var. yellow sarson, Benoy (B9) from a landrace of Karimganj and 66-197-3 from a local landrace of the region (Kumar *et al.*, 2004).

In the case of Jute, the region is known for genetic diversity, particularly in Tossa jute, where variety JRO 632, is a selection from a local landrace. In the case of White jute, the variety JRC 212 is a selection from another local landrace of the region. The variability noted in the wild relative of sugarcane (*Saccharum barberi*) is a part of the gene pool of Indian sugarcane centre which extends from the Gangetic plains to the Gangetic delta.

There is a significant variability in Chilli and Okra. In Okra, the region presents one of the major centres for maximum variability for fruit and plant morphotypes along with the wild relative *Abelmoschus crinitus*. It is noted that variety Pusa Makhmali, which is the parent of Pusa Sawni was derived from a landrace from West Bengal (Dhankhar *et al.*, 2005).

There are a large number of traditional mango varieties such as Bombai, Himsagar, Kishen Bhog, Langra, Malda. In banana, there

are varieties, such as Dwarf Cavendish, Poovan and in Bael there are varieties like Ojha, Azamati. Jack fruit (*Artocarpus heterophyllus*) and Karandas (*Carissa carandas*) are known for their quality fruit and plant characteristics. In spices, the region is known for genetic variability in ginger and turmeric. Betel vine cultivation as a commercial crop is of recent introduction.

7.14 Chotanagpur Agrobiodiversity Region

Location and extent

The Chotanagpur region constitutes south and eastern plateau of Jharkhand and contiguous districts in Orissa. It is generally referred as Chota Nagpur Plateau which comprises all the southern districts of Jharkhand, districts of Purulia and part of Bankura and western Medinapur district of West Bengal, Mayurbhanj and Sundargarh districts of Orissa. The hotspot areas are the districts of Singhbhum, Gumla, Ranchi, Lohardaga, Palamau and Hazaribhag and Santhal Pargana in Jharkhand and Mayurbhanj district in Orissa.

Agroclimate

The climate of the area is characterised by hot summers and cool winters and is sub-humid. The area receives an annual rainfall of 1000 - 1600 mm. The annual rainfall is sufficient for 80 per cent of the annual potential evapotranspiration. The soil is dry for more than 90 days. The mean annual soil temperature is more than 22^0C. The moisture availability for the growing period ranges between 150 - 180 days in a year. The dominant landscape in the area is represented by moderate to gentle slopes. The soil is loamy to clayey, non-calcareous and moderately acidic.

Floristic diversit

The vegetation comprises of tropical dry deciduous and moist deciduous forests. The vegetation is characterized by Sal (*Shorea robusta*), usually in association with *Aegle marmelos*, *Anogeissus latifolia*, Mohua (*Madhuca lonigifolia*), *M. longifolia* var. *latifolia*, *Diospyros melanoxylon*, *Dillenia pentagyna*, *Schleichera oleosa*, *Syzygium cuminii*, *Lagerstroemia parviflora*, *Pterocarpus marsupium*, *Symplocos racemosa*.

Dry scrub forest is the common vegetation type in the Jharkhnad area and the state is apparently named Jharkhand because of the domination of scrubs, locally called "Jharies". The scrubs include bamboos, shrubs such as *Helictres isora*, *Flacourtia indica*, *Flemingia strobilifera*, *Woodfordia fruticosa*, *Ziziphus mauritiana*. The important grasses in the scrub forests are *Arundinella setosa*, *Cymbopogon martinii*, *Cappillipedium assimilis*, *Chrysopogon fulvus*, *Pennisetum pedicellatum*, *Themeda caudata*, *T. quadrivalvis*.

Agriculture and agrobiodiversity

Rainfed agriculture is the traditional farming practice followed in the region. The major crops cultivated are rice, millets, pigeon pea during the rainy season. Rice and wheat are also cultivated under irrigated conditions. Direct sowing of ragi, red gram, black gram is practiced and ridge planting of maize is also followed. A number of horticultural crops are also grown in relation to its topography and its climatic regimes. The cropping systems are as follows: rice - toria, rice – mustard, rice –niger, rice – ground nut, rice – lentil, rice – sesame. Alfisols and related red soil zone: Ranchi zone: Rice- chickpea / linseed; Ground nut – barley; finger millet- chickpea. (Rathore et *al.*, 1991).

Crops and wild relatives:

Cereals: *Oryza sativa*: Rice varieties: *Cauvery*, *Palman*, *Bala*; Rice WR : *O. nivara*, *O. rufipogon;* Sorghum (*Sorghum bicolor*); Maize (*Zea mays*).

Millets: Sanwa (*Echinochloa frumentacea*); Barnyard millet (*E. crus-galli*); Finger millet (*Eleusine coracana*); Mandla (*Eleusine indica*).

Grain Legumes: Tur (Pigeon pea, *Cajanus cajan*), WR Pegionpea*: Cajanus cajanifolia*, *C. scarabaeoides C. sericeus; Rhynchosia bracteata*, *R. minima*, *R. rufescens;* WR Vigna, Moth bean*: Vigna aconitifoila*, *V. hainiana;* Black gram: *Vigna mungo;* Green gram: *Vigna radiata*, *V. radiata* var. *sublobata;* Rice bean: *Vigna umbellata*, WR Vigna: *Vigna triblobata*, Zombi Pea*: Vigna vexillata*.

Vegetables: Amaranth (*Amaranthus. paniculatus*, *A. spinosus*, *A. viridis*)*;* Okra*:* (*Abelmoschus esculentus*), *A. crinitus;* Indian spinach: *Beta vulgaris*

subsp. *maritima*, *Chenopodium album;* Ivy gourd (*Coccinia indica*), Cucumber (*Cucumis sativus*); Indian arrow root: *Curcuma angustifolia;* Bottle gourd (*Lagenaria siceraria*); *Drumstick tree: Moringa concanensis*, *M. oleifera;* Bitter gourd and WR : (*Momordica charantia*), *M. dioica*, *M. subangulata* var. *renigera;* Balsam apple: *Momordica balsamina;* Sweet gourd*: Momordica cochinchinensis;* Banana : *Musa sapientum*, *Sesbania grandiflora;* Brinjal (*Solanum melogena*).

Tubers*:* Taro (*Colocasia esculenta*), Country Potato (*Coleus forskohlii*), *Curcuma angustifolia*, Asiatic Yam (*Dioscorea alata*), Lesser Yam (*Dioscorea esculenta*, WR yam (*Dioscorea belophylla*), *D. glabra*, *D. kalkapershadii*, D. *wightii;* Potato yam (*Dioscorea bulbifera*)*;* Kudzu vine*: Pueraria tuberosa; Flemingia procumbens.*

Fruits: Pine apple (*Ananas comosus*), Mango (*Mangifera indica*), Banana (*Musa sapientum*), Guava (*Psidium guajava*).

Oilseeds*:* Ground nut (*Arachis hypogaea*), Niger (*Guizotia abyssinica*)*;* Linseed (*Linum usitatissimum*), Castor (*Ricinus communis*), Sesame (*Sesamum indicum*).

Spices: Wild Turmeric (*Curcuma aromatica*), Mango ginger (*Curcuma amada*), Turmeric (*Curcuma domestica*), Ginger (*Zingiber officinalis*), *Z. purpureum* var. *palamauensis.*

Other economic plants

Vegetables: (wild and less known): *Cissus repanda*, *Cissus quandrangularis*, *Hibiscus sabdariffa*, *Ipomoea aquatica.*

Fruits*: Aegle marmelos*, *Alangium salvifolium*, *Annona reticulata*, *A. squmosa*, *Artocarpus heterophyllus*, *Borassus flabellfer*, *Buchnania lanzan*, *Diospyros melanoxylon*, *Ficus racemosa*, *Flacourtia indica*, *Gmelina arborea*, *Phoenix sylvestris*, *Phyllanthus emblica*, *Solanum torvum*, *Syzygium cuminii*, *Tamarindus indica*, *Ziziphus maritiana*, *Z. rugosa.*

Medicinal plants: *Alangium salvifolium*, *Celastrus paniculatus*, *Flemingia strobilifea*, *Oroxylum indicum*, *Plumbago zeylanica*, *Soymida febrifuga.*

Timber: *Acacia catechu***,** *Ailanthus excelsa*, *Anogeissus latifolia*, *Buchnania lanzan*, *Dalbergia sissoo*, *Drypetes roxburghii*, *Gmelina arborea*, *Haldinia cordifolia*, *Hardwickia binata*, *Schlechera oleosa*, *Sterculia urens*, *Shorea robusta*, *Tectona grandis*, *Terminalia elliptica*, *T. bellerica.*

Fodder: *Axonopus compressus*, *Arundinella setosus*, *Bridelia squamosa*, *Butea monosperma*, *Capillipedium assimilis*, *Chrysopogon lanceolarius*, *C. fulvus*, *Crotalaria alata*, *Eulaliopsis binata*, *Heteropogon contortus*, *Iseilema laxum*, *Milletia extensa*, *Pennisetum pedicellatum*, *Themeda caudata*, *T. quadrivalvis*, *Wendlandia tinctoria*.

Gums and resins: *Anogeissus indica*, *Boswellia serrata*, *Gardenia gummifera*, *Lannea coromandelica*, *Shorea robusta*, *Sterculia urens*, *Terminalia arjuna*.

Dyes: *Acacia catechu*, *Butea monosperma*, *Lagerstroemia parviflora*, *Lawsonia inermis*, *Mallotus philippinensis*, *Morinda pubescens*, *Nyctanthus arbor-tristis*, *Wendlandia tinctoria*, *Woodfordia fruticosa*.

Multipurpose species: *Butea monosperma*, *Diospyros melanoxylon*, *Madhuca longifolia*, *Phoenix humilis*, *Schleichera oleosa*.

Endemic species: *Acacia donaldii*, *Albizia orissensis*, *Cajanus cajanifolius*, *Erythrina resupinata*, *Pycnocyclea glauca*, *Zingiber montanum*.

Threatened species: *Aglaia haselettiana*, *Carum villosum*, *Pycnocyclea glauca*, *Oryza nivara*.

Associated culture and tribes

The region is mainly inhabited by Adivasis and Austrics. The associated tribes are Mundas, Kols, Paharia, Tamar, Bhumji, Khewar, Asur, Birhar, Birjia, Savar, Hill Kharia, Korwa, Malpaharia, Parhaiyas, Sauria, Santhals, etc. Munda people worship nature and the supreme being is called Sun God or Sing Bonga. Santhals are the third largest tribal communities in India and they are the major tribal community inhabiting the Chotangpur agrobiodiversity region. Santhals mainly celebrate Karam festival in the month of September-October and grow Karam tree in front of their houses. The tribal communities collect non - wood forest products from the forests and they are also engaged in subsistence farming. The tribal community in their "*hats*" (evening markets) sell bamboos and canes, oils and fats, cordage, mats and basketry, non wood forest products such as oilseeds (mahua, sal, neem, karanj etc.), gums, resins, guggul or incense materials, dyes and fermented drinks, soap and cosmetics, wooden toys, drums, musical instruments, brooms and brushes, perfumes (sandalwood oil, *Khus* oil) and Tendu leaves (*Diospyros melanoxylon*). The Oraons mainly

depend on agriculture and are believed to have first introduced plough cultivation in the Chotanagpur Plateau.

Technology and products

The agroecological diversities and terrestrial heterogenieties have generated ecotypes and morphotypes in important crops like rice and kodo millet. In kodo millet, variety JK 41 is a selection from a local germplasm of this region.

The region is known for important traditional varieties of mango i.e.Bathua, Bombai, Himsagar, Kishen Bhog, Sukul extending from lower Gangetic plains. Rich genetic diversity is seen in Jack fruit (*Artocarpus heterophyllus*) especially in the Santhal Parganas for tree morphotypes and fruit characters. Similarly, Karondas (*Carissa carandas*) exhibits variability in fruit and plant type.

Due to unpredictable monsoon, following crops and varieties are being cultivated: *gora* rice, short duration, 85–90 days, drought-tolerant, low-yielding upland rice, in the cultivable uplands and cultivation of traditional minor millets (finger millet, *kodo*, *gundli*) solely or in association with other crops as mixed crops during the monsoon season.

The uplands close to the homesteads, called *barhi*, are supplied with water from dug wells. The *barhi* land is intensively used to cultivate vegetables and potato. Appropriate selection for rice genotypes suited for different terrains i.e. mid-uplands to low lands and this has resulted in generating genetic and varietal diversities in rice. In the mid-uplands (or *baad*), medium-duration rice varieties are selected and grown; whereas, lower down the hilly terrain, especially in the medium land, where soil moisture is available, long-duration rice varieties are grown.These medium lands are known as *ajan* in Giridih and *kanali* in Purulia.

It is seen that most farmers follow the practice of growing selected traditional long-duration rice varieties which require low inputs of manure in the lowlands which has plenty of water.Winter crops such as rapeseed, linseed, barley, lentil, and gram are cultivated successfully following the monsoon-season rice crop using residual soil moisture,

particularly in the mid-uplands. Since there is poor irrigation, the most common cropping pattern is still rice-fallow, which covers 87 per cent of the total medium land fields.

The wild relatives of the cultivated crop Pigeon pea (*Cajanus cajan*) are a source of resistance to pod fly damage and have general resistance to plant diseases (Sharma *et al.*, 2003). The donor wild relaltives of *Cajanus* occurring in the Chotanagpur agrobiodiversity region are *Cajanus scarabaeoides*, *C. sericeus* and *Rhynchosia bracteata*. The crossability studies among the closely related genera of *Cajanus* i.e. *Atylosia* and *Rhynchosia* were studied by Pundir *et al.*, (1985) who detected the crossing barriers.

7.15 Bastar Agrobiodiversiy Region

Location and extent

The Bastar region consists part of the eastern plateau, mainly southern Chattisgarh state which includes the areas of Dandakaranya. The hotspot areas are the districts of Bastar, Bilaspur, Durg, Raipur, Jashpur, Kabirdham, Kanker, Korba, Koria, Mahasamu, Kondaigoan, Rajnandgoan. The Bastar region is a hot sub-humid ecoregion with red and yellow soils.

Agroclimate

The climate of the area is characterised by hot summers and cool winters. The area receives an annual rainfall of 1200 - 1600 mm. of which 70-80 per cent is received between July and September. The annual rainfall covers about 60 per cent of annual potential evopotranspiration. The soil remains dry from December to May. The moisture availability for growing crops ranges from 150-180 days in a year. The dominant landscape in the area is represented by moderate to gentle slopes. The soil is reddish, calcareous and neutral to slightly acidic.

Floristic diversity

The region is very rich in floristic diversity. The natural vegetation comprises of tropical semi-evergreen forests, tropical moist deciduous forests, tropical dry deciduous forests. Important canopy trees of

tropical semi-evergreen forests are *Terminalia elliptica*, *Shorea robusta*, *Stereospermum chelonoides*, *Dalbergia paniculata*. The tropical moist deciduous forests have the following tree species: *Tectona grandis*, *Pterocarpus marsupium*, *Terminalia bellerica*, *T. chebula*, *Haldinia cordifolia*, *Lagerstroemia parviflora*. The important tree species of tropical dry deciduous forests are *Anogeissus latifolia*, *Butea monosperma*, *Diospyros melanoxylon*, *Soymidia febrifuga*.

Agriculture and agrobiodiversity

Rainfed agriculture is the traditional farming system. The major crops cultivated are wheat, millets and pulses. Rice is grown in small areas, but the yield is poor due to scanty rains. Wheat is cultivated as a *rabi* crop during winter months. Wherever irrigation is not available, millets, pulses and ground nut are cultivated. Generally, *rabi* wheat-gram cropping is followed. The *kharif* sorghum, oilseeds and small millets are the alternate crops to wheat and gram. The cropping system is as follows: rice - chickpea, rice – lentil, rice – khesari (*Lathyrus sativus*), rice – linseed, rice – sesame.

Crops and wild relatives:

Cereals: Rice: WR. *Oryza sativa*, O. *nivara*, *O. granulata O. rufipogon*, *Triticum aestivum*, *Triticum sphaerococcum;* wheat varieties*: Kalyansona*, *Sona*, *Sonalika*, *Sonora*, *Jayaraj*; Sorghum (*Sorghum bicolor*). Millets: Finger millet (*Eleusine corcanna*), Little millet (*Panicum sumatrense*), *Paspalum scrobiculatum*, Barnyard millet (*Echinochloa frumentacea*).

Legumes: Pigeon pea WR (*Cajanus cajan*), *Cajanus scarabaeoides*, *C. cajanifolius*, *C. sericeus;* Chickpea (*Cicer arietinum*), *Vicia sativa*, Moth bean (*Vigna aconitifolia*), Black gram (*V. mungo*), Green gram (*V. radiata*). Vegetables*:* Amaranth: *Amaranthus paniculatus*, *A. polygamus*, *A. viridis;* Okra and WR: (*Abelmoschus crinitus*), *A. esculentus;* Chilli : *Capsicum annuum*, Chenopods: *Chenopodium album;* Kundri*: Coccinia indica;* Cucumber*: Cucumis sativus*, Melon*: Cucumis melo.* var. *agrestis*, Pumpkin*: Cucurbita pepo*, Bitter gourd and allies : *Momordica charantia*, *M. balsamina*, *M. tuberosa*. *Banana : Musa sapientum*, *Sesbania grandiflora*.

Tubers*: Amorphophallus paeonifolius*, *Colocasia esculenta*, East Indian arrow root (*Curcuma angustifolia*), Mango ginger (*Curcuma amada*),

Curcuma zedoaria,Yams: *Dioscorea bulbifera*, *D. hispida*, *D. pentaphylla*, *D. wightii*, Kudzu vine: *Pueraria tuberosa*. Sugarcane**:** Sugarcane (*Saccharum officinarum*).

Other economic plants

Fruits*: Aegle marmelos*, *Alangium salvifolium*, *Annona reticulata*, *A. squamosa*, *Cordia obliqua*, *Diospyros melanoxylon*, *Dillenia pentagyna*, *Flacourtia indica*, *Phyllanthus emblica*, *Solanum torvum*, *Syzygium cuminii*, *Tamarindus indica*, *Ziziphus mauritiana*, *Z. rugosa*.

Less known vegetables: *Hibiscus sabdariffa*, *Ipomoea aquatica*.

Dyes*: Butea monosperma*, *Mallotus philippiensis*, *Nyctanthus arbor-tristis*, *Woodfordia fruticosa*. Lemon grass oil (*Cymbopogon martinii*).

Fodder*: Lathyrus aphaca*, *Mucuna pruriens.*

Medicinal plants: *Acorus calamus*, *Adhatoda vasica*, *Aegle marmelos*, *Balinites aegyptiaca*, *Baliospermum montanum*, *Costus speciosus*, *Hemidesmus indicus*, *Plumbago zeylanica*, *Psoralea corylifolia*, *Strychnos nux-vomica*, *Terminalia bellerica*, *T. chebula*, *Tinospora cordifolia*, *Vitex negundo*, *Woodfordia fruticosa*.

Multipurose species*: Artocarpus heterophyllus*, *Dendrocalamus strictus* (paper pulp), *Diospyros melanoxylon* (Beedi leaves), *Madhuca longifolia* (edible, flowers used for brewing), *Phoenix humilis*, *Schleichera oleosa* (lac growing), *Shorea robusta*, *Tectona grandis* (timber).

Endemic species: *Acacia donaldii*, *Albizia orissensis*, *Cajanus cajanifoliius*, *Oryza nivara*, *Tephrosia roxburghiana*.

Threatened species: *Oryza nivara*.

Associated culture and tribes

The region is inhabited by Indo-Ayrans, Austrics and Dravidians races. A number of tribes follow their own traditional ethos in religious practices. The commonly associated tribes are Ojhas, Bhikls, Gonds, Korlcens, Kols, Abujhmarias, Baigas, Bharias, Hill Korwas, Sahariyas and Karnar.

Technology and products

The diversity in agroecology and terrestrial heterogeneity has helped the shaping of agricultural practices of local communities

from ancient times. The region is known for important crops particularly rice and pegionpea. The rice cultivated here is known for variability in grain size, aroma, medicinal value and special type suited for making Indian pudding (*kheer*). In rice, there are reports of 5000 landraces occurring in this region. Farming communities over the years developed a large number of traditional varieties through the process of observation of desired traits, multiplications and repeated selections. To suite the local pudding preparation, farmers here selected specific types with small grains and aromatic varieties of rice. In the pudding rice type a large number of traditional varieties are known that are prefixed with 'Bhog'. *Oryza rufipogon*, a wild relative of rice occurring here has several useful genes and is very important for breeding purposes. Native fruits Chiironji (*Buchanania lanzen*) and Karondas (*Carrisa carandas*) have rich diversity. Karondas has variability for fruit characteristics, particularly the flesh, having white and red colour (Vashishtha *et al.*, 2005).

The farming communities practise terrace cultivation which allows the diversity of the same crops in different terraces. In the terrace systems, upper levels are cultivated with meticulously selected drought tolerant paddy landraces and lower most with flood tolerant types. This process allows natural cross-pollination of different landraces allowing the farmers to select the best land race having the desired traits. Farming communities have made selection in naturally occurring interbreeding populations between wild relatives and cultivated species. For example, farming communities have practiced selection from the natural interbreeding populations in the case of brinjal involving wild *Solanum* species; in the case of pigeon pea invloving wild *Cajanus cajanifolius*, C. *scarabaeoides* and *C. albicans*; and in the case of sesame involving *Sesamum indicum* with *S mulayanum*. This natual interbreeding and selection of elite varieties have helped the evolution and development of several new varieties and cultivars enriching the agrobiodiversity.

The Oraon tribes of the region generally speak Kurukh language. The Oraons mainly depend on agriculture. It is believed that Oraons tribal community first introduced plough cultivation in the Chotanagpur Plateau. They have developed a system of pasture land management

system. The region is known for sacred groves where sanctity is attached to venerated trees particularly used in religious rituals and medicinal plants. This traditional belief has helped the conservation and protection of forests.

7.16 Koraput Agrobiodiversity Region

Location and extent

The Koraput region forms part of Eastern Ghats in south western Orissa and north eastern districts of Andhra Pradesh (Vizagapatnam, Vijanagaram, Srikakulam.). The Koraput region is the home of ancient tribal communities of India i.e. Gonds, Khonds, Lahqulas and Kinnaras. The undulating topography of the northern Eastern Ghats, which includes the hill peaks i.e. Diwodi Munda (alt.1598 m above MSL), Nimgiri (alt.1515 m above MSL), Singaraju (alt.1516 m above MSL), Mahendragiri (alt. 1501 m above MSL), having climatic regimes of varied rainfall patterns, is a repository pristine wild relatives of crop plants and ethnic agricultural practices. Following are the major constituent areas: (i) Rayagada area consisting of two fertile valleys of the Nagavali and the Vansadhara, (ii) Koraput area from Kasipur to Vizagapattam plains. The Koraput plateau lies on a section of Eastern Ghats having mean elevations from 150 -1000 m above MSL. The hotspot area includes the districts of Malkangiri, Sonabeda, Jeypore, Koraput, Nabrangpur, Kalahandi, Bolangir, Rayagada and districts of north eastern Andhra Pradesh i.e. Srikakulam Vijanagaram, Vizagapatnam.

Agroclimate

Mean average annual rainfall is 1521mm. The area is drained by five rivers, namely, Vansadhara, Nagavali, Indravati, Kolab and Mackanand. The south west monsoon (June to September) is the principal source of rains. The rainfall varies from 1100 - 1650 mm. of which 79 per cent is received between July and September. The annual rainfall meets about 60 per cent of annual potential evopotranspiration. The soil remains dry from December to May. The moisture availability for growing crops ranges from 150-180 days in a year. The period from October to December is the post monsoon period with its characteristic frequent cyclones and cyclonic rains. Red sandy soils

Oryza officinalis subsp. ***malampuzhaensis***

Vigna radiata var. ***sublobata***

V. khandalensis

are characteristic of deciduous forest belt and the hills tops and slopes are covered with loose talus of the different gneisses. The delataic alluvial soils are also common along the hill slopes. Laterite patches are also seen in few scattered patches.

Floristic diversity

The region is a reservoir of floristic diversity consisting of around 2500 species of flowering plants. The forest types ranges from tropical semi-evergreen to dry deciduous. The dominant species in the tropical semi-evergreen forests are *Dalbergia latifolia*, *Dillenia pentagyna*, *Firmiana colorata*, *Macaranga peltata*, *Mesua ferrea*, *Syzygium cuminii*, *Terminalia elliptica*. The tropical moist deciduous forests are associated with canopy trees of Sal (*Shorea robusta*), *Callicarpa arborea*, *Diospyros melanoxylon*, *Haldinia cordifolia*, *Pterocarpus marsupium*, *Terminalia elliptica*, *Toona ciliata*. The tropical dry deciduous forests have the following dominant species: *Anogeissus latifolia*, *Buchnania lanzan*, *Boswellia serrata*, *Diospyros melanoxylon*, *Sterculia urens*, *Shorea robusta*.

Agriculture and agrobiodiversity

Rainfed farming is the prevalent agriculture practice in this region. The rice is the predominant crop having about 40 per cent of land under its cultivation. The other crops are maize (*Zea mays*), finger millet (*Eleusine coracana*), green gram (*Vigna radiata*), black gram (V. *mungo*), mustard (*Brassica juncea*), sesame (*Sesamum orientale*), and ground nut (*Arachis hypogaea*). The tribal communities in the hills grow minor millets, little millet (*Panicum miliaceum*), foxtail millet (*Setaria italica*), niger (*Guizotia abyssinica*), pigeon pea (*Cajanus cajan*) and horsegram (*Macrotyloma uniflorum*), etc. The region is also rich in medicinal and aromatic plants and more than 1200 medicinal plant species are recorded from this region. Horticultural crops cultivated, include : Lablab bean (*Lablab purpureus*), cucurbits, Brinjal (*Solanum melongena*), Chilli (*Capsicum annuum*), Ridge gourd (*Luffa acutangula*), Sponge gourd (*L. aegyptiaca*), Bitter gourd (*Momordica charantia*); Yam (*Dioscorea alata*); Sweet potato (*Ipomoea batatas*); Karonda (*Carissa carandas*); Pomello (*Citrus maxima*); *Cinnamomum tamala; Curcuma longa; Musa balbisiana;* Jack fruit (*Artocarpus heterophyllus*); Mango (*Mangifera indica*), *Phyllanthus emblica*, Date palm (*Phoenix dactylifera*);

Pepper (*Piper nigrum*); *Zingber zerumbet*, Halwa Tendu (*Diospyros kaki*); Teak (*Tectona grandis*); Tamarind (*Tamarindus indica*), etc. The cropping patterns are as follows: In the Koraput-Jeypore belt and along coastal belt of Orissa, rice is grown under rainfed and irrigated conditions. In the Bastar- Koraput belt the main alternate crops cultivated are ragi, pearl millet, *kharif* sorghum, small millets and pulses. Following are the cropping systems: rice – niger, rice – ground nut, rice – toria/mustard, rice – sesame, rice – potato – ground nut/sesame.

The Jeypore tract is considered as the centre of origin of Aus ecotype of rice (Sharma *et al*., 2000). Ramaiah (1953) first identified the Jeypore tract as an independent centre of the origin of cultivated rice. The M. S. Swaminathan Research Foundation (MSSRF), Chennai has further established Jeypore tract of Orissa as an important agrobiodiversity hotspot for rice. The region is also very rich in genetic diversity having a total of about 340 landraces of rice including 26 aromatic, 18 flood tolerant and 1 drought resistant genotypes. Some of the drought tolerant rice varieties identified by MSSRF are *Bhakadhan*, Scented varieties: *Bainshipala*, *Basuabhog*, *Chalianagi*, *Desia Dubraj*, *Deulabhoga*, *Donger haldi*, *Dubraj*, *Dudhamala*, *Dumri*, *Gangabli*, *Haldichudi*, *Jhagudu*, *Kalahandla meher*, *Kalajeera*, *Karburakoli*, *Loclimachhi*, *Mashiaphula*, *Miti miti*, *Nadiakarka*, *Nadiarasa*, *Nilamachhi*, *Nimma dhan*, *Rangsur*, *Samudrabali*, *Suru dhan*, *Swapur lochiai;* Flood tolerant varieties: *Baikhana*, *Basnimundi*, *Baunsaganthgii*, *Bilatichudi*, *Dhobkhuji*, *Garmukhi*, *Goindi*, *Gurumukhi*, *Haldiganthi*, *Kanar chudi*, *Kandulakanthi*, *Kharkoili*, *Kosam chudi*, *Kasanijabha*, *Madras chudi*, *Menchha*, *Nime chudi*, *Sopuri*.

Crops and wild relatives:

Cereals: Rice: *Oryza sativa*, *O. sativa* var. *plena*: landraces of rice: *Baddu dhan*, *Bayagunda*, *Bidamasolpuru*, *Budama*, *Chinna kondangi*, *Ekobit*, *Erra Budama*, *Kodu*, *Budhama*, *Meraka vari*, *Metta Budagalu*, *Padadhan*, *Pantoor*, *Paramayipalu*, *Pasupusanalu*, *Potti basangulu*, *Sagara*, *Sannalu*, *Sanna dhanyam*, *Sitamma savaralu*, *Sopuru dhan*, *Tella budama*, *Toka budama*, *Voldisopuru*, *Vooda sannalu* (Pokali varieties); WR Rice *Oryza jeyporensis*, *O. meyeriana* var. *granulata*, *O. rufipogon*.

Millets: *Echinochloa frumentacea*, Barnyard millet (*E. cruss-galli*), *Panicum hippothrix*, *P. trypheron*, Kodo millet (*Paspalum scrobiculatum*), Finger

millet (*Eleusine coracana*), Italian millet (*Setaria italica*); Landraces of little millet: *Kosla*, *Swan*.

Legumes: Pigeon pea and WR: (*Cajanus cajan*), *C. cajanifolius*, *C. scarabaeoides*, *C. sericeus*: landraces of Pegion pea: Kutti kandalu, Gaya saan, Kaanti sissam, Mara jang saan, Nadipi kundulu, Nemali pitta kundulu, Tarba saan, Tella siri kandi, Tulu masaan, Yerra siri kandi; *Canavalia gladiata*, Horsegram (*Macrotyloma uniflorum*), Purple bean (*Macroptelium atropurpureum*) *Mucuna monosperma*, *M. pruriens* var. *utilis*, *Vigna triloba*, Rice bean (*V. umbellata*), *Vigna unguiculata* .

Vegetables: Okra and WR: (*Abelmoschus esculentus*), *A. ficulneus*; Amaranth: *Amaranthus dubius*, *A. tenuifolius*, *Amaranthus viridis;* Ash gourd (*Benincasa hispida*), Chilli (*Capsicum annuum*), *Capsicum frutescens*, *Canavalia gladiata*, Karonda (*Carissa carandas*), Pomello (*Citrus maxima*), Ivy gourd (*Coccinia indica*), *Cucumis hystrix*, *C. melo*, C. *pubescens*, *C. sativus*, Gurguria, leaves used for flavouring (*Eryngium foetidum*), Kenaf (*Hibiscus cannabinus*), Roselle (*Hibiscus sabdariffa*), Bitter gourd: *Momordica balsamina*, *M. tuberosa;* Banana: (*Musa sapientum*), *Musa ornata*, Brinjal (*Solanum melongena*) *S. nigrum*, *S. torvum*.

Fruits : Grapes: *Vitis vinifera* (*cult.*), *V. heyneana*.

Yams and tubers: *Amorphophallus paeonifolius;* Taro (*Colocasia esculenta*), East Indian arrow root (*Curcuma angustifolia*), Mango ginger (*Curcuma amada*); Turmeric: *Curcuma longa*, *C. zedoaria;* Yam WR (*Dioscorea alata*), *D. belophylla*, Potato yam (*D. bulbifera*), *D. glabra*, *D. glabra*, *D. hispida*, *D. intermedia*, *D. oppositifolia*, *D. pentaphylla*, *D. puber*, *D. tomentosa*, *D. wallichii*, *D. wightii;* Indian Kudzu vine (*Pueraria tuberosa*), *Vigna vexillata*.

Edible oil: Sesame (*Sesamum indicum*). Non edible oilseeds: Physic nut: *Jatropha curcas*, *Jatropha gossypifolia*, Castor (*Ricinus communis*).

Spice: *Curcuma aromatica*, *C. domestica*, *C. montana*, *C. pseudomontana*, *Eryngium foetidum*, *Cinnamomum tamala*, *Vanilla wightii*.

Other economic plants

Fruits: Jack fruit (*Artocarpus heterophyllus*), *Carissa inermis;* Lime (*Citrus aurantifolia*); WR Persimmon (*Diospyros embryopteris*), Kendu

(*D. exsculpta*), Sweet Persimmon (*Diospyros kaki*), Beedi leaf (*Diospyros melanoxylon*); WR Persimmon: *Diospyros racemosa*, *D. sylvatica*, *D. tomentosa; Elaeagnus latifolia*, Kharpet (*Garuga pinnata*); WR Phalsa (*Grewia tenax*), Wood apple (*Limonia acidissima*); Mango (*Mangifera indica*, *M. sylvatica*); Gooseberry: *Phyllanthus emblica*, *P. narayanaswami;* Jamun: *Syzygium cuminii*, *S. alternifolia*, *S. zeylanicum;* Tamarind (*Tamarindus indica*); *Ziziphus horrida*. Less known fruits and vegetables: *Ampelocissus indica*, *Cissus repanda*, (stem provides water), *C. repens.*

Medicinal plants: *Curcuma pseudomontana*, *Centella asiatica*, *Helicteres isora*, *Piper longum*, *Piper nigrum*, *Plumbago zeylanica*, *Rauvolfia serpentina*.

Timber: *Chloroxylon sweitenia*, *Dalbergia latifolia*, *D. paniculata*, *Lannea coromandelica*, *Lagerstroemia parviflora*, Sal (*Shorea robusta*), Teak (*Tectona grandis*), *Terminalia paniculata*. Multipurpose species: *Bauhinia vahlii* (leaves used in making leaf plates), Tendu (*Diospyros melanoxylon*), Mahua (*Madhuca longifolia*), *Phoenix humilis*, *P. sylvestris*, *P. robusta*, Castor (*Ricinus communis*). White mulberry: *Morus alba*.

Endemic species: *Acacia donaldii*, *Aglaia haslettiana*, *Albizia orissensis*, *A. thomsonii*, *Bupleurum andhricum*, *Cajanus cajanifolius*, *Dimeria orissae, Oryza jeyporensis*, *O. nivara*, *Phyllanthus narayanaswamii*, *Plebophyllum jeyporensis*.

Threatened species: *Acacia donaldii*, *Albizia orissenis*, *A. thompsonii*, *Argyreia arakuensis*, *Cajanus cajanifolius*, *Oryza officinalis* var. *malampuzhaensis*, *O. jeyporemsis*, *Zingiber roseum*.

Associated culture and tribes

Muchkund valley is inhabited by primitive tribes notable among whom are the Bonda, Porajas, Koyas and Didayis etc. The major tribes are: Bodo-Gadaba, Bondo Poroja, Gutob Gadaba, Khond Poroja, Parangi Poroja, Dongaria Khonds, Konda Savaras, Kutia Birhor, Didayi, Mankidias, Lodha, Bondo, Dongaria Kondhs, Kutia Kondhs, Lanjia Saora, Paudi Bhuyan, Saora, Karias, and Juangs. One subgroup of Kondhas called the Dongria Kondhas live in parts of Rayagada and Koraput and they are well known for protecting hills and streams. Dongria khondas are excellent fruit farmers and

Shola forests- A pristine habitat in high altitude mountains in Southern peninsular India, notable as a reservoir of several valuable plant genetic resources

***Elettaria cardamomum*-** The Malabar agrobiodiversity region is rich in the genetic resource base of the cardamom of commerce

Curcuma aromatica–A wild relative of turmeric

Curcuma harita- A wild relative of turmeric in Malabar agrobiodiversity region

Alpinia galanga-The source of Galanga - a high value medicinal plant

Alpinia calcarata- A wild relative of Galanga

Alpinia manii- A wild relative of Galanga

they grow oranges, pineapple, turmeric, ginger and papaya, jack fruit and mango. Besides, Dongrias also practice shifting cultivation called "Podu Chasa". It is reported that tribal farmers synchronise the growing of a particular variety of rice in relation to different festivals like Chaitra Parva during April, Lakshmi Puja during November, annual ceremony of ancestors and temple deities during November and Shakti Puja during December. The scented rice variety "Kala Krishana" is grown for all festivals. The scented rice variety "Tulsi" is grown for Chaitra Parva, the short -grained and tasteful rice variety "Machhakante" is grown for Lakshmi Puja. The rice variety "Mer" with black grains and medicinal properties is grown for annual ceremonies of ancestors and the scented rice variety "Kala jeera" is grown for worshipping temple deities. The long- grained, tasteful rice variety "Haladichudi" is grown for Shakti Puja. The short-grained, reddish tinged and mildly scented "Deulabhoga" is preferred for worshipping temple deities (Arunachalam *et.al.* 2006).

Technology and products

The Adivasis are the main inhahitants of the region. The people of this region, belonging to different tribal groups, have conserved a large number of landraces of rice, millets, pulses and medicinal plants, using diverse traditional cultivation practices, which have been developed as an answer to the topographical and ecological diversity of the region.

The topographic heterogeneity of the region has resulted in a wide diversity in the ecosystems under which rice is cultivated in upland, medium land (irrigated and rainfed) or low land conditions. Within each ecosystem, number of rice varieties are grown by the farmers depending on the local preferences for morphotypes, such as plant height, pigmentation, grain shape, presence of awns or cultural practices, such as broadcasting, transplanting, food quality and utility (cooked rice, popped rice, puffed rice) and palatability (aromatic and non-aromatic). The rice genome has been subjected to selection pressures for salinity tolerance, drought tolerance, inundation tolerance, grain palatability, grain storage quality, quality of rice grains for pudding, pilave, puffed rice and this has resulted in the development of useful variability and genetic diversity in rice.

Jeypore-Koraput tract is considered by the rice researchers as a centre of genetic diversity and secondary centre of origin of rice. Hence the Koraput region is considered as one of the Globally Important Agricultural Heritage Systems (GIAHS).

The selection pressures of local communities have resulted in generating useful characterisation for various traits, like Pokali rice varieties with salinity tolerance. Ptb 33 landrace from the region is known for resistance to brown plant hopper with gene bph3, whereas Veluthachira is a source of Gall midge resistance. Similarly variability is noticed in the case of minor millets, which are the second most important crops and staple food of local community. In little millet, the variety GLM 203 has been developed through selection from landrace Koraput local, while in finger millet, the variety PR-202 is selected from local dry ragi (Methachadi) of Araku valley of Vishakapatnam (Seetharama *et al.*, 2006).

In pigeon pea, landraces, like ICP 1903 from Andhra Pradesh, tolerant to pod borer has been used in the development of cultivar, Abhya. In cow pea, rich variability exists for the traits such as growth habit, flower colour, colouration of plants, including pod and seed, and their size. It is noted that urad bean has good plant morphotypes.

In the case of oilseed crops, significant variability has been recorded in the case of sesame, where variety Vinayak is a selection from a local landrace of Mathasathi. Similarly in niger, bold seeded type has been known from the region and variety like, Deamali (GA10) is selected from a local landrace, while the varieties GA 2 and GA 10 are selected from Gaudaguda local of Vijaynagram.In vegetable crops, the region has recorded high variability in the case *Solanum melongena*, and chillies for fruit colour, shape, size and pungency (Kalloo *et al.*, 2005). Also, in cucurbits high variability has been recorded, as reflected by the presence of several wild relative species, such as *Cucumis hystrix*, *Luffa acutangula*, *L. graveolens*, *L. umbellata*, *Momordica cochinchinensis*, *M. dioica*, *Trichosanthes tricuspidata*, *T. cordata*, *T. multiloba* ,*T. ovigera* (Sirohi *et al.*, 2005). Also, in okra there is maximum variability for fruit and plant types along with the presence of *Abelmoschus crinitus* (Dhankhar *et al.*, 2005).

In fruits the region is known for traditional varieties in mango, such as Baneshan, Langra, Neelum, Suvarnarekha. The Koraput region has rich variability in ginger having traits of adaptability, maturity, fibre content, and dry matter recovery. Several varieties have been developed through clonal selection from local collections, like Suprabha and Suruchi from collections of Kunduli, Orissa and Surabhi, from Rudrapur local. Similarly, in turmeric, Roma was derived from T. Sunder and Ranga from Rajpuri local through clonal selection; while Suroma was a mutant selection from T. Sunder (Ravindran *et al.*, 2005).

The farmers have also taken advantage of naturally occurring interbreeding populations between wild relative and cultivated species in the case of cross-pollinated crops like *Solanum* and *Cajanus* species resulting in the development and adoption of diversity within a crop species.

Farmers here usually use plough for the wetland (Bed) cultivation; while they use axe and hoe for shifting cultivation called "Podu". Highly sophisticated terracing and contour bunding are practiced along slopes and gradients. It is worth noting that the wild relatives of rice i.e. *Oryza granulata*, *O. officinalis*, and *O. nivara* have contributed useful genes and thus significantly helped in developing improved varieties of cultivated *Oryza sativa* with low incidence of grassy stunt virus, bacterial blight, brown plant hopper and green leaf hopper (Khush, 1977). The endemic species *Cajanus cajanifolius* occurring in the Koraput region has contributed to the higher pod and seed yield in the cultivated crop species *Cajanus cajan* (Vavilov, 1951).

7.17 Southern Eastern Ghats Agrobiodiversity Region

Location and extent

The Southern Eastern Ghats Agrobiodiversity region constitutes southern parts of Andhra Pradesh comprising areas south of river Godavari and includes Nallmalai-Palkonda ranges, Seshachalam hills, Rayalaseema, Tirupati hills and adjacent semi arid districts. The hotspots are the districts of Chittoor, Ananthapur, Cuddapah,

Kurnool in Andhra Pradesh and districts of Bellary, Raichur and Kolar in Karnataka.

Agroclimate

The Southern Eastern Ghats region represents a large area of tropical dry deciduous and thorn forests of the southern Deccan plateau and dry districts on the lee-ward side of the southern Western Ghats mountain ranges. These extend across the southern Andhra Pradesh, uplands of southeastern Karnataka. The southern Eastern Ghats and the southern Deccan Plateau receive very little rainfall during winters with annual rainfall of 500 – 1000 mm. The region is a hot semi-arid eco-region with red loamy soil. The climate of the region is characterised by hot and dry summer and very mild cold season. The length of growing period extends from 120 to 150 days in a year. The major landscape of the area is moderate to gentle sloping. Generally, the soil is non-calcareous and slightly acidic in nature in some patches. However, in some patches, the soil is calcareous and moderately alkaline in reaction.

Floristic diversity

The natural vegetation comprises of tropical dry deciduous and tropical thorn forests. The dry deciduous forests of this region are flanked by the moist deciduous forests along the lower elevations, which receive south west monsoon, and by thorn scrub in regions, which receive north east monsoon. The forests in the Eastern Ghats show distinct zonation with altitude, scrub forest 400 m (foot hills), deciduous forest 300-900 m (slopes), evergreen forest 800-1300 m (Plateau) and sholas 1200-1600 m.

The vegetation is characterised by *Anogeissus latifolia*, *Acacia catechu*, *Boswellia serrata*, *Terminalia tomentosa*, *T. paniculata*, *T. bellerica*, *Albizia amara*, *Cassia fistula*, *Hardwickia binata*, *Dalbergia latifolia*, *Sterospermum personatum*, *Pterocarpus marsupium*, *Diospyros montana*, and *Shorea tumbuggaia*. The vegetation of Eastern Ghats is significant due to the presence of threatened and economically important species, such as *Cycas beddomei*, *Eriolaena lushingtonii*, *Hildegardia populifolia*, *Pterocarpus santalinus*, *Shorea tumbuggaia*, *Santalum album*, *Terminalia pallida*.

Agriculture and agrobiodiversity

It is seen that the farmers of the region follow rainfed farming. The important crops cultivated in the semi dry southern Andhra Pradesh are millets, pulses and oilseeds in *kharif* season and sorghum and oilseeds in *rabi* season. Ground nut is cultivated in southern Andhra Pradesh and northeastern Tamil Nadu both under irrigated and non-irrigated conditions. In the dry districts of Ananthapur and Cuddappa, shifting cultivation "Podu" and nomadic pastoralism are common.

Cropping pattern

In the Ananthapur Dry region, the following crops are cultivated: early maturing sorghum varieties, pegionpea, castor, mesta. The crops Pearl millet, Foxtail millet and ground nut are sown (Rathore *et al.*, 1991) if there is late rainfall. . In the Kolar semi-arid region, *kharif* crops like maize, red gram and ragi are grown, while in the eastern zone of this region sorghum, pearl millet, ground nut and cowpea are grown. The cropping patterns are as follows: rice - sesame, rice - ground nut, rice – sunflower, sesame – fingermillet, mung bean/ urad bean – ground nut, fingermillet – rice – ground nut, rice – rice – ground nut, rice – rice – sesame – ground nut, rice-rice-sesame. The following combination of crops are practised for mixed crop farming: Castor + ginger / turmeric; Castor + sesame; Castor +sesame/ Pigeon pea + ground nut.

Crops and wild relatives:

Cereals: Rice (*Oryza sativa*): rice varieties: (*Ratna*, *Padma*, *Kumar*, *Parijata*, *Annapurna*, *Suphala*, *Hema*, *Rajeswari*, *Jaya*, *Sakti*, *Vijaya*, *Jayanti*, *Pankaj*, *Mahasuri*, *Jaganath*, *Cauvery*, *Bala*, *Kalinga*); landraces of rice: *Thella sanna Vodlu*, *Yerra sanna Vodlu;* Oryza WR: *Oryza meyeriana* var. *granulata*, *O. officinalis* var. *malampuzhaensis*; Sorghum (*Sorghum bicolor*). Millets: *Dactyloctenium aegypticum*, Digitaria (*Digitaria tomentosa*), Finger millet (*Eleusine coracana*), WR Finger millet (*Eleusine indica*), WR Barnyard millet (*Echinochloa colona*), Barnyard millet (*E. cruss-galli*), Japanese Barnyard millet (*E. frumentacea*), *Panicum geradei*, Proso millet, (*P. miliaceum*), *P. trypheron*, Kodo millet (*Paspalum*

scrobiculatum), Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*).

Legumes*:* Ground nut (*Arachis hypogaea*), Pigeon pea (*Cajanus cajan*), *C. scarabaeoides*, *C. candollei;* Pigeon pea landraces :Natu Kandi, Peda kandi, Tota kandi; Chickpea (*Cicer arietinum*), Purple bean (*Macroptelium atropurpureum*), Green gram (*Vigna radiata*), *V. triloba*, Hyacinth bean (*Lablab purpureus*)*:* Field bean landraces*: Anapa*, *Natu anumulu; Trigonella occulta.*

Vegetables: *Abelmoschus esculentus*, *A. ficulneus; Allium cepa:* landraces of Onion: *Chinna erragada*, *Erra gada*, *Tella gadda;* Amaranth*: Amaranthus spinosus*, *A. tenuifolius*, *A. viridis*, *A. dubius;* Pumpkin: *Cucurbita pepo*, Melon: *Cucumis melo* var. *agrestis*, *C. pubesens;* Cucumber*: Cucumis sativus;* Bitter gourd*: Momordica charantia*, *M. tuberosa: Balsam Apple : Momordica balsamina;* Kudzu vine: *Pueraria tuberosa;* Brinjal (*S. melongena*): landraces of Brinjal: *Sanna vanga*, *Saara vanga*, *Tella mulaka*, *Tella vanga; Solanum erianthum*, *S. nigrum*, *S. surattense.*

Tubers*:* Elephant-foot Yam (*Amorphophallus paeonifolius*), Mango ginger (*Curcuma amada*), Turmeric (*Curcuma longa*), *C. zedoaria*, Potato Yam *Dioscorea bulbifera*, *D. pentaphylla*, *D. intermedia*, *D. wightii*, *D. wallichii*.

Edible oilseeds*:* Mustard (*Brassica rapa* subsp. *campestris*), Sesame (*Sesamum indicum*), *S. alatum*, *S. laciniatum*, *S. prostratum*. Non edible Oilseeds: Castor (*Ricinus communis*), Physic nut (*Jatropha curcas*), *J. gossypifolia;* Aromatic oils*: Cymbopogon flexuosus*, *C. martinii*.

Other economic plants

Fruits: *Aegle marmelos*, Palmyra (*Borassus flabellifer*)*;* Karonda (*Carissa carandas*) *Carissa inermis;* Lime (*Citrus aurantifolia*) Pomello (*Citrus maxima*), Khonda mavu (*Commiphora caudata*); Wood apple (*Limonia acidissima*); Mango (*Mangifera indica*) landraces of Mango: *Baganapalli*; *Phyllanthus emblica*, *P. fischeri; Phoenix pusilla*, *P. sylvestris*, *P. robusta;* Clove tree (*Syzygium aromaticum*), *S. alternfolia*, *S. zeylanicum*, Rose apple (*S. Jambos*), Jamun (*S. cuminii*)*;* Grapes (*Vitis vinifera*), *Ziziphus horrida*.

Wild plants used as vegetables: *Corchorus aestuans* (tender leaves), *Digera muricata*. *Hibiscus aculeatus*, *H. cannabinus.* Fibre crops: Sunhemp (*Crotalaria juncea*), Roselle (*Hibiscus sabdariffa*), Kenaf (*Hibiscus cannabinus*), *Decaschistia cuddaphensis*, *D. rufa;* Cotton (*Gossypium hirsutum*, *G. arboreum*); Gums and resins: *Sterculia foetida*, *Sterculia urens.* Fodder: *Iseilema laxum*, *Mucuna pruriens* var. *pruriens*, *Sorghum halepense.*

Ornamentals: Scarlet Ixora (*Ixora coccinea*); Bluebell barleria (*Barleria cristata*), *Bauhinia purpurea; Crossandra infundibuliformis; Gomphrena globosa;* Jasmine WR : *Jasminum angustifolium*, *J. auriculatum*, *J.scandens*

Medicinal plants: *Andrographis paniculata*, *Centella asiatica*, *Costus speciosus*, *Gloriosa superba*, *Phyllanthus amarus*, *Piper longum*, *Plumbago zeylanica*, *Strychnos nox-vomica*, *Tacca leontopetaloides*, *Terminalia bellerica*, *T. chebula*. *Tinospora cordifolia*.

Endemic species: *Albizia sikharamensis*, *Andrographis nallamalayana*, *Boswellia ovalifoliolata*, *Crotalaria madurensis*, *Cycas beddomei*, *Decaschistia cuddaphensis*, *Decaschistia rufa*, *Erioloena lushingtonii*, *Hildegardia populifolia*, *Indigofera barberi*, *I. mysorensis*, *Luffa acutangula* var. *amara*, *Oryza officinalis* subsp. *malampuzhaensis*, *Parahyparhenia bellariensis*, *Pterocarpus santalinus*, *Shorea tumbuggaia*.

Threatened species: *Acacia campbelli*, *Albizia thompsonii*, *Asparagus rottleri*, *Crotalaria paniculata* var. *nagerjunekondensis*, *C. willdenowiana* subsp. *glabrifoliolata*, *Cycas beddomei*, *Erythrina variegata* forma *mysorensis*, *Indigofera barberi*, *I. constricta*, *Madhuca diplostemon*, *Oryza nivara*, *O. officinalis* subsp. *malampuzhaensis*.

Associated culture and tribes

The hilly areas of the Eastern Ghats in Andhra Pradesh are inhabited by large tribal communities. The major tribes among them are Bagatas, Chenchus, Jatapus, Khonds (Samantas), Kondadoras, Konda Kammaras, Konda reddis, Koyas, Lambadis (Sugali), Nuka doras (Muka doras), Porjas (Gadabas), Savaras and Valmikis. Some Negritos tribes-Irulas, Kodars, Paniyans and Kurumbas-are also found in patches.

On the day of "Peddala amavasya", a day for worshipping ancestors, Foxtail millet (*Setaria italica*) is cooked as a sweet pudding; while chickpea (*Cicer arietinum*) is used for making *bhaji*. Pudding using ground nut (*Arachis hypogaea*) is also prepared during the festival days of Ugadi. The tribe Chenchus live in forested areas and they collect mahua flowers, tamarind, tubers and honey and sell them in the village market.

Technology and products

The region is known for dryland agriculture and it is seen that there are drought tolerant landraces in most crops. In rice, the area is known for variability in sticky nature of rice and the popular variety Sona Masuri. In bread wheat, the semi-arid districts of Karnataka region is known for variability in grain weight/ spike, grain colour; whereas, in the case of durum wheat, the characteristics are leaf colour at fifth leaf stage, spike length, awn length, grain weight/spike, grain number/ spike, etc. (Singh[3] *et al.*, 2006). In the Karnataka part of the region, dicoccum wheat is also grown. Khapli dicoccum is well known for quality, stem rust resistance and is being widely used in breeding programmes. In minor millets, variability exists for different desirable features resulting in the selection of varietal products, for example in foxtail millet variety, SrA 326, a selection from local Garladinne village of Kurnool (Seetharama *et al.*, 2006). In finger millet, sources of several physiological traits have been identified, such as GE 94 with low stomata number, low leaf area, high photosynthetic efficiency and higher water use efficiency under stress; while the varieties DES172 and PR202 are known for good germination in the parched soil of Andhra Pradesh region. Whereas, GE187, has low stomata number, low leaf area, high photosynthetic efficiency; GE 1097 with high leaf area, high dry matter and moderate to high photosynthetic efficiency; whereas the variety GE2338 has higher water use efficiency under stress, high biomass production and high harvest index (>35%); GE 1179, GE 2327, GE 500, GE 3302 with high biomass production and high harvest index (>35%); The varieties IE 2643, IE 3200, IE 2333 from Karnataka region have drought tolerance. In Karnataka, pearl millet landraces have characteristics of tall height with larger and broad leaves and small spike. A unique landrace IS 530, with bristled ears have been collected from Andhra Pradesh.

Among oilseed crops, significant genetic diversity has been observed in the case of niger for medium seed size, high oil contents (40 – 43%) from Karnataka, and drought tolerance. Niger varieties No.71 (KRN1) and RCR66 are selections from local landraces from Raichur (Duhoon[1] *et al.*, 2004). Besides, safflower variety A-300 has been derived from a local landrace. In vegetable crops, the region has recorded high variability in the case of brinjal (*Solanum melongena*), and chillies for fruit colour, shape, size and plant type. Similarly, variability has been recorded in okra for various desirable features in fruit. There are many traditional varieties in mango, such as Banganpalli, Totapari, Cherukurasam, Himayuddin, Suvarnarekha. There is significant variability in the case of ginger and turmeric. The region is also known for variability in seed spices like coriander, where several varieties have been developed from local collections through mass selection. For example, Sadhna was developed from Alour collection, Swathi from Nandyal collection and Sindhu from a local collection (Ravindran *et al.*, 2005).

The forest areas of the region are known for sandalwood (*Santalum album*) and red Sander tree (*Pterocarpus santalinus*). Useful and profitable cultivation practices of the area are the intercropping of marigold with chillies for control of pests and nematodes, use of Neem (*Azadrachta indica*) for the control of insect pests. There are large number of underutilised edible greens and fruits which serve as life supporting species during periods of scarcity caused by vagaries of monsoon rains.

For improved management of water, Cheruvu reservoirs are developed to store runoff water in Chitoor, Cudappa districts of Andhra Pradesh. They are provided with thoomu (sluices), alugu or marva or kalju (flood weir) and kalava (canal).

7.18 Kaveri Agrobiodiversity Region

Location and extent

The Kaveri agrobiodiversity region includes the coromandel plains comprising the districts of Chengai Anna, South Arcot, North Arcot, Ambedkar, the alluvial plains of the Kaveri delta in

the east (districts of Thiruvannamalai, Tiruchirapalli Thanjavur, Pudukottai, Thiruvarur), and the Javadi hills, Shevaroy hills, Kolli malai, Pachaimalai hills, Sirumali hills encomposing the districts of Vellore, Kanchipuram, Salem, Erode, Namakkal, Karur and Dindigul. The Kaveri delta has delta head and delta proper which includes Valar doab, Kaveri doab, main delta plains and marshy low and dune belt near Vedaranyam salt swamps. The hotspot area consists of the districts of Chengai Anna, South Arcot, North Arcot, Ambedkar, Thiuvannamalai, Tiruchirapalli, Pudukottai, Thiruarur, Vellore, Kanchipuram, Dharmapuri, Salem, Namakkal, Karur and Dindigal.

Agroclimate

The region is a warm ecoregion with constituent alluvial loamy soil in the delta region, ferruginous loam in the interior and patches of black cotton soil in the north western districts. The climate of the region is characterised by hot dry summers from March to August with intermittent rains from south west monsoon and mild summer from September to February with good rainfall from northeast monsoon from October to December. The annual temperature ranges from 25° C- 40° C. There is severe drought during the growing period in the Javadi, Kolli hills and Pachamalai hill areas. The annual rains in the dry Javadi hills, Pachamalai hills, Kolli hills vary from 760 - 1020 mm per annum. The length of growing period extends from 90 to 150 days in a year. The annual rainfall in the deltaic region ranges from 1000 to 1140 mm and the growing period varies from 120 to 200 days.

The rapid decrease in rainfall pattern from the coastal region to the Tamil Nadu hills is notworthy as the coastal areas receive rains from northeast cyclonic rains. Kaveri delta and the riverine beds in the plains have loamy river alluvial soil. The major portion of the interior has either ferrugenous sandy soil or ferugenous loam. Black cotton soil, which has characteristic properties of shrinkage and cracking, is seen in parts of Tiruchirapalli, South Arcot and North Arcot and Dharmapuri districts. Red soil is seen in pockets of Tiruchirapalli and Pudukottai areas.

Floristic diversity

The vegetation comprises of tropical dry deciduous and tropical thorn forests. tropical dry deciduous strand vegetation and mangroves. The Tropical thorn forest of Tamil Nadu, is differentiated into (i) Southern thorn forest (ii) Carnatic umbrella thorn forest (iii) Southern euphorbia scrubs, and (iv) Southern thorn scrubs. The characteristic tree of Carnatic umbrella thorn forest is *Acacia planifrons*. The Southern euphorbia scrub has characteristic plants, *Euphorbia antiquorum*, *E. tirucalli*, *Capparis spinosa* and *Barleria spinosa*. The landscape is dotted with tall Palmyra trees (*Borassus flabellifer*). The common trees of Dry deciduous forests are *Acacia chundra*, *A. leucophloea*, *Azadirachta indica*, *Dichrostachys cinerea*, *Plecospermum spinarum*, *Strychnos nux-vomica*, *Wrightia tinctoria*. The tidal mangroves represented in Pichavarm mangrove area include the following representative species: *Aegiceras corniculatum*, *Avicennia marina*, *A. officianalis*, *Ceriops decandra*, *Rhizophora apiculata*, *R. mucronata*. Wherever there are sea intrusions along the coast, there are salt tolerant species: *Apluda mutica*, *Atriplex repens*, *Eremopogon fovealatus*, *Sporobolus tremulus*, *Suaeda sp.*

Agriculture and agrobiodiversity

The farmers of the region follow rainfed farming in the dry Tamil Nadu hilly outcrop areas of Shevaroy, Javadi, Kolli and Pachamalai hills and irrigated farming along the hinterland of Kaveri basin and delta. The important crops cultivated in the semi dry hills are millets, pulses and oilseeds in *kharif* season and sorghum and oilseeds in *rabi* season. Ground nut is cultivated in the northeastern Tamil Nadu both under irrigated and non-irrigated conditions. The Kaveri basin is a granary of paddy as the area is supported by network of irrigation canals. In the black cotton soil belt, cotton and sunflower is cultivated in large scale. Tapioca is cultivated in Erode and Salem for the flourishing starch industry. Plantain and coconut are cultivated on commercial scale wherever irrigation facilities are available. The cropping patterns are as follows: rice – sunflower, sesame – finger millet, mung bean/ urd bean – ground nut, rice – rice – ground nut, rice – rice – sesame – ground nut, rice -rice- sesame. The important species of the Javadi and Dharmapuri

forest is sandalwood (*Santalum album*) which is of commercial importance. MSSRF has identified Kolli hills in Tamil Nadu as an important agrobiodiversity centre for millets and rice and is engaged in the conservation of genetic resources. Some of the rice varieties identified by MSSRF are as follows: Resistant to pests and diseases: *Arcot kitchilli*, *Bangalore kar*, *Kattu nellu*, *Kurvai nellu*, *Kullan kar*, *Madumulungi*, *Paguna palai*, *Pulithikar*, *Samba mosanam*, *Samba nellu*, *Vella puzhithi;* Flood tolerant varieties: *Karum puzhithi*; Drought tolerant varieties: *Aadimodan*, *Kappa kar*, *Karum puzhithi*, *Kotta nellu*, *Thungara*, *Vadan Samba;* Scented varieties: *Aarcadu kitchedi Samba*, *Jeeranga Samba*.

Crops and wild relatives

Cereals: *Oryza meyeriana* var. *granulata*, *Oryza officinalis* var. *malampuzhaensis*; Resistant to pests and diseases: Arcot kitchilli, Bangalore kar, Kattu nellu, Kurvai nellu, Kullan kar, Madumulungi, Paguna palai, Pulithikar, Samba mosanam, Samba nellu, Vella puzhithi; Flood tolerant varieties: Karum puzhithi; Drought tolerant varieties: Aadimodan, Kappa kar, Karum puzhithi, Kotta nellu, Thungara, Vadan Samba; Scented varieties: Aarcadu kitchedi Samba, Jeeranga Samba. Millets: Finger millet (*Eleusine coracana*), Thipa ragi (*Eleusine indica*), Vedalu (*Echinochloa colona*), Barnyard millet (*E. crus-galli*), *Panicum geradei*, Proso millet, (*P. miliaceum*), *P. trypheron*, Kodo millet (*Paspalum scrobiculatum*), Pearl millet (*Pennisetum glaucum*), Foxtail millet (*Setaria italica*).

Vegetables: Okra: (*Abelmoschus esculentus*), *A. ficulneus;* Amaranth: *Amaranthus dubius A. spinosus*, *A. tenuifolius*, *A. viridis;* Canavalia (*Canavalia ensiformis*); Chilli *Capsicum annuum*, *C. frutescens; Water* melon (*Citrulus lanatus*), Gherkin: *Cucumis anguria*, Musk melon: *Cucumis melo;* Cucumber: *Cucumis sativus;* Pumpkin (*Cucurbita pepo*), Winter squash: *C. maxima;* Ridge gourd (*Luffa acutangula*), *L. aegyptiaca*, Bottle gourd *Lagenaria siceraria*; Purple bean (*Macroptelium atropurpureum*); Balsam apple: *Momordica balsamina*, Bitter gourd *Momordica charantia*, *M. tuberosa;* Drumstick (*Moringa oleifera*); Agasthi: *Sesbania sesban*. Brinjal (*Solanum melongena*), *S. nigrum*, *S. surattense*, *S. torvum*; Snake gourd (*Trichosanthes cucumeriana* var. *anguina*), *T. cucumeriana* var. *cucumeriana*, *T. dioica*.

Fruits: Palmyra (*Borassus flabellifer*), Plantain (*Musa acuminata*, *M. sapientum*), Mango (*Mangifera indica*); *Phoenix pusilla*, Tamarind (*Tamarindus indica*); Grapes: *Vitis vinifera*.

Tubers: Elephant-foot Yam (*Amorphophallus paeonifolius*), Potato Yams: *Dioscorea bulbifera*, *D. alata;* Sweet Potato (*Ipomoea batatas*)*;* Tapioca (*Manihot esculentum*)*;* Indian Kudzu: *Pueraria tuberosa*.

Edible oilseeds*:* Sunflower (*Helianthus annuus*), Sesame (*Sesamum indicum*)*;*

Non edible oilseeds: Pongam oil tree (*Pongamia pinnata*), Castor (*Ricinus communis*), Physic nut*: Jatropha curcas*, *J. gossypifolia*, *J. villosa* var. *ramnadensis.*

Fruits: Sapota (*Manilkara zapota*), Aegle *marmelos*, Karonda (*Carissa carandas*), *Carissa inermis;* Lime (*Citrus aurantifolia*), Lemon (*Citrus limon*), Pomello (*Citrus maxima*), *Mangostan* (*Garcinia mangostana*), Wood apple (*Limonia acidissima*), Mango (*Mangifera indica*); *Phyllanthus emblica*; Guava (*Psidium guajava*)*;* Clove tree (*Syzygium aromaticum*), S. *alternfolia*, *S. zeylanicum*, Rose apple (*S. jambos*), Jamun (*S. cuminii*), Tamarind: *Tamarindus indicus; Ziziphus horrida*. Fibre crops: Sunhemp (*Crotalaria juncea*), Roselle (*Hibiscus sabdariffa*), Cotton (*Gossypium hirsutum*), *Sansevieria roxburghiana*. Dye yielding species: Indigo WR**:** *Indigofera coerulea* var. *coerulea*, *I. tinctoria*; *Acacia catechu*, *A. nilotica; Caesalpinia pulcherrima*, *C. sappan; Hibiscus rosa-sinenesis; Lawsonia inermis.*

Ornamentals: Scarlet Ixora (*Ixora coccinea*), Bluebell barleria (*Barleria cristata*), *Bauhinia purpurea*, *Crossandra infundibuliformis*, *Gomphrena globosa*, *Jacaranda acutifolia; Sandal* wood: *Santalum album;* Beverages*: Coffee* (*Coffea arabica*)*;* Sugarcane*: Saccharum officinarum*. Multipurpose species: Katha (*Acacia catechu*), Wood (*Albizia amara*), *Dalbergia latifolia*, Timber (*Tectona grandis*), Palmyra palm (*Borassus flabelifer*), Host for silkworm (*Morus alba*), *Sesbania sesban*, *Terminalia elliptica*, *T. paniculata*, *T. bellerica*.

Medicinal plants: *Abelmoschus manihot*, *Acorus calamus*, *Adhatoda vasica*, *Alangium salvifolium*, *Bacopa monnieri***,** *Centella asiatica*, *Eclipta prostrata*,

Hemidesmus indicus, *Pergularia daemia*, *Piper longum*, *Senna alexandrina* (syn. *Cassia senna*), *Sida cordifolia*, *Terminalia arjuna*, *Tylophora indica*.

Endemic species:

Acrachne henrardiana, *Albizia lathamii*, *Chloris bournei*, *Crotalaria madurensis*, *Dalbergia coromandeliana*, *Dichrostachys santapaui*, *Eragrostis rottleri*, *Eriolaena lushingtonii*, *Hildegardia populifolia*, *Jatropha villosa* var. *ramadensis*, *Sorghum stapfii*, *Vernonia shevaroyensis*.

Threatened species:

Acacia campbellii, *Albizia lathamii*, *Albizia thompsonii*, *Asparagus rottleri*, *Ceropegia odorata*, *Hildegardia populifolia*, *Indigofera constricta*, *Oryza officinalis* var. *malampuzhaensis*, *Rhynchosia velutina*.

Associated culture and tribes

The hilly areas of the Shevroy hills, Pachaimalai hills, Kolli hills occurring in the districts of Dharmapuri, North Arcot, Salem, South Arcot, Tiruchirapalli have the major tribal communities called "Malayali". The tribal men and women of Pachamali hills (Malayali tribes) are known to possess traditional knowledge on various treatments using local plants for curing ailments of cattle. The other major tribes here are Irular, Kadar, Kond Kapus, Konda reddis, Malai Pandaram. The cropping patterns followed by the tribal communities ensure the sustainability of the land by adopting mixed cropping. The local tribal communities usually mix the seeds of common millet, finger millet, pulses, castor seeds and grain amaranths and then sow or broadcast them during the onset of rains. The tribal communities harvest the crops in different harvesting cycles which would ensure steady supply of food and crops assuring sustainability and maintainence of soil fertility through the nitrogen fixing leguminous crops. Along the field bunds vegetable crops such pumpkin, ash gourd and bitter gourd and sanke gourd are cultivated which would serve as supplementary food (Ravishankar *et al.*, 1997).

The traditional rice cultivars used by Malayali tribal communities are Mottanellu, Kottanellu and Manvari; for little millet, the traditional cultivars are Vellasami, Kothusamai, Karunsamai, and Odusamai. The

cultivars of Ragi (finger millet) maintained by tribal communities are Vellasurattai, Karunsurattai, Vellari, Periya ragi, Shendu ragr; the cultivars of Kodo millet are: Thiri varagu, Pani varagu, Varagu; the cultivars of Foxtail millet are Kurumthinnai, Vellanthinnai, Korai; the cultivars of Pearl millet are Malakambu, Kattukambu; the cultivars of maize Mokkosolam, Sillipisolam, Pottusolam. In a study of Chengam taluk in the district of Thiruvannamalai, it was observed that the marginal farmers returned to traditional varieties in times of poor rainfall and water shortage as the cultivation of high yielding varieties (HYVs) was not sustainable because of the high water requirement (Vijayalakshmi *et al.*, 1997). This study was undertaken in the background of higher HYV cultivation prevalent in most of the districts of Tamil Nadu compared to the local varieties cultivation. The method of conserving grains in traditional granaries in villages are through participation and involvement of all village communities.

Technology and products

The Kaveri biodiversity region is known for variability in rice having several desirable traits, such as stem borer resistance (TKM-6 rice and Co4 rice and several other ADT 37, ADT 43, etc.), tungro virus resistance, drought tolerance, and speciality features for pudding, different types for pongal and pilavu and scented varieties (Siddiq *et al.*, 2006). Mudgo landraces from the region is known for resistance to brown plant hopper with gene bph1. The landraces of pearl millet have tall culm with large and broad leaves and small spikes. The proso millet variety Co 3 was developed from a local landrace Coimbtore local (Seetharama *et al.*, 2006). In finger millet, accession GE476 has been identified as a good variety having large leaf area, high dry matter and moderate to high photosynthetic efficiency.

Significant genetic diversity has been recorded in the case of sesame and several varieties have been developed from local landraces through selection, such as TMV-5 from a landrace of Srivaikundam, TSS6 (SVPRI) from landraces of Western Ghats and KRR1 and KRR2 from Karur local (Duhoon[2] *et al.*, 2004).

There is rich genetic diversity in vegetables and a number of varieties have been developed. For example in *Cucurbita moschata*, Co1 and

Co 2 have been developed through selection from local cultivars; in *Lageneria*, Arka Bahar has been developed from Karnataka local and Co1 from Tamil Nadu local; in *Luffa acutangula*, Co1 and Co2 and in *Luffa aegyptiaca*, *Co1* has been developed from Coimbtore locals (Sirohi *et al.*, 2005). In onion, Co2 and Co3 have been developed through mass selection in Tamil Nadu local, whereas, MDU1 through mass selection in Somlathi local (Pandey *et al.*, 2005). The Kaveri region has wild okra (*Abelmoschus angulosus*) which is an important genetic resource.

There are number of traditional varieties in mango: Banganpalli, Bangalora, Neelum, Rumani, Mulgoa; in banana with Pachable, Karpurvalli, Monthan, Morris, Mysore Poovan, Nendran, Pachanadan, Rasthali, Kathali, chevazai (Red Banana), Mala vazai (Hill banana) Robusta etc. In Acid lime, *C. aurantifolia*, PKM1 is a seedless line; in lemon, *C. limon*, Galgal and Eureka are traditional cultivars; in Pomegranate (*Punica granatum*), variety Ganesh has been derived from local Alandi, and G173 from Ganesh (Karihaloo *et al.*, 2005). Additionally, the region has a very rich genetic diversity of tamarind (*Tamarindus indica*).

In seed spices, coriander, several products have been developed using local germplasm: Co1 is a selection from Koilpatti local, Co2 is a reselection from collection P2 from Gujarat; CS287 is another reselection from Guntur collection and Co3, a reselection from Acc 695 of IARI (Ravindran *et al.*, 2005).

The region also offers genetic variability in tuber crops, in aroids- taro, *Colacasia*, elephant foot yam, (*Amorphophallus*), tennia, (*Xanthosoma sagittifolium*) and giant taro (*Alocasia macrorrhizos*) are common. Elephant foot yam collections include two distinct types, namely 'Chena' from Kerala with very large discoid rhizomes, and 'Karuna' from Tamil Nadu with small discoid mother rhizome bearing oblong tuberous cormels (Edison *et al.*, 2005).

7.19 Deccan Agrobiodiversity Region

Location and extent

The North Western Deccan Agrobiodiversity hotspot is part of the hot semi-arid eco-region situated on the leeward side of the

Western Ghats from the Satpura-Mahadeo hills in the north to the Bellary-Dharwar in the south which includes the leeward districts of Maharashtra, northern dry districts of Karnataka and northern Andhra Pradesh. The terrain is undulating and the soil generally is medium blackish. The hotspot area includes the districts of Jalna, Hingoli, Pharbhani, Beed, Nanded, Latur, Osmanabad, Solapur, Sangli, Gondia, Gadchiroli in Maharashtra and the districts of Adilabad, Karimnagar, Warangal and Khamman in Andhra Pradesh and districts of Bidar and Gulbarga in Karnataka.

Agroclimate

The climate of the region is characterised by hot summers and mild winters. The mean annual rainfall ranges from 600 - 1000 mm, which covers 40 per cent of the annual potential evapotranspiration. The moisture availability period ranges from 90 - 150 days. The region is characterised by shallow and medium black soils. The common landscape of the region is moderate to gentle slopes. The soil is shallow loamy, skeletal and highly calcareous in nature. In some patches the soil is clayey, calcareous and moderately alkaline.

Floristic diversity:

The floristic diversity is not rich, but the region has a high diversity of grass flora. The main forest types are dry deciduous forests, thorn forests and scrub jungles. The dry deciduous forests are represented by some of the following tree species: *Aegle marmelos*, *Anogeissus latifolia*, *Boswellia serrata*, *Buchnania lanzan*, *Diospyros melanoxylon*, *Madhuca longifolia* var. *latifolia*, *Phyllanthus emblica*, *Terminalia elliptica*, *Tectona grandis*. Small trees are *Acacia pennata*, *Butea monosperma*, *Cassia fistula*, *Eriolaena hookeriana*, *Morinda pubescens*, *Wrightia tinctoria*, *Ziziphus mauritiana*. The main scrub forest elements are *Acacia catechu* var. *chundra*, *A. horrida*, *Acacia nilotica* subsp. *indica*, *Acacia leucophloea*, *Capparis divaricata*. The common grasses of fodder value are, *Andropogon pumilus*, *Chloris dolichostachya*, *Cynodon dactylon*, *Eleusine indica*, *Eragrostis tenella*, *Pennisetum pedicellatum*, *Setaria pumila*, *Urochloa panicoides.*

Agriculture and agrobiodiversity

The farmers of the region traditionally follow rainfed farming. The major rainy season crops cultivated in the area are sorghum, pigeon

pea, and pearl millet. The post-rainy season's crops are grown on soils which have residual moisture and the crops cultivated are sorghum, safflower and sunflower. It is seen that prolonged dry spell adversely affects the crop growth leading to frequent crop failures. The *kharif* sorghum is cultivated in the semi dry districts and cotton, pulses, ground nut and small millets are sown as alternate crops. Sugarcane is an important crop in the Deccan areas of Maharashtra and northern Karantaka where irrigation facilities through tube wells and irrigation canals are available. Sugarcane is planted during December-February for 12-month crop period which is called "eksali". In the extremely dry areas of Deccan in Andhra Pradesh which is a rain-shadow region, bajra is cultivated. In the ground nut based cultivated areas, the alternate crops are sorghum and small millets. In the dry districts of Deccan in northern Karnataka, the ground nut based crop region has sorghum as an alternate crop. Cotton is an important crop in the rainfed areas of Deccan which includes the semi-arid districts of northern Karnataka and northern Andhra Pradesh. In this area, the alternate crops are sorghum (*kharif* and *rabi*), ground nut and small millets. The cropping patterns in different areas of the Deccan Plateau are as follows: (i) Vertisols and related black soil zone: Sholapur dry land region: Green gram - sorghum; (ii) Bijapur dry land region: Cowpea-sorghum; green gram- safflower; (iii) Akola dry land region: Green gram / ground nut / sorghum- safflower (Rathore *et al.*, 1991). (iv) Bellary dry land region: On the basis of annual rainfall (500 mm), the rabi crops are sorghum, safflower and grain crops that are sown in September. Besides, the following cropping patterns are followed: sorghum – safflower / sunflower / ground nut, soyabean – safflower, soybean – chickpea, cotton – sunflower, cotton – ground nut, pigeonpea – sesame. Sorghum, cotton, pigeonpea are intercropped with soybean, sesame, ground nut.

Crops and wild relatives:

Cereals: Rice (*Oryza sativa*): *Radhanagari Panvel*, *Jalgaon*, *Gangasagar*, *Karjat;* Rice landraces: *Bobbili gantalu*, *Chalka buchi vadlu*, *Cheruku luchchalu*, *Chinna sindhu bayalu*, *Chinna vodlu*, *Duppi tokalu*, *Erra vadlu*, *Goranka mukkulu*, *Kare budamalu*, *Kattakichidi*, *Nalla vadlu*, *Roti singaralu*, *Sudi vanja*, *Vulliguththulu*. Barley (*Hordeum vulgare*), Sorghum

and WR (*Sorghum bicolor*), S. *deccanense*, *S. stapfii:* Sorghum landraces in Maharhastra Deccan : *Alluna jola*, *Badi jowar*, *Dagadi jowar*, *Gulbendi*, *Harni jowar*, *Hulgi jola*, *Kavaali*, *Maldandi*, *Pandhari*; Sorghum landraces in the Deccan region of Andhra Pradesh: *Chiruthalavalu*, *Dhanijowar*, *Gingrijowar*, *Pandimuttejonna*, *Patchajonna*, *Pelalajonna*, *Sad gurujonna*, *Tekdarijonna*, *Vanijowar;* Wheat (*Triticum aestivum*)*:* Wheat varieties:*Kalyansona*, *Sonnalika*, *Malavika*, *Choti Lerma*); Maize (*Zea mays*).

Millets: Makra (*Dactyloctenium aegypticum*), Finger millet (*Eleusine coracana*), Thipa ragi, (*Eleusine indica*), Barnyard millet (*Echinochloa crus-galli*), Japanese barnyard millet (*E. frumentacea*), Dhane (*Eragrostis tenella*), Chirka (*E tremula*), Pearl millet (*Pennisetum glaucum*), Proso millet (*Panicum miliaceum*), Little millet (*Panicum sumatrense*), Foxtail millet (*Setaria italica*), *Trilobachne cookie.* Pseudocereals*: Amaranthus hypochondriacus.*

Legumes: Ground nut (*Arachis hypogaea*), Chickpea (*Cicer arietinum*), Pigeon pea (*Cajanus cajan*), *Melilotus alba*, *Vigna hainiana*, Black gram (*V. mungo*), Green gram (*V. radiata*), Rice bean (*V. umbellata*), Cowpea (*V. unguiculata*), Pillipesara (*V. trilobata*, *V. trilobata* var. *pusilla*).

Vegetables **:** Amaranth (*Amaranthus caudatus*, *A. polygamus*, *A. viridis*), Chilli (*Capsicum annuum*), Pumpkin (*Cucurbita pepo*), Cucumber (*Cucumis sativus*), Musk melon (*Cucumis melo*), Brinjal (*Solanum melongena*).

Tubers*:Amorphophallus paeoniifolius var. campanulatus*, *Dioscorea bulbifera*, *D. pentaphylla*, D. *intermedia*, *D. wightii*, *D. wallichii*.

Oilseeds: Mustard (*Brassica juncea*), Safflower (*Carthamus tinctorius*), Niger (*Guizotia abyssinica*), Castor (*Ricinus communis*), Sesame (*Sesamum indicum*).

Other economic plants:

Fruits: Orange cultivated (*Citrus sinensis cultivated*) Kondai (*Flacourtia indica*), Lovi-lovi (*Flacourtia inermis*), Wood apple (*Limonia acidissima*), Mango (*Mangifera indica*), Jamun (*Syzygium cuminii*), Grapes (*Vitis vinifera*).

Pot herbs: *Cissus repanda*, *Cissus quadrangularis*, *Corchorus depressus* (Leaves as pot herb), Adavi gogu, leaves as pot herb (*Hibiscus aculeatus*), Kenaf (*Hibiscus cannabinus*).

Fibre: Asiatic cotton (*Gossypium arboreum*), Levant cotton (*Gossypium herbaceum*), American cotton (*Gossypium hirsutum*). Jute WR *Corchorus antichorus*, *C. urticaefolius.*

Gums and resins: *Acacia leucophloea*, *Acacia nilotica* subsp. *indica*, *Boswellia serrata*.

Dyes: Indigo WR: *Indigofera deccanesis*, *I. glandulosa* var. *sykesii*.

Essential oil: *Blumea eriantha*, *B. lacera*, *Cymbopogon martinii*, *Santalum album*.

Tannins: *Acacia farnesiana*, *A. leucophloea*, *A. pennata*, *Albizia lebbeck*, *Anogeissus latifolia*, *Terminalia arjuna*, *T. bellerica*.

Fodder: *Andropogon pumilus*, *Brachiaria ramosa*, *Chloris dolychostachya*, *Cynodon dactylon Dactyloctenium aegyptium*, *Dichanthium annulatum*, *Eleusine indica*, *Eragrostis deccanensis E. tenella*, *E. unioloides*, *Eriochloa procera*, *Heteropogon contortus*, *Ischaemum rugosum*, *Panicum psilopodium*, *Pennisetum pedicellatum*, *Perotis indica*, *Sehima nervosum*, *Setaria pumila*, *Urochloa panicoides.*

Endemic species: *Alysicarpus luteovexillatus*, *Cassia montana*, *Chloris bournei*, *Crotalaria decasperma*, *C. rigida*, *C. sandoorensis*, *Digitaria tomentosa*, *Eragrostis deccanensis*, *Indigofera deccanesis*, *I. glandulosa* var. *sykesii*, *I. trifoliata* var. *duthei*, *I. trista* var. *purandharensis*, *Iseilema anthephoroides*, *Oryza nivara*, *Panicum deccanense*, *P. phoiniclados*, *Sophora interrupta*, *Vetiveria lawsonii*.

Threatened species: *Acacia campbellii*, *Asparagus rottleri*, *Cajanus sericeus*, *Crotalaria paniculata* var. *nagarjunekondensis*, *C. willdenowiana* var. *galbrifoliata*, *Erythrina variegata* forma *mysorensis*, *Indigofera constricta*, *I. deccanensis*, *Madhuca diplostemon*.

Associated culture and tribes

The major tribes associated are Adivasi, Girijan and Vanya Jati, Maria Gond, Katkari, and Kolam. During the festival days of Ugadi and

Diwali, sweet meats are prepared using ground nut (*Arachis hypogaea*) and chickpea (*Cicer arietinum*). On the Farmers' festival day "Erokku Ponnami", all the bullocks in the farming community of the village are decorated and taken out in a procession (Satheesh, 2002). During "Bhootalli" festival for worshipping Mother Earth, songs mentioning and encouraging farmers to grow Sagam (Sorghum) are chanted i.e. "Olega Sagam Olega Beliya Jolave". During the festive days farmers cook " Bajikoora" which includes all the vegetables, leafy and tender stems, pulses (pigeonpea, chickpea, green peas, amaranthus, chillies) growing in the village as a ritual symbol meant for the conservation of the life supporting plants of the village (Satheesh, 2002). It is worth highlighting the role of Deccan Development Society which, through participatory approach, has transformed a dryland farming community that includes marginal farmers, women, dalits and tribal communities of Medak into a productive community so that these self help groups have organised "Community Gene Bank" in order to conserve native seeds and cultivars a nd "Community Grain Fund" in order to distribute grains to the needy during crop failure (Satheesh, 1997).

Technology and products

In south Maharashtra, *dicoccum* wheat is grown extensively. Khapli dicoccum, is well known for quality, stem rust resistance and is being widely used in breeding programme (Singh[3] *et al.*, 2006). Similarly, variabilities with desirable traits have been evolved in sorghum, and local landraces are being used in breeding programme: i.e. seed parent of hybrid CHS-4 was a cross between CK60A and PJ8K, a local landrace from Maharashtra; SPV-462, a very popular variety which has been developed through a cross between an American introduction and local IS1151 from Maharashtra and BP53 from Gujarat; CSV216R is a selection from landrace collected from Maharashtra. Most of the landraces of the region have the ability to survive under stress condition (Elangovan *et al.*, 2004). Additionally several sources of resistance to important pests and diseases have also been identified from the region: for example, IS1044 from Parbhani, IS1054, IS1055 from Pune and IS1151 from Khandesh for stem borer resistance; IS14332 for anthracnose and IS18758 for grain mould, sugary

disease, rust, charcoal rot, zenate leaf spot and anthracnose from Akola. In finger millet, sources of useful genes for physiological traits have been identified, such as GE 325 for low stomata number, high photosynthetic efficiency and low leaf area and useful gene GE717 for higher biomass and high harvest index (>35%), from finger millet collected from Akola.

A significant amount of variability in pigeonpea is noticed in the Deccan region. Here ICR1093 a local landrace from Andhra Pradesh is a source of pod borer tolerance and has been used in the development of variety Abhya (ICPL 332), while ICPL161 is a short duration landrace. It is seen that variability exists in cowpea regarding its habit, flower colour, colouration of plants, including pod and seed, and their size. There are also bold seeded types in the case of mung bean and good plant type in the case of urad bean.

Among oilseeds, variability has been recorded in the case of black mustard, *Brassica nigra* and variety Surya has been developed through selection from a local landrace. In ground nut, the region presents significant genetic variability and local landraces, such as Kadari-3, Robut (naturalised from Israel) in Andhra Pradesh and Jalgaon local in Maharashtra has been used in the development of varieties, such as Robut 33-1 and JL-24, which are the best varieties. Similarly in sesame, several varieties have been developed through selection from local landraces, i.e. variety N58-2 from landrace of Nasik, D-77-11-1 from landrace of Dhule, Madhavi (SP1181) and TM6 from landrace of Andhra Pradesh, Gouri from landrace of Kakkirapalli, N-8 and N-128 from Nagpur local. In niger, No.5, N-12-3, N-87, Ottacmund from Nagpur landraces. In safflower, N-630, Nagpur-7, N62-8 are selections from local landraces of the region.

In vegetable crops, the region presents significant variability for *Solanum melongena* and chilli for plant types and fruit characteristics. In several crops the local cultivars/landraces have been used for the development of varietal products: for example in the case of *Cucumis sativus*, Phule Shubangi has been developed through selection from a local landrace; in okra the Red Wonder of Hyderabad has contributed to development of Co1; in onion, N53, Akra Pragati, Akra Kalyan, Akra Niketan, Agrifound Dark Red, Agrifound White

and Red were developed through mass selection in the collections from Nasik; variety Baswant-780 was developed from the collection of Pimalgaon, Maharashtra. In garlic, variety Godavari has been developed through mass selection from collections from Maharashtra (Pandey *et al.*, 2005).

The region is known for traditional varieties of mango, such as Alphonso, Mankurad, Muloga, Pairi, Banganpalli, Totapari. Among *Citrus*, the region is known for varieties such as Nagpur in Mandarin, (*Citrus reticulata*); for Mosambi, Sathagudi, Malta, Blood Red in Sweet orange, (*Citrus sinensis*); for Kagzi lime, PKM-1, Vikram, Baramasi, Sai Sarbati, Seedless Lime etc. in Acid lime, (*Citrus aurantifolia*) (Karihaloo *et al.*, 2005). Besides, the region has large variability in the case of custard apple, *Annona squamosa* and *Tamarindus indica*.

Among spices, the region is known for variability in turmeric, where variety such as Krishna has been developed through clonal selection from Tekurpeta collections.

The local tribes have developed several practices for sustainability and increased productivity; for example, Warli tribes of north Maharashtra harvest multiple crops from the same plot without irrigation as they sow pigeon pea, sorghum or cowpea in the paddy seedling beds. On the borders of seedlings beds, they plant ambadi (*Hibiscus cannabinus*), Lal ambadi (*Hibiscus sabdariffa*) or Okra. While Cucumber and Okra are inter-cropped between rows of maize, kenaf, khorasni, and wild *Vigna mungo* are also cultivated on the borders of fields. Warli tribes practice mulching and this is done by keeping leaves of khair (*Acacia catechu*) immersed in the water channel. The mulching would help in controling brown spot diseases of paddy.

In several parts of the region, farmers use the rhizosphere soil beneath banyan tree and this would help improve the soil fertility. *Amritpani*, the special bio-inoculants prepared from cow dung, cow ghee and honey are used for treating seeds as it is considered that this would increae germination efficiency.

Some of the traditional water harvesting technologies followed by the people are: in Maharashtra Kohli Tanks, Bhanadaras and Phad

are being used. In Kohli Tank system, a small groups of cultivators build number of water tanks of different sizes. These tanks of varied sizes have provision to bring water to the doorstep of their village farms. They are also used to impound water from reservoirs. Usually, villagers or individuals, receive rent-free lands in return for their efforts in constructing the water tanks. Phad is a community-managed irrigation system prevalent in north-western Maharashtra. The system starts with a bhanadara built across river. From here, it is branched out to kalvas (canals) with a discharge capacity of about 450 litres per second. The farming communities here construct Charis (distributaries) for diverting water from kalva to different areas of the phad Sarans (field channels) and this would channelise water to individual fields.

The region is also known for sacred groves and generally communities attach sanctity to plants which are venerated from ancient times. The existence of sacred groves or "Deva vanas" helps the facilitation of the conservation of biodiversity including components of agrobiodiversity.

7.20 Konkan Agrobiodiversity Region

Location and extent

The Konkan Agrobiodiversity region includes northern Western Ghats and Konkan plains. The northern Western Ghats is locally referred as Sahyadri hills. The agrobiodiversity area consists of western coastal plains of Maharashtra and Goa, called as Konkan plains and the crest of the Sahyadri ranges which includes part of the districts of Pune, Satara and Kolhapur. The Konkan is a narrow strip, west of the Sahyadri from the river Tapti to Kalinadi. The area includes the districts of Thane, Mumbai, Raigad, Ratnagiri, Sindhudurg and Uttar Kannada districts and Goa. The Mahabaleswar and Harischandragad are the important peaks. The hotspot area includes coastal districts of Thane, Raigad, Ratnagiri, Sindhudurg and part of Sahyadri districts of Pune, Satara and Kolhapur of Maharashtra, all the districts of Goa and Uttar Kannda district of Karnataka.

Agroclimate

The climate of the region is tropical with hot summers and heavy to moderate rains from the southwest monsoon. The climate is monsoonal and the weather is equitable as there is no extreme hot season or cold season. The Konkan region gets about 2540 mm of rainfall annually. There are seasonal dry spells during February to April. The western slopes of the mountains experience heavy rains while eastern slope is the rainshadow region. The region has long growing period of more than 270 days in a year. Along the western slopes of the Sahyadri, the soil is reddish and lateritic, while the coastal plains have alluvium soil. The soil is clayey, acidic in nature and is poor in base saturation.

Floristic diversity

Konkan being part of the Western Ghats, is one of the biodiversity hotspots of the world and has a rich floristic diversity. The forest types include semi-evergreen forests, montane subtropical evergreen forests, moist deciduous forests, dry deciduous forests, scrub forests and grasslands. The sem-evergreen forest consists of *Albizia lebbeck*, *Elaeocarpus serratus*, *Holigarna arnottiana*, *Lagerstroemia lanceolata*, *Macaranga peltata*, *Sterculia guttata*, *Syzygium cuminii*, *Terminalia bellerica*, *T. chebula*. The tropical deciduous forest is represented by *Careya arborea*, *Dillenia pentagyna*, *Canthium dicoccum*, *Macaranga peltata*, *Pterocarpus marsupium*. The dry deciduous forests have the following important species: *Acacia chundra*, *Anogeissus latifolia*, *Butea monosperma*, *Cassia fistula*, *Dalbergia latifolia*, *Haldinia cordifolia*, *Lagerstroemia parviflora*, *Sterculia urens.* Some of the scrub forests species are represented by *Acacia chundra*, *A. nilotica* subsp *indica*, *Barleria priontis*, *Carissa congesta*, *Capparis divaricata*, *Dichrostachys cinerea*, *Flacourtia indica*, *Holarrhena pubescens*.

Agriculture and agrobiodiversity

The Konkan region has intensive *kharif* cultivation of rice along with ragi, pulses, rabi jowar, sugarcane and oilseeds. In the upper laterite zones in recent times, tapioca and cashewnut are also cultivated. There is high genetic diversity in rice and other horticultural crops like mango.

Crops and wild relatives

Cereals: Rice (*Oryza sativa*), *O. meyeriana:* rice varieties*: Ratnagiri*, *Ratna*, *Early Kolpi*, *Radhanagari*, *Palghar*, *Jaya*, *Vijaya*, *Satya*, *Surya*, *Suhasini*, *Karjat*, *Pankaj*, *Ambemohar* (*scented variety*)*;* Sorghum (*Sorghum bicolor*).

Millets: Makra (*Dactyloctenium aegypticum*), Finger millet: (*Eleusine coracana*), Cheena or Proso millet (*Panicum miliare*), *Panicum hippothrix;* Pearl millet (*Pennisetum glaucum*)*;* Foxtail millet (*Setaria italica*).

Legumes: Jack bean*: Canavalia gladiata*, Pigeon pea: *Cajanus cajan* (cultivated) *Cajanus lineatus*, *C. sericeus;* Chickpea (*Cicer arietinum*), Lablab bean (*Lablab purpureus*)*;* Horsegram (*Macrotyloma uniflorum*), WR Vigna: *Vigna dalzelliana*, *V. khandalensis*, Black gram (*V. mungo*), Green gram (*V. radiata*), *V. radiata* var. *sylvestris*, *V. radiata* var. *setulosa*, Cowpea (*V. unguiculata*), Rice bean (*V. umbellata*), Pillipesara (*V. trilobata*), Zomba pea (*V. vexillata*).

Vegetables: Amaranth: *Amaranthus hybridus*, *A. paniculatus*, *A. polygamus*, *A. spinosus;* Okra*:* (*Abelmoschus esculentus*), *A. angulosus*, *A. ficulneus*, *A. manihot* subsp. *manihot;* Chilli (*Capsicum annuum*); Kundri (*Coccinia indica*); Pumpkin (*Cucurbita pepo*)*;* Cucumber (*Cucumis sativus*)*;* Kharbuj (*Cucumis melo*), *C. ritchei*, *C. setosus*), Lablab bean (*Lablab purpureus*), Lentil (*Lens culinaris*), Bottle gourd (*Lagenaria siceraria*); Ridged gourd (*Luffa acutangula*), Bitter gourd (*Momordica charantia*) *M. dioica*, *M. tuberosa;* Brinjal (*Solanum melongena*), Snake gourd (*Trichosanthes cucumeriana* var. *anguina*).

Fruits: Pineapple (*Ananas comosus*), Coconut (*Cocos nucifera*), Mango *Mangifera indica* (landraces): Strawberry: *Fragaria nilgerrensis*, Mango varieties: (Mancuradi, Maussarda, Fernandine, Xayer, Alphonso) *Mangifera sylvatica*, Banana (*Musa acuminata*, *M. sapientum*).

Tubers**:** Elephant-foot Yam: *Amorphophallus commutatus*, *A. sylvaticus*, *A. konkanensis;* Taro*: Colocasia esculenta* var. *esculenta;* Yam*: Dioscorea bulbifer*, *Dioscorea esculenta; Flemingia procumbens;* Sweet Potato*: Ipomoea batatas*; Tapioca (*Manihot esculentum*); Indian Kudzu: *Pueraria tuberosa;* Potato*: Solanum tuberosum*.

Spices: Arecanut (*Areca catechu*), Cinnamon: *Cinnamomum verum* (*cultivated*), *C. goaense;* Turmeric and WR : (*Curcuma longa*), *C. decipiens*, *C. inodora*, *C. purpurea*, *C. pseudomontana; Galangal* (*Kaempferia galanga*); Nutmeg*: Myristica malabarica*, *M. dactyloides;* Pepper and WR : *P. nigrum*, *Piper argyrophyllum*, *P. galeatum*, *P. hookeri*, *P. hymenophyllum*, *P. trichostachyon; Vanilla; Vanilla wightiana* Ginger and WR*: Zingiber cernuum*, *Z. neesanum Z. nimmonii*, (*Z. officinale*), *Z. zerumbet*.

Oilseeds: Niger (*Guizotia abyssinica*), Sesame (*Sesamum indicum*), Mustard (*Brassica juncea*). Edible nuts*:* Cashewnut (*Anacardium occidentale*); Beverages: Coffee: *Psilanthus crassifolia*, *P. wightianus.*

Other economic plants

Fruits: *Annona cherimola*, *Annona squamosa*, *Artocarpus heterophyllus*, *Carissa congesta*, *Citrus medica*, *Euphoria longan*, *Elaeagnus latifolia*, *Garcinia indica*, *G. morella*, *G. talbotii*, *Limonia acidissima*, *Mangifera indica* (landraces), *Manilkara hexandra*, Sapota: *Manilkara zapota; Mimusops elengii*, *Phyllanthus emblica*, *Rosa leschenaultina*, *Spondias pinnata*, Jamun (*Syzygium cuminii*), *Ziziphus glabrata*.

Less known edible plants*: Cissus repanda*, *Cissus quadrangularis*, *Corchorus depressus Hitchenia caulina*, *Flemingia macrophylla*, *Ougenia oojeinensis*

Fodder: *Albizia lebbeck*, *Andrographis pumilus*, *Apluda mutica*, *Aristida adscensionis*, *Chloris dolichostachya*, *Chloris virgata*, *Chrysopogon fulvus*, *Dactyloctenium aegyptium*, *Desmostachya bipinnata*, *Echinochloa colonum*, *Eragrostis ciliaris*, *E. unioloides*, *E. unioloides* var. *tremela*, *Heteropogon contortus*, *Gliricidia sepium*, *Leucaena leucocephala*, *Mucuna pruriens* var. *pruriens*, *Paspalidum flavidum*, *Pennisetum pedicellatum*, *Perotis indica*, *Sehima sulcatum*, *Pueraria montana* var. *lobata*.

Dye yielding plants: Heartwoods of *Acacia catechu*, leaves of *Acacia nilotica* subsp. *indica*, Barks of *Acacia nilotica*, flowers of *Caesalpinia pulcherrima*, *Hardwickia binata*, *Hibiscus rosa-sinenesis*, *Lawsonia inermis*, *Memecylon umbellatum*, capsules of *Mallotus philippiensis*, *leaves of Phyllanthus emblica*, *Symplocos racemosa*, *Syzygium cuminii*.

Aromatic oils: *Cymbopogon citratus*, *C. martinii*, *C. nardus.*

Timber: *Albizia chinensis*, *Canarium strictum*, *Chloroxylon swietenia*, *Chukrassia tabularis*, *Dipterocarpus indicus*, *Hopea parviflora*, *Lagerstroemia microcarpa*, *Mesua ferrea*, *Palaquium ellipticum*, *Tectona grandis*, *Toona ciliata*, *Vateria indica*.

Gums and resins**:** *Acacia nilotica*, *Anogeissus latifolia*, *Boswellia serrata*, *Pterocarpus marsupium*, *Sterculia urens.*

Multipurpose species: *Diospyros melanoxylon*, *Morus alba*, *Rhus sinuata*.

Bamboos:*Bambusa arundinacea*, *Dendrocalamus strictus*, *Pseudoxytenanthera ritcheyi*.

Ornamentals: *Carvia callosa*, *Ceropegia fantastica* Lily: *Crinum brachynema*, *C. elenorae*, *C. woodrowii*, *Delphinium malabaricum* var. *ghaticum*, *Frerea indica*, Doum plant (*Hyphaene dichotoma*, *Hyphaene thebaica*, *Jacaranda acutifolia*, *Rosa leschenaultina*.

Endemic species: *Abutilon ranadei*, *Amorphophallus konkanensis*, *Arundinella spicata*, *Carvia callosa*, *Ceropegia attenuata*, *C. evansii*, *C. huberi*, C. *maccanii*, *Chlorophytum borivillianum*, *Coelachne minuta*, *Crinum brachynema*, *C. elenorae*, *C. woodrowii*, *Cucumis ritchei*, *C. setosa*, *Curcuma purpurea*, *Dalbergia horrida* var. *concanensis*, *Delphinium malabaricum* var. *ghaticum*, *Dendrobium lawianum*, *D. ovatum*, *Dichanthium maccanii*, *D. panchganiense*, *D. paranjpyeanum*, *Garcinia indica*, *Glyphochloa goaensis*, *G. ratnagirica*, *Habenaria gibsonii* var. *gibsonii*, *H. panchganiensis*, *Indopoa paupercula*, *Iphigenia stellata*, *Lavendula lawii*, *Nilgrianthus reticulatus*, *Syzygium utilis*, *Strychnos dalzellii* var. *dalzellii*, *Triplopogon ramosissimus*, *Vigna khandlensis*, *V. trilobata* var. *pusilla*, *V. vexillata* var. *sepiaria*, *V. vexillata*. var. *stocksii*, *Zingiber cernuum*.

Threatened species: *Abutilon ranadei***,** *Cajanus lineatus*, *Calamus brandisii*, *Ceropegia attenuata*, *Crinum eleonorae*, *Delphinium malabaricum* var. *ghaticum*, *Indigofera dalzellii*, *I. deccanensis*, *Iphigenia stellata*, *Nogra dalzellii*, *Oryza officinalis* subsp. *malampuzhaensis*, *Pancratium parvum*, *Scilla viridis*, *Vigna khandalensis*, *Zingiber cernuum*, *Zingiber neesanum*.

Associated culture and tribes

The Warli Adivasi community living in the Warli hills of Maharashtra follows mixed crop farming (at the varietal level) which assures the

minimum yield since mixed farming is an insurance against crop failures due to pests, drought and irregular rains. In this region, the tribal community sow 10- 15 varieties of paddy which includes (i) varieties of high yield but susceptible to diseases and drought (ii) varieties with low yield but resistant to drought and diseases. (Winin Pereira et *al.*, 1990).

Technology and products

The Konkan region has rich gene pool in different crops especially rice, pigeon pea, *Vigna* and mango. The region is one the major centres of wild species of *Vigna*. Of the 24 *Vigna* species reported from India the following species occur or cultivated in the Konkan agrobiodivesity region: *Vigna aconitifolia*, *V. angularis*, *V. dalzelliana*, *V. khandalensis*, *V. mungo*, *V. radiata* var. *sublobata*, *Vigna radiata* var. *sylvestris. V. trilobata* var. *trilobata*, *V. trilobata* var. *pilosa*, *V. umbellata, V. unguiculata*, subsp. *sesquipedalis*, *V. vexillata* var. *sepiaria*, *V. vexillata* var. *stocksii*. On an evaluation of the wild species of *Vigna*, it is mentioned that the higher yield in *V. radiata* is due to a trait donated by the wild speices *V. sublobata* (Jain *et al.*, 1980). For example, landrace Turk-thogai (ICP7217) of pigeon pea, which has its origin in Karnataka has been released directly as a variety; similarly a high performing ratoonable landrace, PR5193 selected from the fields of ethnic communities of Attapadi, of Kerala Western Ghats is released directly as a variety for crop livestock system (Remanandan *et al.*, 1997). Among the wild species, *Cajanus lineatus*, *C. sericeus* have been identified as source of resistance to sterility mosaic virus. *C. sericeus* is also resistant to blight. In vegetables, the region represents a significant and high variability in cucurbitaceous crops, such as *Cucurbita*, *Cucumis*, *Luffa graveolens*, *Momordica cochinensis*, *M. subangulata*, *Trichosanthes tricuspidata* used in breeding programmes (Sirohi *et al.*, 2005). In Okra, the region has natural hybrid between *Abelmoschus esculentus* and *A. caillei*, which is naturalised with significant variability.

The region is also well known for high quality mango varieties, such as Alphonso, Mancurad, Maussarda, Fernandine, Xayer, Colaco. Konkan is known for high value varieties of Jack fruit: Cappco and Rassal. The other national collections in Jack fruit include landraces Koozha, Navarikka, Varikka, and Rudrakha koozha originating from

the region. In spices, the region exhibits cultivar variability in pepper, ginger and cinnamon. In Cinnamon, variety Konkan Tej is a selection from Ceylon type with superior quality.

Among the wild species, *Cajanus lineatus*, *C. sericeus* have been identified as source of resistance to sterility mosaic virus. *C. sericeus* is also resistant to blight occurring (especially during rabi season) on the leeward side. Appropriate infrastructure facilities with quality greenhousing would help the production of horticultural crops for world market.

7.21 Malabar Agrobiodiversity Region

Location and extent

The Malabar agrobiodiversity region is situated in the southern region of the Western Ghats extending from Dakshin Kannada district in the north to Kanyakumari district in the south. The region includes all the districts of Kerala state, the Dakshina Kannada, Kodagu, and Udipi districts of the Karnataka state and the Western Ghats mountain districts of Tamil Nadu i.e. Nilgiri, and Kanyakumari districts. The Malabar region is a hot, humid-perhumid eco-region with red and alluvium soils. The highest peaks in the Western Ghats, Anamudi (alt.2695 m above MSL) and Dodabetta (alt. 2636 m above MSL) are situated in this region. The hotspot areas are the districts of Kasargod, Kannur, Wayanad, Kozikode, Malappuram, Palakkad, Thrissur, Idukki, Ernakulam, Alappuza, Kollam, Kottayam, Pathanamthitta, Thiruvananthpuram in Kerala, Udhagamandalam (Nilgiri) and Kanyakumari districts of Tamil Nadu and districts of Dakshin Kannada, Kodagu, Udipi in Karnataka. From ancient times, the Malabar region is known as the land of spices.

Agroclimate

The climate of the region is characterized by hot and mild summers and rainy season. Most of the region has average annual precipitation exceeding 2000 mm. The rainfall covers the entire annual potential evapotranspiration. Due to seasonal dry spells, especially during February to April there is some moisture deficit in the affected areas. The region is represented by long growing season, which may extend

more than 270 days. Besides, there is abundant water availability due to the extensive network of rivers, streams, lakes and backwaters. The region has red and lateritic soils and the alluvium derived soils occur in the coastal plains. The soil is deep, clayey, profoundly to moderately acidic in nature and are poor in base saturation.

Floristic diversity

The region is very rich in floristic diversity, as it is part of the Western Ghats biodiversity hotspot. The southern Western Ghats is one of the major tropical evergreen forest regions of India and exhibits rich plant diversity. The flora is characterised by typical evergreen elements belonging to the families Dipterocarpaceae, Guttiferae, Myristicaceae, Myrtaceae, Piperaceae, Araceae and Zingiberaceae. There are about 1286 endemic species in the southern Western Ghats compared to about 234 endemic species in the northern Western Ghats (Nayar, 1996). The natural vegetation comprises the following forest types: tropical moist wet evergreen forests, tropical semi-evergreen forests, tropical most deciduous forests, tropical dry deciduous, montane and shola forests. The top canopy of tropical evergreen forests are represented by *Acrocarpus fraxinifolius*, *Antiaris toxicaria*, *Artocarpus hirsutus*, *Canarium strictum*, *Dipterocarpus indicus*, *Mesua ferrea*, *Palaquium ellipticum*, *Terameles nudflora*, *Vateria indica*. The tropical semi-evergreen forests include the following species: *Alstonia scholaris*, *Artocarpus hirsutus*, *Hydnocarpus pentandra*, *Knema attenuata*, *Sterculia guttata*, *Terminalia paniculata*. The tropical moist deciduous forests consists of *Albizia amara*, *Dillenia pentagyna*, *Macaranga peltata*, *Tectona grandis*. The tropical riparian forests consist of *Calophyllum apetalum*, *Garcinia gummigutta*, *Homonoia riparia*, *Ochreinauclea missionis*, *Holigarna arnottiana*. The tropical hill top forests consist of *Cullenia exarillata*, *Elaeocarpus serratus*, *Mesua ferrea*, *Gluta travancorica*. The montane wet semi temperate forests in the sholas are represented by the following species: *Ilex wightiana*, *Michelia nilagirica*, *Vaccinium leschenaultii*, *Rhodomyrtus tomentosa*, *Eurya nitida*.

Agriculture and agrobiodiversity

From ancient times, agriculture in the Malabar region is influenced by the topographical features of hills and valleys which occur in

several layers and labryinths. The Malabar region is known for homestead gardens or *Purayadams* where the lay of the land having the top of hills sloping down to valleys favour habitats for diversity of species. i.e. rice culivation at the bottom gradient where there is plenty of water. The rice cultivation supplies the farmer with food and hay for his cattle. The middle gradient houses the farmer where he cultivates coconut, tuber crops, vegetables, taro, elephant-foot yam, yams, pepper, ginger, turmeric, plantain, jacktree, mango, tamarind and other essential medicnal plants and also houses his cattle in cowsheds. The upland portion is used for grazing his cattle and for the cultivation of timber and fruit yielding trees, Anjili (*Artocarpus hirsutus*), Bread fruit (*Artocarpus incisus*), Mango (*Mangifera indica*), Teak (*Tectona grandis*), Indian copal tree (*Vateria indica*). Since the topography offers different spatial ecological niches each homestead garden is rich in biodiversity.

Paddy cultivation and harvesting is done two or even three times in a year. Among field crops, coconut is the major crop. The terrain is heterogeneous with varied topography and rainfall is heavy causing flash flooding and inundation. There is ingress of salinity in low lying areas especially Kuttanad as the area is below sea level. "Pokali" cultivation is practiced widely where there is inundation.

In laterite dry zones, tapioca is being cultivated. Beside these crops, Kerala is the main producer of spices, especially pepper and cardamom which are cultivated and traded since 3000 years. The region produces 96 per cent of the pepper of the country. The other important species are cinnamon, clove, turmeric, nutmeg, ginger and vanilla. MSSRF has identified Waynaad in Kerala as an important agrobiodiversity hotspot for rice, pepper and tuber crops and has listed the following rice varieties for conservation: Scented varieties: Anakkodan, Gandakasala, Jeeragasala, Kundipullu, Mullanchanna; Food tolerant varieties: Kotta nellu, Kuttadon, Oormundakan; Salt tolerant varieties: Chettiviruppu, Chovvaryan; Drought tolerant varieties: Thekkenthouvan, Vella thouvan, Veliyan; Medicinal rice varieties: Chennellu, Njavara, Vattan.

The commercial crops which play an important role in the agro-economy of Kerala, are coconut, rubber, tea, coffee, cashewnut. The

region accounts for 91 per cent of India's rubber production. During the last three decades, rubber being a highly profitable commercial crop has made inroads into the Kerala's traditional homestead gardens. The vast agricultural biodiversity in the homestead gardens is being replaced by rubber plantations which is a monocrop. This perceptible change even led to the conversion of paddy fields into rubber plantations which created serious environmental problems concering the loss of water recharging acquifers. This is also causing crisis leading to the short fall in vegetable and rice production. The Government of Kerala, aware of this problem is bringing out a new legislation to restrain such activities. In the southern Western Ghats districts of Karnataka besides rice, the alternate crops cultivated are arecanut and coffee.

Crops and wild relatives:

Cereals: Rice: *Oryza sativa:* important rice varieties Kerala: *Jyothi*, *Rohini*, *Annapurna*, *Triveni*, *Jaya*, *Aswathy*, *Sabari*, *Bharathy*, *Mahsuri*, *Navara*, *Ponni*, *Samba;* Important rice varieties in Kodgu, Dakshin Kannada, Mysore: *Annapurna*, *Mangala*, *Jaya*, *Puspa*, *Madhu*, *Pankanj*, *Vani*, *Sona*, *Pakash*, *Phalguna*) *Oryza officianalis* var. *officianalis*, *O. officianalis* var. *malampuzhaensis*, *O. meyeriana* var. *granulata*, *O. nivara*. *O. rufipogon*, *O. spontanea*. Landraces of rice: Scented varieties: *Anakkodan*, *Gandakasala*, *Jeeragasala*, *Kundipullu*, *Mullanchanna;* Food tolerant varieties: *Kotta nellu*, *Kuttadon*, *Oormundakan*; Salt tolerant varieties: *Chettiviruppu*, *Chovvaryan;* Drought tolerant varieties: *The kkenthouvan*, *Vella thouvan*, *Veliyan*; Medicinal rice varieties: *Chennellu*, *Njavara*, *Vattan*, *Kinjinellu*, *Erummakari*, *Narinellu*, *Karuthchmpavu*, *Kavinginpoothala*. *Pokali* rice cultivation is done in lands where there is intrusion of sea water along backwaters and Kuttanad which lies below the sea level.

Vegetables: Okra and WR**:** *Abelmoschus angulosus*, *A. crinitus*, *A. esculentus*, *A. manihot* subsp. *manihot*, Chilli: (*Capsicum annuum*), *C. frutescens***,** Musk melon: *Cucumis melo* var. *melo*, Cucumber: *Cucumis sativus* var. *sativus*, *C. callosus*, *C. setosus;* Banana*: Musa acuminata*, *M. kattuvazhana*, *M. rosacea*, *M. sapientum M. superba;* Sponge gourd*: Luffa aegyptiaca* (*cultivated*)*;* Ridged gourd: *Luffa acutangula* var. *acutangula*, *L. acutangula* var. *amara*, *L. umbellata;* WRBitter gourd*: Momordica*

charantia (cultivated.), *M. charantia* var. *muricata*, *M. tuberosa; Drumstick Moringa oleifera;* Snake gourd and WR: *Trichosnathes cucumeriana* var. *anguina*, *T. anamalayensis*, *T. cucumeriana* var. *cucumeriana T. nervifolia*, *T. tricuspidata* var. *tomentosa*, *T. villosula*, Wild Brinjal*: Solanum aculeatissimum*, *S. anguivii* var. *multiflora*, *S. erianthum*, *S. macrocarpum*, *S. melongena* var. *melongena*, *S. melongena* var. *incanum*, *S. nigrum*, *S. pubescens*, *S. torvum*.

Leafy greens*:* Amarnath*: Amaranthus hybridus*, *A. paniculatus*, *A. polygamus; Basella alba*, *Moringa oleifera*, *Sesbania sesban*.

Legumes: Pigeon pea (*Cajanus candollei*, *C. lineatus*)*;* Sword bean (*Canavalia gladiata*)*;* Lablab bean: *Lablab purpureus* L., Moth bean (*Vigna aconitifolia*), Vigna WR: *V. bourneae*, Black gram (*V. mungo*), *V. pilosa*, Green gram *V. radiata* var. *radiata*, *V. radiata* var. *sublobata*, *Cowpea*, (*V. unguiculata* var. *unguiculata*), Rice bean (*V. umbellata*), Pillipesara (*V. trilobata*), *V. vexillata* var. *wightii*.

Tubers: Giant taro: *Alocasia cucullata*, *A. macrorrhizos;* Elephant foot Yam: *Amorphophallus paeonifolius*, *A. commutatus*, *A. hohenakeri*, *A. mysorensis*, *A. bonacordensis*, *A. smithsonianus*, *A. bulbifer*, *A. nicolsianus;* Taro (*Colocasia esculenta* var. *esculenta*), *Colocasia esculenta* var. *antiquorum* with several cultivars and morphotypes; Yam*: Dioscorea alata*, *D. bulbifera* var. *sativa*, *D. belophylla*, *D. bulbifera* var. *bulbifera*, *D. intermedia*, *D. oppositifolia*, *D. pentaphylla*, *D. tomentosa*, *D. hispida*, *D. hamiltonii*, *D. spicata*, *D. wightii*, *D. wallichii;* Country Potato*:* (*Coleus parviflorus*, *C. rotundifolius*), Tapioca (*Manihot esculentum*), Sweet Potato: *Ipomoea batatas;* Indian Kudzu*: Pueraria tuberosa*, Potato*: Solanum tuberosum*

Spices*: Amomum cannaecarpum*, *Amomum pterocarpum*, *A. muricatum; Carum strictocarpum;* Cinnamon*: Cinnamomum veram* (cultivated), *C. filipedicellatum*, *C. heyneanum*, *C. keralense*, *C. macrocarpa*, *C. malabatrum*, *C. nicolsianum*, *C. perrotteii*, *C. riparium*, *C. sulphuratum*, *C. travancoricum*, *C. walaiwarense*, *C. wightii;* Turmeric*:* (*Curcuma longa*), Mango ginger (*Curcuma amada*), Wild turmeric (*C. aromatica*), *C. albiflora*, *C. aurantiaca*, *C. caesia, C. cannanorensis*, *C. coriacea*, *C. decipiens*, *C. ecalcarata*, *C. harita*, *C. karnatakensis*, *C. kudagensis*, *C. nilamburensis*, *C. neilgherrensis*, *C. oligantha*, *C. raktakanda*, *C. reclinata C. thalakaveriensis*, *C. vamana*, *C. zedoaria;* Cardamom (*Elettaria cardamomum*), Nutmeg: *Myristica fragrans* (cultivated), *M. malabarica*, *M. dactyloides*; Pepper &

allies *: Piper nigrum*, *P. argyrophyllum*, *P. barberi*, *P. galeatum*, *P. hapnium*, *P. hookeri*, *P. longum*, *P. pykarahense*, *P. schmidtii*, *P. silentvalleyensis*, *P. trichostachyon*, Clove tree*: Syzygium aromaticum* (cultivated)*;*Vanilla: *Vanilla planifolia*, *V. wightiana* Ginger*: Zingiber officinale* (*cultivated*), *Z cernuum*, *Z. neesanum*, *Z. purpureum*, *Z roseum*, *Z wightianum*, *Z. zerumbet*.

Oilseeds: Coconut (*Cocos nucifera*), Oil Palm (*Elaeis guineensis*) Linseed WR : *Linum mysorense*, Sesamum: *Sesamum indicum S. laciniatum*, *S. malabaricum*, *S. mulayanum*, *S. radiatum*. Beverages: Tea (*Camellia sinensis*), Coffee (*Coffea arabica*): *Psilanthus travancoricus*, *P. crassifolius*, *P. wightianus.* Latex**:** Rubber (*Hevea brasiliensis*).

Other economic plants

Fruits: Custard apple: *Annona cherimola*, *A. reticulata*, *A. squamosa*, Jack fruit*: Artocarpus heterophyllus*, *A. gomezianus* var. *zeylanicus*, *A. hirsutus; Baccaurea courtallensis; Buchanania barberi;* Karuanda*: Carissa macrocarpum*, *C macrophylla*, *C. paucinervia*, *C. perrottetii*, *C. sulphuratum;* Lime (*Citrus aurantifolia*)*;*Persimmon*: Diospyros nilagirica*, *D. bourdillonii*, *D. malabarica*, *D. pruriens;*WR Rudraksh: *Elaeocarpus oblongus*, *E. serratus;* Wild banana (*Ensete superbum*), Strawberry WR: (*Fragaria nilgerrensis*)*;* Malabar Tamarind: *Garcinia gummigutta*, *G. gummigutta* var. *conicarpa*, *G. gummigutta* var. *papilla*, *G. travancorica*, *G. morella*, *G. wightii*, *G. indica*, *G. xanthochymus; Lansium domesticum;* Wood apple (*Limonia acidissima*)*;* Barbadose cherry (*Malpighia glabra*)*;* West Indies cherry (*Malpighia punicifolia*); Mango*: Mangifera indica* (several varieties)*;* Mahua*: Madhuca bourdillonii*, *M. longifolia* var. *longifolia*, Spanish cherry: *Mimusops elengii; Manilkara hexandra*, Sapota: *Manilkara zapota;* Banana: *Musa sapientum*, *M. rosacea;* Rambuttan: *Nephelium lappaceum;* WR Olive*: Olea glandulifera;* Avocado*: Persea americana* (cultivated); Indian Gooseberry*: Phyllanthus acidus*, *P. emblica*, *P. indofischeri;* Guava*:Psidium guajava*, *P. guinnense*, Strawberry Guava *Psidium catlleianum*, Jamun*: Syzygium cuminii*, WR Java Plum*: Syzygium jambos*, *S. arnottianum*, *S. bourdillonii*, *S. bracteatum*, *S. jambos*, *S. mundagum*, *S. malabaricum*, *S. montanum*, *S. singampattiana;* Grapes*: Vitis vinifera.*

Nuts: Cashewnut (*Anacardium occidentale*), Macadamia nut (*Macadamia ternifolia*)

Sunnhemp*: Crotalaria clarkei*, *C. digitata*, *C. grahamiana;* WR China grass (*Boehmeria malabarica*). Aromatic oils**:** lemon grass*: Cymbopogon flexuosus* var. *coimbatorensis*, *C. martini* var. *tofia*, *C. polyneuros*, *C. travancorensis*, *Dichanthium oliganthum* (scented leaves).

Bamboos*: Dendrocalamus strictus*, *Ochlandra beddomei*, *O. ebracteata*, *O. travancorica*, *O. talbotii*, *O. scriptoria*, *O. wightii*, *Oxytenanthera stocksii Pseudotenanthera bourdillonii*, *P. monodelpha*, *Schizostachyum beddomei*, *Yushania wightiana*.

Canes: *Calamus brandisii*, *C. dranfieldii*, *C. gamblei*, *C. hookerianus*, *C. huegelianus*, *C. lakshmanae C. metzianus*, *C. nagbettai*, *C. neelagiricus*, *C. prasinus*, *C. rheedii*, *C. stoloniferus*, *C. travancoricus*, *C. vattayila*.

Gums and resins: *Dipterocarpus bourdillonii*, *Hydnocarpus macrocarpa;* White Dammar (*Vateria indica*).

Ornamentals: *Arenga pinnata*, A. *wightii*, *Caryota urens*, *Elaeocarpus munronii*, *E. recurvatus*, *E. venustus*, *Ixora coccinea*, *I. notoniana*, *Lilium neilgherrensis*, *Jacaranda acutifolia*, Jasmine WR *Jasminum angustifolium*, *J. auriculatum*, *J. flexile*, *J. malabaricum*, *J. mesnyi*, *J. multiflorum; Michelia champaca; Milletia rubignosa*, *M. splendens;* Water lillies *Nymphaea nouchali*, *N. rubra; Pelargonium graveolens*, *Rhododendron arboreum* ssp. *nilgiricum*.

Timber: Anjali (*Artocarpus hirsutus***)**, Rosewood (*Dalbergia volubilis*, *D. beddomei*, *D. travancorica*)*; Diospyros bourdillonii;* White cedar (*Dysoxylum malabaricum*), *D. beddomei*, *Gluta travancorica* (scarlet wood), *Haldinia cordifolia*, *Hopea parviflora H. glabra*, *H. wightiana*, Malabar Mahogany (*Kingiodendron pinnatum*), *Mesua ferrea*, *Palaquium ellipticum*, *Poeciloneuron indicum*, *Pterocarpus marsupium*, *Syzygium cuminii*, *Swietenia mahagoni Tectona grandis*, *Terminalia arjuna*, *T. paniculata*, *Xylia xylocarpa*.

Multipurpose species*: Falcataria moluccana*, *Leucaena leucocephala*, *Morus alba*, *Stylosanthes humilis*, *S. scabra* Oilseeds*: Sesamum laciniatum*, *S.malabaricum*, *Sesamum mulayanum*, *Sesamum radiatum;* Beverages: Coffee: *Coffea arabica*, C. robusta, WR *Psilanthus crassifolius*, *P. travancoricus*, *C. wightianus*, Tea*: Camellia sinensis.*

Endemic species: *Agrostis peninsularis*, *A. schmidii*, *Amomum muricatum*, *Amorphophalus bonaccordensis A. commutatus*, *A.*

smithsonianus, *Aralia malabarica*, *Arenga wightii*, *Artocarpus hirsutus*, *Arundinaria densiflora*, *Baccaurea courtallensis*, *Calaophyllum apetalum*, *Chorophytum malabaricum, Cinnamomum keralense*, *C. macrocarpum*, *C. malabathrum*, *C. travancoricum*, *Curcuma cannanorensis*, *C. cannanorensis* var. *lutea*, *C. kudagensis*, *Croton malabaricus*, *Cymbopogon flexuosus* var. *coimbatorensis*, *Diospyros pruriens*, *D. nilagirica*, *Dipterocarpus indicus*, *Elaeocarpus munronii*, *E. recurvatus*, *Embelia gardeneriana*, *Eragrostis unioloides* var. *tremela*, *Eugenia argentea*, *E. discifera*, *Ficus beddomei*, *F. dalhousiae*, *Flacourtia latifolia*, *F. montana*, *Garcinia gummigutta*, *G. travancorica*, *G. wightii*, *Hopea glabra*, *H. parviflora*, *Indigofera trita* var. *marginulata*, *Ixora notoniana*, *Jasminum malabaricum*, *Lilium neilgherrense*, *Madhuca roxburghiana*, *Milletia rubiginosa*, *M. splendens*, *Mucuna pruriens* var. *hirsuta*, *Myristica malabarica*, *Ochlandra travancorica*, *Piper barberi*, *P. galeatum*, *P. hapinum*, *P. schmidtii*, *P. trichostachyon*, *P. wightii*, *Paphiopedilum druryi*, *Polyalthia fragrans*, *Pterospermum reticulatum*, *Rauvolfia hookeri*, *Rhododendron arboreum* subsp. *nilgiricum*, *Sorghum stapfii*, *Syzygium bourdillonii*, *S. chavaran*, *S. densiflorum*, *S. microphyllum*, *S. malabaricum*, *S. mundagam*, *S. palghatense*, *S. parameswaranii*, *S. travancoricum*, *Trichosanthes anamalaiensis*, *Vigna bourneae*, *V. vexillata*.

Threatened species: *Amorphophallus dubius*, *Cajanus lineatus*, *Calamus brandisii*, *Cinnanomum travancoricum*, *Psilanthus crassifolius*, *Cortalaria clarkei*, *C. digitata*, *C. grahamiana*, *Dioscorea wightii*, *Diospyros bourdillonii*, *Elaeocarpus recurvatus*, *Garcinia wightii*, *Heracleum candolleanum*, *Iphigenia sahyadrica*, *Ipsea malabarica*, *Luffa umbellata*, *Madhuca bourdillonii*, *M. insignis*, *Meliope indica*, *Meteoromyrtus wynaadensis*, *Momordica subangulata*, *Myristica fatua* var. *magnifica*, *Oryza officinalis* subsp. *malampuzhaensis*, *Pancratium parvum*, *Paphiopedilum druryi*, *Piper barberi*, *P. hapnium*, *P. pykarahense*, *Syzygium beddomei*, *S. benthamiana*, *S. bourdillonii*, *S. chavaran*, *S . courtallense*, *S. palghatense*, *S. singampattiana*, *Vanilla wightiana*, *V. walkerae*, *Vigna bourneae*, *Zingiber cernuum*, *Z. neesanum*.

Associated culture and tribes

The main tribes associated with region are Hill Pulaya, Irulan, Kadar, Kanikar, Kuruman, Kuricha Malai Pandaram, Pannayan, Ulladan. Jenu Kuruba, Koraga Cholanaickens, Kadar, Kurumbas, Kattunaickan.

Cholanaikens are the cave-dwellers of Nilambur forests and they are hunter gatherers. The tribal community Kurichias are inhabitants of Wayanad and they wear sandwood paste as Kuri as part of their ethos. They raise crops like pepper, turmeric, ginger on their small patches of land. Though Kurichias are primarily farmers, they are experts in archery. The other tribes living in the Malabar agro biodiversity region usually collect forest non wood products and medicinal plants for their livelihood.

Technology and products

The Malabar region is known through out the world as the land of spices. i.e. cinnamon, cardamom, ginger, pepper, nutmeg, , arecanut, turmeric. The region is known for the production of quality pepper, cardamom, ginger, cinnamon, nutmeg, arecanut and other spices.

The region has rich genepool of rice having medicinal properties, long shelf life, flood and salinity tolerance, etc. More than 600 varieties have been recorded with diverse properties, including medicinal and nutraceutical values. The local varieties of rice have been extensively used in the rice crop improvement programme. Pattambi varieties have been developed using local varieties, such as Aryan, Pannaryan, Vellari, Tharalakkannan, Thekkancheera, Thekkanchitteni, Vadakkanchitteni, Thekkan, Vellari, Cheriyaryan, Kodiyam, Kattamodan, etc. (Tiwari, 2004). There are several landraces known as source of disease resistance, like Ptb21 from Thrissur for Gall midge resistance. Significant genetic diversity has been observed in sesame, where variety like Kayamkulam has been selected from a local landrace from Onattukara local. The wild relatives of Sesame i.e. *Sesamum laciniatum* and *S. mulayanum* available from this region have contributed traits for the resistance to phyllody and powdery mildew to the cultivated crop species *Sesamum indica* (Mehetre *et al.*, 1994).

The region represents rich genetic diversity in vegetable crops. In *Cucurbita moschata*, variety Ambili has been developed from Kerala local. In Okra, the region has natural hybrids between *Abelmoschus esculentus* and *A. caillei*, which is naturalised here. The wild relative, *Abelmoschus angulosus* is a useful genetic resource.

The Malabar region is well known for different cultivars of banana from red skinned Kappa, large yellow skinned Nedran to small yellow

skinned Kadali, Rasakadali, Poovan, Matti, Monthan, Palayamkodan to green skinned Padachi and Morris. The region is also known for traditional varieties of mango: Mundappa, Olour, Pairi. In Jack fruit, Varikka landrace has quality fruit which is preferred by people. The other landraces are Koozha and Navarikka. Coorg Mandarin (*Citrus reticulata*) from Karnataka region is a popular cultivar.

Among spices, the local cultivars of pepper presents the maximum variability. In the case of pepper several cultivars have been developed through clonal selection from local types, as for example, Panniyur 4 from Kuthiravally, Sreetara from Karimunda, Panchami from Aimiriyam, Pournani from Ottaplackal, PLD 2 from Kottanadan and Panniyur 6 from Karimunda. In ginger significant variability is found, and products like IISR Varada have been derived through clonal selection from Kerala local. Cardamom (*Elettaria cardamomum*) has three distinct types, Malabar type, Mysore and Vazhukka from the region and a number of cultivars have been developed, like Mudigere-1 by clonal selection from Malabar type, PV1 from Walayar, ICR11 from Chakkupalam collections, ICR-13 from Malabar type and ICR-14 from Vadagaraparai type. The region is also rich in genetic diversity for large cardamom. In turmeric, (*Curcuma longa*) significant variability exists for yield and drying quality. There are well known cultivars such as Allepey, which is considered high yielding with quality rhizome. Suguna Shobha is a clonal selection from local germplasm (Ravindran *et al.*, 2005). The spice nutmeg (*Myristica fragrans*), introduced from Indonesia and naturalized here, presents variability due to dioecious nature and sexual propagation, for characters, such as fruit size, shape, mace and seed volume (Krishnamoorthy *et al.*, 1996). High yielding Konkan Sugandha was selected from local germplasm collections. Cinnamon is indigenous with large number of endemic species and Malabar region is one of the centres of variability. The leaf oil cinnamon contains cinnamaldehyde. Products like Navasree, a seedlings selection from Sri Lankan collections and Nithyasree from the Indian collections have been developed. Malabar Tamarind (*Garcinia gummi-gutta*) also has considerable variability. A drink, called Kokam has been developed using fruit extract.

The region is rich in several minor tuber crops like arrowroot (*Maranta arundinacea*), Chinese potato (*Coleus parviflorus*), Queensland arrowroot (*Canna indica*). Winged bean (*Psophocarpus tetragonolobus*) and Yam bean (*Pachyrhizus erosus*) are alternative food crops which are grown in Kerala. The variety Sree Dhara, was developed in Chinese potato through clonal selection in CP58. The variety Rajendra Mishrikand-1 of yam bean developed through seedling selection from local collections has resistance to insect pests. (Edison *et al.*, 2005)

The region is known for production of quality rubber, cashewnut, tapioca besides spices and coconut. The southern Karnataka portion of the Malabar region is also characterised with areca gardens intercropped with coffee, banana, vanilla, pepper, etc.

The malabar agrobiodiversity region is known for sacred groves, called " Kavu" or "Serpa Kavu" or "Deva kadu" for worshipping sacred plants as per Hindu rituals. Usually households during ancient times set aside the south west corner of their land for sacred groves which was dedicated to plants and snakes. At present, sacred groves whch are mostly private lands are on the decline along with their rich biodiversity due to urbanisation.

7.22 Islands Agrobiodiversty Region

Location and extent

The Andaman and Nicobar archipelago consists of about 350 islands and over 200 islets situated in the Bay of Bengal (latitude 6° N- 14°N and longitude 92°-94°E) and the islands are oriented in the form of an arch in a south to north direction stretching over 912 km. The 10-degree channel separates the Andaman group of islands from the Nicobar group of islands. With about 8290 sq. km of geographical area, the highest peak is the Saddle Peak (alt. 720 m above MSL) in the Andaman group while Mt. Thullier (alt. 670 m above MSL) is the highest peak in the Nicobars.

Agroclimate

The climate is characterized by the tropical conditions with very little difference between the mean summer and winter temperatures.

The annual rainfall ranges from 1600-3000 mm, which meets the entire annual potential evapotranspiration. There is water shortage during December - March, while water deficit is acute during during February - March. Appropriate water catchment technologies have to be developed for sustainable management of heavy rains. The moisture availability extends the growing period to more than 270 days, which is sufficient to support double cropping system as well as plantation crops. The soil is medium to very deep, red, loamy, acidic and is moderate to low in base saturation.

Floristic diversity

The region is very rich in floristic diversity with about 249 endemic species of which 96 species are arborescent (Nayar, 1996). The vegetation includes tropical evergreen rain forests, moist deciduous forests, littoral swamp forests and Mangroves. The evergreen forest comprises of the following representative canopy trees: *Dipterocarpus andamanicus*, *D. incanus*, *D.turbinatus*, *Hopea odorata*, *Planchonia andamanica*, *Sideroxylon longipetiolatum*. Some of the following canopy trees representing the tropical moist deciduous forests are *Canarium euphyllum*, *Parishia insignis*, *Pterocarpus dalbergioides*, *Terminalia bialata*, *T. mannii*, *T. procera*. The tidal swamp forest consists of *Cerbera odollam*, *Heriteria littoralis*, *Excoecaria agallocha*, *Barringtonia racemosa*. The most common mangrove trees are *Avicennia marina*, *Bruguiera gymnorrhiza*, *B. parviflora*, *Ceriops tagal*, *Nypa fruticans*, *Rhizophora apiculata*, *R. mucronata*.

Agriculture and agrobiodiversity

The settled agriculture is of very recent origin. Farming is confined to specific areas around habitations and the dominant crop grown is rice (*Oryza sativa*). Generally, the land use is dominanted by the planation crops such as coconut, arecanut, oil palm. There are plantations with inter cultivation of crops like pineapple, tapioca, pepper and aroids. Some of the species cultivated are Green gram (*Vigna radiata*), Black gram (*Vigna mungo*), Bottle gourd (*Lageneria vulgaris*), Brinjal (*Solanum melongena*), Jamun (*Syzigium cuminii*), Fig (*Ficus carica*), Cardamom (*Hornstedtia fenzlii*), Garcinia (*Garcinia jalinekii*), Yam (*Amorphophallus muelleri*), Custard apple (*Annona*

squamosa), Drumstick (*Moringa oleifera*), Indian coral tree, Noni (*Morinda citrifolia*), Kokum (*Garcinia indica*). Agriculture is very recent activity confined to habitations and there is no traditional farming

Crops and wild relatives

Cereals: Rice: *Oryza sativa*, wild rice (*Oryza indandamanica*). Tubers: Yam: Elephant-foot Yam: *A. muelleri*, *A. longistylus*, *A. onchophyllus;* Taro*: Colocasia esculenta*, *C. mannii; Dioscorea bulbifera*, *D. glabra*, *D. vexans*; *Tacca leontopetaloides.*

Other economic plants

Fruits: Bael (*Aegle marmelos*), Jack fruit (*Artocarpus heterophyllus*, *A. incisa*), *Baccaurea sapida*, Wild fig (*Ficus andamanica*), Garcinia (*Garcinia jalinekii*, *G. calycina*), Mango: (*Mangifera andamanensis*, *M. camptosperma*)*; Mimusops andamaica*, *Manilkara littoralis*, Wild Jamun (*Syzygium andamanicum*, *Syzygium clavifolium*, *S. polyanthum*, *S. samarangense; Salacia chinensis*, *Semecarpus kurzii*, *Terminalia catappa*, *T.mannii*.

Vegetables: Wild and less known vegetables: Kachnar (*Bauhinia nicobarica*), *Canavalia turgida*, *Pandanus andamanensium*, *P. lerum*, *P. tectorius*; Vigna: *Vigna marina*.

Spices: Wild Cardamum (*Hornstedtia fenzlii*), Pepper: *Piper sarmentosum*, Nutmeg*: Myristica connaroides*, (*Horsfieldia macrocarpa*), *Knema andamanica*, *Vanilla andamanica*.

Timber: (Hard wood): Gurjan (*Dipterocarpus andamanica*), Khari Mahua (*Manilkara littoralis*); Padauk (*Pterocarpus dalbergioides*); White Bombay (*Terminalia procera*), White Chuglum (*Terminalia bialata*), Black Chiglum (*Terminalia mannii*)*;* (Soft wood): *Pterygota alata*, *Bombax insigne*, *Canarium euphyllum*, *Planchonia andamanica*, *Sideroxylum longiptiolatum*. Mutipurpose species: Water coconut (*Nypa fruticans*), *Pandanus lerum*, *P. tectorius*, *Vigna marina*, *Strychnos andamanensis. Strychnos narcondamensis.*

Endemic species: *Aglaonema nicobarica*, *Aglaia fusca*, *Amoora mannii*, *A. wallichii, A. longistylus*, *A. oncophyllus*, *Hornstedtia fenzlii*, *Bauhinia nicobarica*, *Bentinckia nicobarica*, *Bombax insigne*

var. *andamanica*, *B. insigne* var. *polystemon*, *Brassaiopsis andamanica*, *Calamus andamanicus*, *C. baratangensis*, *C. basui*, *C. calycina*, *C. jelinekii*, *C. kurzii*, *C. nicobaricus*, *C. pseudorivalis*, *Canarium mannii*, *Dillenia andamanica*, *Dipterocarpus andamanicus*, *D. vexans*, *Dysoxylum andamanicum*, *Euodia parkinsonii*, *Garcinia andamanica* var. *andamanica*, *G. calycina*, *G. jelinekii*, *G. kurzii*, *Horsfieldia macrocarpa* var. *connarioides*, *Jasminum andamanicum*, *J. cordifolium*, *J. multiflorum*, *J. unifoliolatum*, *Knema andamanica* subsp. *andamanica*, *Macaranga nicobarica*, *Mangifera andamaica*, *Miliusa andamanica*, *M. tectona*, *Mimusops andamanica*, *Myristica connarioides*, *Pandanus andamanensis*, *Polyalthia parkinsonii*, *Schefflera pushpangadanii*, *Semecarpus kurzii*, *Strychnos andamanensis*, *S. narcondamensis*, *Syzygium andamanicum*, *S. manii*, *Tabernaemontana crispa*. var. *nicobarica*., *Terminalia mannii*, *Vanilla andamancia*, *Walsura candollei*.

Threatened species: *Bombax insigne* var. *andamanica*, *B. insigne* var. *polystemon*, *Corypha macropoda*, *Garcnia andamanica* var. *andamanica*, *G. jelinekii*, *G. kingii*, *G. kurzii*, *Mangifera andamanica*, *Oryza indandamanica*, *Syzygium andamanicum*, *S. mannii*, *Vanilla andamanica*.

Associated culture and tribes

The Nicobarese constitutes the largest tribal group numbering about 22000 who live in the islands of Great Nicobar and Car Nicobar. They have subsistence farming: coconut, tuber crops cutivation and rearing pigs form the main components of their agriculture. Shompens in the Great Nicobar islands have mongoloid features and they constitute a very small group of about 223 people. They are mainly hunter gatherers and also fish along the sea front. The Jarawas, Sentelenese, Onges and Great Andamanese are small tribes of hunter-gatherers whose number is dwindling to the level of extinction.

Technology and products

As agriculture is recent to the region, it is yet to develop commercial products and practices. However, the Andaman & Nicobar islands present a significant genetic diversity in coconut and in many horticultural and medicinal palnts. There are untapped genetic

resources in rice i.e. *Oryza indandamanica* is a recent discovery from Andamans. In fruits, the region is rich in wild mango *Mangifera andamanensis* and *M. camptosperma*. The region also has significant variability for certain species of medicinal importance, such as, *Morinda citrifolia*, which has gained importance in recent years because of anti-oxidant properties. Recently, large scale cultivation of oil palm and rubber are being done to boost the economy of the islands. There are large number of untapped and underutilised wild relatives of *Dioscorea*, *Colocasia*, *Myristica*, *Piper Cinnamomum*, *Garcinia*, *Syzygium*, *Pandanus* in the islands.

LIST OF ACRONYMS

BDA	Biological Diversity Act
BSI	Botanical Survey of India
CBD	Convention on Biological Diversity
CGIAR	Consultative Group on International Agricultural Research
CGRFA	Commission on Plant Genetic Resources for Food and Agriculture
CoP	Conference of Parties
DUS	Distinctiveness, Uniformity and Stability
FAO	Food and Agriculture Organisation
GIS	Geographical Information System
HYV	High Yielding Variety
ICAR	Indian Council of Agricultural Research
IPGRI	International Plant Genetic Resources Institute
IPR	Intellectual Property Rights
IUCN	International Union for the Conservation of Nature and Natural Resources; also known as The World Conservation Union
IUPGR	International Undertaking on Plant Genetic Resources
MoEF	Ministry of Environment and Forest, New Delhi
MSSRF	M. S. Swaminathan Research Foundation
NBA	National Biodiversity Authority
NBPGR	National Bureau of Plant Genetic Resources, New Delhi
NGB	National Gene Bank, New Delhi
NGO	Non-Governmental Organisation
NISCAIR	National Institute of Science Communication and Information Resources
PGR	Plant Genetic Resources

PGRFA	Plant Genetic Resources for Food and Agriculture
PPV & FRA	Protection of Plant Varieties and Farmers' Rights Act
TRIPS	Trade Related Intellectual Property Rights
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme.
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Scientific and Cultural Organization
UPOV	International Union for the Protection of New Varieties of Plants.
USAID	United States Agency for International Development
WTO	World Trade Organisation
WWF	World Wide Fund for Nature

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PROTECTION OF PLANT VARIETIES & FARMERS' RIGHTS AUTHORITY

NASC Complex, DPS Marg, Opp. Todapur Village, New Delhi-110012

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Vol. I

Indian Parliament passed the Protection of Plant Varieties and Farmers' Rights Act in October, 2001, to fulfill obligations under Article 27.3 (b) of TRIPs. The main objective of this Act is to provide for the establishment of an effective system for protection of plant varieties, the rights of farmers and plant breeders and to encourage the development of new varieties of plants.

Section 45(1)(a) of the PPV & FR Act, 2001 stipulates that the Central Government shall constitute a National Gene Fund for : benefit sharing, compensation purposes, supporting conservation and sustainable use of genetic resources including *in-situ* and *ex-situ* collections.

Rule 70 (2), of the Protection of Plant Varieties and Farmers' Rights Act, 2001, prescribes that the Gene Fund shall be applied for meeting the following purposes :

(a) to support and reward farmers, community of farmers, particularly the tribal and rural communities engaged in conservation, improvement and preservation of genetic resources of economic plants and their wild relatives, particularly in areas identified as agrobiodiversity hot spots,

(b) for capacity building on *ex-situ* conservation at the level of the local body, particularly in regions identified as agro-biodiversity hotspots and for supporting *in-situ* conservation.

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