Maharashtra Genebank Programme

A multi-institutional project funded by Rajiv Gandhi Science & Technology Commission, Govt. of Maharashtra

Executive Summary





Coordinated by Indian Institute of Science Education and Research Pune

SUMMARY REPORT

Maharashtra Gene Bank Project

A project financed by Rajiv Gandhi Science and Technology Commission, Govt. of Maharashtra

Key words: Biodiversity, genetic resources, agro biodiversity, marine biodiversity, freshwater biodiversity, grasslands biodiversity, livestock, forest biodiversity, bio- prospecting, informatics, Community led initiatives, *Ex- Situ* and *In -Situ* conservation pilots across Maharashtra

I. Premable

The Rajiv Gandhi Science and Technology Commission (RGSTC) of Maharashtra Government, had invited Dr. Madhav Gadgil to prepare a program on Gene Bank for Maharashtra in the year 2006.

Extensive consultations with the Government agencies like NBPGR, NBAGR, NBFGR, and Agricultural Universities etc. were held to crystallize the ideas and to avoid duplication of ongoing conservation efforts. It was decided that the Maharahstra Gene Bank Project would take a broader view and design a live gene bank with both in situ and ex situ components. This was followed by state-wide consultations with various stake holders to finalize the approach and themes.

The comprehensive, face to face consultations that have followed have taken the form of 122 events held in 24 districts and involving the representatives from all the 35 districts. Based on these above discussions and consultations Dr. Madhav Gadgil submitted to RGSTC a project proposal with 9 projects and 26 subprojects in 2009.

In 2011, Dr. Anil Kakodkar, Chairman of RGSTC, took active steps to roll out this project. It was decided that the project will be coordinated by IISER Pune. Since there has been a long gap after the submission of the project, the entire project was revised and resubmitted to RGSTC. RGSTC approved and sanctioned the project in January 2014.

MGB is a collaborative process of knowledge generation, documentation, validation and propagation of successful community-driven practices of conservation of biodiversity. The project is coordinated by IISER Pune, involving 3 national R & D institutes, 2 Academic Institutions and 15 dedicated NGOs, of which two are pan-India organisations, that help facilitating a reach-out to the people involved in conservation activities. The project was initially sanctioned for 5 years, i.e. up to March 2019. After a couple of extensions, during the Covid 19 pandemic, the project came to a conclusion on 31 December 2020. A consolidated report of each of the organisations is included in this compilation.

The program has identified the following seven major thematic areas:

- 1. Ex situ conservation of marine biodiversity
- 2. On farm conservation of crop genetic diversity
- 3. On farm conservation of livestock genetic diversity
- 4. Conservation and sustainable use of indigenous fish and shellfish diversity in selected water bodies
- 5. Conservation of grassland and savanna biodiversity
- 6. Eco restoration of community forest resource lands employing a diversity of life sustaining and economic plant species
- 7. Participatory management of relevant information

II. Objectives

- 1. Documentation of biodiversity, traditional wisdom, and conservation practices adopted by communities in different ecosystems and eco-zones in Maharashtra
- 2. Validation and upholding of successful conservation practices by observations, experimentations, data collection and analysis

- 3. Propagation of these successful practices by communication and intervention at the academic, policy and societal level, from the regional to the international scale.
- 4. To sustain our rich heritage of biodiversity resources on a long term basis to be able to address the issue of climate change related vulnerability and food and nutrition insecurity.

Except for 6 districts, viz. Buldana, Yavatmal, Wardha, Nagpur, Raigad and Thane, each of the districts of Maharashtra is covered by one or more of the thematic areas of the project.

III. Salient Features of the project

- **i. Cross-institutional process:** The uniqueness of MGBP lies in the fact that it brought together several grass-root workers and social scientists, and marginalised communities together towards achieving a common goal of conservation of biodiversity.
- **ii. Inter-disciplinary process:** Although the eight thematic areas are distinct from each other, the dialogue has resulted in beginning syntheses about broad questions and ideas cutting across themes.
- **iii. Scientific validation:** Using the modern scientific methodology to separate the chaff from the grain from the massive pool of traditional Indian wisdom has been a significant achievement.
- iv. Documentation of local knowledge and biodiversity related wisdom of communities and preparation of Peoples Biodiversity Registers (PBR): The project could help documenting vast traditional knowledge resource that local communities have on their surrounding biodiversity. In many villages, such knowledge could be compiled in the form of People's Biodiversity Registers.
- v. Scouting and introduction of crop cultivars and livestock breeds for better adaptation to climate change and variability: Number of local crop types and local livestock breeds were seen performing better during climatic variability in many project clusters. These genotypes could be focussed and conserved in respective agro-climatic zones to help reduce vulnerability of farming communities. This is proving as an important strategy for building resilience of local tribal communities.

vi. Demonstrating solutions to ensure food and nutritional security for marginalized communities

The project has helped in documenting many local vegetables and crops which are on the verge of extinction and which once served as a rich resource for food security. Local crop and vegetable based traditional recipes and related knowledge has also been documented and being transferred to the next generation. The project could demonstrate how food and nutritional security can be achieved by introducing perennial and seasonal vegetable crops through kitchen gardens.

vii.Creating a model of community-led conservation in India

The project has helped strengthening many local level institutions in the form of Village Biodiversity Committee/Seed Savers groups, fishing communities, Breeders Association, Self Help Groups, Farmer's collectives, User Groups and Gram Sabhas. The project could demonstrate how community led actions for conservation and management of biodiversity is possible and effective. The project has helped creating a field evidence of model focusing on participatory and collaborative actions to facilitate long-term conservation of diverse, native bio-resources. The success of MGBP will serve as a model to be implemented in other states of India.

viii. Contribution to and alignment with the State and National Level Policies and Programs:

1. Dialogue could be established with Maharashtra State Biodiversity Board. The People's Biodiversity Registers could be prepared for nearly 25 Project villages. Partners could facilitate

village level meetings with the BMCs. A strategy note is also submitted to Maharashtra State Biodiversity Board (MSBB, Nagpur) on the theme of "Biodiversity Conservation Augmentation through Government/Non-government Projects and Programs with Special Emphasis on Cultivar Diversity Conservation "to mobilise funds through CSRs.

- 2. As a strategy, linkages have been established with Protection of Plant Variety & Farmers Rights Authority, New Delhi and 54 landraces have been registered under PPVFR Act, while 74 cultivars have been registered with NBPGR as IC numbers.
- 3. As a result of the work on Grassland diversity conservation, the Govt. of Maharashtra has constituted a joint Working group of Animal husbandry and Forestry Departments for giving recommendations for Grassland development. (जा.क. वैवि.अ. 6(20))/2084-85/ प. स. 14 दि. 22-10-2020.) which has One of the PIs of the Grassland diversity program, Shri Kaustubh Pandharipande as member. Shri Pandharipande has also been invited to submit a plan for a grassland development plan with community participation under CAMPA programme of Maharashtra Forest department (क्रमांक. कक्ष/कम्पा/प्र.क्रा. 47/2020-21/500 दि. 2-2-2021.
- 4. Work could be presented and shared on national and state level and to state Agriculture Universities, KVKs, Botany Department of Universities, Line Departments of government which could help getting better partnerships.

ix. Facilitated inputs from experts and collaborations with scientific & government Institutes

Project could benefit from the inputs from experts of various premier scientific and research organizations like, PPVFRA Authority, NBPGR, NBAGR, SAU of many states, KVKs etc. and peer reviewers.

IV. Thematic Highlights

1. Inventory and bio-prospecting of Marine Invertebrates of the Maharashtra Coast with special emphasis on Sponges and Associated Microorganisms

Participating Institutes: IISER Pune, CSIR-NIO, CoF, Ratnagiri, and NCCS Pune

Rationale for the study

Marine ecosystems are rich in floral and faunal diversity with exceptional bio-medical potential. India's on-going efforts to explore, document, conserve and utilize its natural wealth of biological resources; however, falls short of understanding true potential of marine capital. With the only exception of fish and other edible species, marine organisms, especially invertebrates, are relatively neglected. Marine invertebrates and associated microorganisms are known to produce a variety of novel secondary metabolites as defense mechanisms against predators and pathogens, which are hitherto not isolated from terrestrial ecosystems. Several of these metabolites are of pharmaceutical importance and need attention from pharma and biotech research and development sectors. The increasing realization of the importance of marine biodiversity in ecosystems functioning and sustaining livelihoods and the growing demands of the pharma and biotech research and development sectors for isolating novel compounds, there is a need for dedicated efforts to study, document and conserve marine invertebrates and their unexplored potential. This was the motivating thoughts behind the current project.

Special emphasis was placed on marine sponges as they have been shown to possess most potent and diverse bioactive molecules. Further, marine sponges are known to be associated with a wide diversity of microorganisms that are known to produce many bioactive compounds including polyethers, terpenoids, alkaloids, macrolides and polypeptides. Additionally, sponges play an important role in ecosystem functioning by cleaning and maintaining the healthy environment of a coral reef ecosystem as a result of

removing pathogenic bacteria. As a result, studying sponges and their microbiota has a potential to understand the dynamics for the healthy working of marine ecosystems. Unfortunately, a comprehensive documentation of the number of diverse sponge species from the Maharashtra coast, associated organisms, their microbiota and bio-medical potential are not yet available. Therefore, the present study attempts to fill these knowledge and data gaps.

Objectives

- (i) Creating an inventory of species of sponges in the intertidal zones and up to a depth of 20 meters in 4 selected locations along the Maharashtra coast line.
- (ii) Classical as well as molecular taxonomy of sponges, tunicates and soft coral species along the Maharashtra coast.
- (iii) Outlining strategies for in situ conservation of species.
- (iv) Exploring means of ex situ conservation and gene bank through cryopreservation and any other appropriate strategy.
- (v) Isolation and identification of microbial associates of sponges using cultural and molecular approaches.
- (vi) Screening of sponges, tunicates, soft corals and other invertebrates and the associated microorganisms for bioactive compounds using a battery of assay systems.
- (vii) Isolation and characterization of active compounds.
- (viii) Taking necessary steps towards commercialization of compounds of potential interest.

Key Achievements

Inventory of marine sponges and associated eukaryotic organisms

Extensive inventory of marine sponges and associated organisms was prepared. A total of 45 species of marine sponges were identified from the coast of Maharashtra and Goa. CoF documented 20 species of



18 Sponge species identified along the Ratnagiri coast

sponges under Class Demospongiae and Calcarea from 11 locations along the coast of Maharashtra, while CSIR-NIO documented 31 species from the coast of Maharashtra and Goa. Sponges were identified using traditional morphological taxonomy and molecular taxonomic methods using nuclear ITS1 and 28S rRNA markers and mitochondrial 16S rRNA and COI markers at CSIR-NIO and NCCS. CSIR-NIO generated genetic information for 22 specimens while NCCS generated genetic information for 31 specimens of marine sponges.

In addition to the sponges, sponge associated flora and fauna was documented by CoF, which included species of seaweeds, mollusks, Echinoderms, Nudibranchs, Corals, Phytoplankton and Zooplankton. A total of 25 species of hard corals, one Non-Scleractinian and four soft corals were identified by CSIR-NIO, where Porites was the most dominant genus. CSIR-NIO reported Foraminifera, Anthozoa, Turbellaria, Polychaeta, Crustacea, Bivalvia, Gastropoda, Ophiuroidea, Nematoda, and Sipuncula associated with the two most common sponge species *Cinachyra cavernosa* and *Ircinia fusca* of Maharashtra and Goa coast.



A new species of sponge from Maharashtra coast

Research team at CSIR-NIO described a new bioeroding sponge species, *Cliona thomasi*, from the central west coast of India. It belongs to the *Cliona viridis* species complex. The new species was described using traditional morpho-taxonomy and molecular data from nuclear ITS1 and 28S rRNA genetic markers. *Cliona thomasi*, is locally very abundant and a key bioeroder of corals. Discovery of *Cliona thoamasi* was recognized as among the "Ten remarkable new marine species from 2019" by LifeWatch, Belgium.

Inventory of prokaryotes isolated from sponges and associated environments

Both culture dependent and culture independent metagenomic approaches were used for understanding the prokaryotic diversity associated with sponges and their environment. Research team at IISER Pune isolated 2821 cultivable prokaryotes out of which 1961 were identified. The identified prokaryotes belonged to 111 genera. Out of the total 1961 identified bacteria and archaea, 386 were actinobacteria and there were seven archaea of the genera *Halobacterium* and *Methanococcus*. Actinobacteria from sponges and associated environments showed a rich phylogenetic diversity. The study provided first report of nine species, namely *Brachybacterium murisi, Jonesia denitrificans, Nocardiopsis salina, Pseudonocardia kongjuensis, Rhodococcus zopfii, Rothia terrae, Serinicoccus marinus, Streptomyces smyrnaeus* and *Streptomyces viridobrunneus*, from marine sponges. With the help of NCCS research team all the isolated prokaryotes isolated by IISER Pune are deposited in the Microbial Culture Collection (MCC) of NCMR, NCCS, Pune.

Culture independent metagenomics study to understand microbial diversity associated with the two phylogenetically distinct intertidal marine sponges, viz. *Callyspongia fallax* and *Amorphinopsis maculosa* was performed by NCCS. Sponge heterogeneity was found to drive the differences seen in bacterial community structure. The predominance of bacterial phylum Proteobacteria in this study was in coherence with the earlier reports published on sponge-microbial symbiosis across the world. NCCS also performed culture dependent prokaryotic diversity especially for halotolerant and halophilic organisms. Total 50 halotolerant bacteria and 13 haloarchael strains were isolated from 4 types of sponges collected from west coast of India.

Microbial community analysis of *Cliona thomasi* the newly described bioeroding sponge species was performed by CSIR-NIO. The 16SrRNA amplicon sequencing analysis performed on one specimen of

Cliona thomasi revealed that reads for bacterial prokaryotes dominated the overall community composition, followed by Archaea. Bacteria strongly prevailed in diversity and abundance over all other taxa we amplified, in the sponge tissue, as well as in the ambient sediment.

Ecological studies on sponges and associated organisms

Ecological studies on sponges and associated organisms are scarce in Indian context. Qualitative and quantitative studies were performed to understand abundance, biodiversity profile, seasonal variation, habitat preferences, and environmental variables associated with sponge diversity and distribution. Based on quantitative transect sampling, CoF researchers studied seasonal dynamics on diversity profile of sponges in four localities. The study revealed marked seasonal variation in the sponge diversity. They also studied the environmental physico-chemical determinants of sponge abundance and observed seasonal trends in environmental parameters and associated sponge diversity.

CSIR-NIO also performed quantitative survey of sponge associated organisms for two dominant sponges *Cinachyra cavernosa* and *Ircinia fusca*. Sponge associated fauna showed variation across sampling locations and strong seasonal variation. The fauna was also different for the two sponge species. Eight taxa were identified wherein Foraminifera, Polychaeta, Crustacea, Bivalvia, Ophiuroidea, Nematoda, Nemertea, and Sipuncula associated with *Cinachyra cavernosa* sponge. A total of 26 taxa were collected associated with the sponge *Ircinia fusca*. Ophiuroidea, was the most dominant group, present in all months, and the second abundant was the Polychaeta. Among Polychaeta, Family Syllidae was the most abundant family, followed by Eunicidae. Other taxa included Ophiuroidea, Polychaeta, Crustacea, Bivalvia, Sipuncula, Nematoda, Foraminifera and Gastropoda.

Documentation of threats to marine ecosystems

One major hindrance for designing and implementing conservation action for marine ecosystems is the lack of knowledge on the threats to the habitats and their biota. An attempt was made to understand the threats to the habitats and populations. A detailed study of reef biodiversity, the extent of the reef formation, the health status of reef-forming corals, and the impact of coastal pressure and changing climatic condition was planned and executed by CSIR-NIO. The study revealed recurrent coral bleaching events and subsequent coral mortality in the Malvan Marine Sanctuary (MMS) from October 2014 to April 2019. The coral disease prevalence was found to have amplified from the initial observations at all study sites during the monitoring period. Physical damage to corals due to fishing activities and recreational activities was also documented. In addition to this, sewage pollution was predicted based on fecal and sewage associated bacteria, *Aeromicrobium massiliense* and *Glutamicibacter mysorens*, isolated from sediments at Harne by IISER Pune.



Status of Malvan at Present (April 2019)

- Coral Bleaching
- Sponge Encrustation on Corals
- Coral Disease
- Seaweed overgrowth

Ex-situ conservation

An attempt was made to establish sponge culture under laboratory setup, which provided promising results. CoF was successful in culturing two sponge species *Clathria* (*Microciona*) pennata and *Haliclona* (*Reniera*) manglaris under laboratory conditions. Given the complex ecological niche of sponges and threats to their populations and habitats, such laboratory setups will not only provide valuable data on ecology of the species but can also serve as potential method for ex situ conservation.

Bioactive compounds from sponges and algae

New experimental setup for culture of sponges



Screening for active compounds from extracts of marine sponges and algae at IISER Pune yielded nine bioactive compounds with anti-bacterial, anti-fungal, anti-malarial, cytotoxic and anti-inflammatory activities. Sponge *Iricinia fusca* provided maximum number of novel secondary metabolites with broad spectrum antibacterial, antifungal and cytotoxic activities. Sponge *Mycale (Zygomycale) parishii* contributed two novel secondary metabolites both with antibacterial and anti-fungal activities. Sponge *Amphimedon viridis* provided one novel compound with cytotoxic and anti-inflammatory activity. While, red algae *Halymenia floresii* provided a novel secondary metabolite with anti-malarial activity.

Antibiosis, antibacterial activity and growth inhibition by bacterial isolates

Bacterial isolates from sponges and associated environments were used for screening for antibiosis, production of antibacterial compounds and growth inhibitors at IISER Pune. Of the 50 actinobacterial isolates screened for antibacterial activity, 25 showed antibiosis against at least one target organism. *Streptomyces, Nocardiopsis* and *Kytococcus* showed antibiosis against both Gram-negative and Grampositive target species, while *Glutamicibacter* and *Rothia* showed antibiosis against Grampositive organisms only. In addition, *Bacillus sonorensis* isolated from sponges showed antibiosis against Grampositive target species, *Lysinimicrobium mangrove* and *Paracoccus haendensis* showed antibiosis against both Gram-positive and Gram-negative target species, while *Bacillus licheniformis* showed antibiosis against both Gram-positive and Gram-negative target species. Further isolation of active compound from *Nocardiopsis synnemataformans* revealed presence of bioactive compound Pentanyl-3 acetate.

Enzyme inhibitors

Actinobacterial isolates were screened for production of enzyme inhibitors at IISER Pune. Out of 50 actinobacterial isolates screened for inhibition of three proteoletic enzymes and angiotensin converting enzyme, 30 isolates inhibited at least one of the enzyme. The most prolific genera to produce enzyme inhibitors were *Streptomyces* and *Nocardiopsis*. Enzyme inhibitors have potential bio-medical applications. As a result, marine actinobacteria need special attention.

Anti-biofilm activity

Several actinobacterial isolates screened for anti-biofilm activity at IISER Pune showed good potential for biofilm inhibition. Actonobacteria of the genera *Nocardiopsis*, *Rhodococcus*, *Streptomyces*, *Kytoccous*, and *Cellulosimicrobium* isolated from marine sponges and associated habitats showed good anti-biofilm activity. Since, biofilms play a vital role in bacterial infectious diseases, exploring marine actinobacteria for active anti-biofilm compounds could lead to discovery of novel metabolites of therapeutic value.

Predatory actinomyces as potential for novel bioactive compounds

One of the major themes that was explored by IISER Pune research team was the non-obligate epibiotic predatory activity of actinobacteria and its potential for yielding novel bioactive compounds with

pharmaceutical applications. Several important discoveries were made with respect to predatory actinobacteria, the ecology of predation and possible metabolites involved in predation. Out of the total 50 actinobacterial isolates screened for non-obligate epibiotic predatory activity, 26 isolates showed predation on at least one of the 14 target organisms. There was a significant association between the source of isolation (sponge or associated environment) and predatory behavior, where the isolates from sponge showed proportionately more predatory behavior. In the current study, for the first time, we show predatory behavior in six genera of actinobacteria, other than the known genera Agromyces, Streptomyces and Streptoverticillium, namely Brevibacterium, Glutamicibacter, Micromonospora, Nocardiopsis, Rhodococcus and Rothia. An interesting observation made when comparing the predation and antibiotic production by actinobacteria, was that, while predation was equally effective against Gram-positive as well as Gram-negative target species, antibiotic production was mainly effective against Gram-positive bacteria. It is therefore possible that studying the predatory behavior of actinobacteria and predation specific metabolites could lead to discovery of novel therapeutic agents that are more broad-spectrum. Initial attempts at isolating and characterizing predation specific compounds yielded small molecular metabolites that were expressed only in the presence of predation. Further studies on the compound is likely to yield new insights into the predation ecology and its bio-medical application.

Data for Relational Database Management System (RDBMS)

Data of marine prokaryotes and eukaryotes collected in the present study by all four partners were included in Relational Database Management System (RDBMS). There are 1900 data entries for prokaryotic database, which has 36 attributes (Table 1) and 520 data entries for eukaryotic diversity database, which has 34 attributes (Table 2).

Attribute	Data type	Description
Domain	Character	Name of Domain
Phylum	Character	Name of Phylum
Class	Character	Name of Class
Order	Character	Name of Order
Family	Character	Name of Family
Genus	Character	Name of Genus
Species	Character	Name of Species
Data provider	Characters	Data providing institute
Culture repository number	Alphanumeric	Code used for data collection
Collection code	Alphanumeric	Code used for data collection
Location	Character	Name of locality
Latitude (°N)	Numeric	Decimal degrees
Longitude (°E)	Numeric	Decimal degrees
Isolation source	Character	Source of isolation
Habitat	Character	Type of habitat
Isolation medium	Character	Name of the medium
Habitat pH	Numeric	pH value
Habitat salinity (ppm)	Numeric	Salinity in ppm
Habitat TDS (ppm)	Numeric	Total dissolved solids in ppm

Table 1 Attributes for data on marine prokaryotic diversity.

Attribute	Data type	Description
Habitat conductivity (microS)	Numeric	Conductivity in microS
Habitat Dissolved Oxygen (ppm)	Numeric	Dissolved oxygen in ppm
Habitat Temperature (°C)	Numeric	Temperature in degree Celsius
Genes sequenced	Characters	Present/absent (for what marker)
GenBank accession number	Alpha numeric	GenBank accession for sequences
Sequencing institute	Characters	Institute that performed molecular work
Colony size (mm)	Numeric	Diameter of the colony
Colony shape	Character	Shape of the colony
Colony margin	Character	Margin of the colony
Colony elevation	Character	Elevation of the colony
Colony color	Character	Color of the colony
Colony opacity	Character	Opacity of the colony
Colony consistency	Character	Consistency of the colony
Gram character	Character	Gram staining character of the colony
Publication status	Characters	Whether the observation is published
Reference	Characters	Reference for published observation
Remarks	Characters	Remarks, if any

Table 2 Attributes for data on marine eukaryotic diversity	ity.
--	------

Attribute	Data type	Description
Phylum	Character	Name of phylum
Order	Character	Name of order
Family	Character	Name of family
Genus	Character	Name of genus
Species	Character	Name of species
Common name	Character	Common name in English
Location	Character	Name of locality
Latitude (N)	Numeric	Decimal degrees
Longitude (E)	Numeric	Decimal degrees
Collection code	Alphanumeric	Code used for data collection
Museum voucher number	Alphanumeric	Museum voucher of specimen
Location of voucher specimen	Character	Name of the museum
Method of sampling	Character	Method used for sampling
Frequency/Abundance	Numeric	Abundance of the organism
Association	Character	Co-occurring species
Habitat type	Character	Type of habitat
Habitat pH	Numeric	pH value
Habitat salinity (ppm)	Numeric	Salinity in ppm
Habitat TDS (ppm)	Numeric	Total dissolved solids in ppm
Habitat conductivity (microS)	Numeric	Conductivity in microS
Habitat Dissolved Oxygen (ppm)	Numeric	Dissolved oxygen in ppm

Attribute	Data type	Description
Habitat Biological Oxygen Demand (ppm)	Numeric	BOD in ppm
Threats to the habitat	Characters	Description of Threats to habitat
Photographs of Species	Alphanumeric	Code of photograph
Photograph of habitat	Alphanumeric	Code of photograph
Genes sequenced	Characters	Present/absent (for what marker)
GenBank accession numbers	Alphanumeric	GenBank accession for sequences
Molecular service provider	Characters	Institute that performed molecular work
Date of observation/collection	Alphanumeric	Date as dd-mmm-yyyy
Name of the observer/collector	Characters	Name of the observer
Institute	Characters	Data providing institute
Remarks	Characters	Remarks, if any
Published (yes/No)	Characters	Whether the observation is published
Reference	Characters	Reference for published observation

Outreach Activities

"Aquatic Ecosystems: Sustainability and Conservation", a national conference on aquatic conservation, was organized on 20th and 21st December 2019, which was hosted by Indian Institute of Science Education and Research, Pune (IISER-P). There were total 125 participants, 20 invited talks and 48 posters for the conference. The aim of this conference was to provide a common platform for researchers and young investigators in the field of aquatic diversity, ecology, conservation biology and socio-economics to share their experiences and knowledge for a collective effort towards building science based conservation policies and sustaining livelihoods of the future.

The 'First Porifera Identification Workshop in India' was organized by the CSIR- National Institute of Oceanography, Goa from 20th to 22nd November 2019. During this workshop, hands-on training was provided to identify sponges morphologically, carry out histology on certain orders of sponges, sectioning and extraction of spicule along with learning measurement, assign sponges to at least Order or Genus level and to overall enhance the taxonomic skills on sponge identification. International sponge expert Dr. J. Hooper (Queensland Museum, Australia), Dr. T. Samaai and Ms. Liesl Janson (Ministry of Environment, South Africa) were the key resource persons. The experts shared their knowledge with the participants. A handbook of sponge identification guide entitled "Sponge taxonomy guidelines" was published during the events.

A number of outreach activities focusing on marine diversity and conservation were organized by CoF and include Biodiversity of Maharashtra exhibition; series of workshops on Mangrove culture and protection; workshop on Sponge identification techniques; seminar on Role of mangroves in our ecosystem; and a program on Biodiversity of the Rocky Shores for school students.

Publications and presentations

Scientific articles

Findings of the study are published in 22 peer reviewed research articles (10 from IISER Pune, 12 from CSIR-NIO and 1 from NCCS). In addition, 5 manuscripts are currently in preparation.

Conference presentations

Research conducted as a part of current study was presented in conferences (7 by IISER Pune, 11 by CSIR-NIO, 3 by CoF and 4 by NCCS).

Dr. Ulfat Baig from IISER Pune participated in the DST-AWSAR (Augmenting Writing Skills for Articulating Research) was selected as one of the top twenty articles in the post-doctoral fellow category for her article about her work on predatory bacteria that kill other bacteria and consume them for their own growth.

Popular articles

Four popular articles are published, online forum Gotul (IISER Pune) and Agrowan (CSIR-NIO, CoF Ratnagiri and IISER Pune).

Project material developed

Marathi leaflet "Kharfuti", giving the information of Mangroves and there uses, was developed by CoF.

2. Crop Genetic Diversity

Participating Institutes: Gramin Yuva Pragatik Mandal (GYPM, Bhandara); Institute of Integrated Rural Development (IIRD, Aurangabad); Sanskruti Samvardhan Mandal (SSM, Sagroli, Nanded); Sheti Pariwar Kalyan Sanstha (Atpadi); Lokpanchayat (Ahmednagar); BAIF, Pune

Background

Crop genetic diversity is the thematic group of organizations working closely with farmers' groups and farmers from remote parts of different agro-climatic regions of Maharashtra. Traditional farming practices take in account many indigenous, community conserved cropping patterns. Many of the crops are drought resistant and have greater significance in sustaining farmer's economy in changing climate. Some of the crops are specific to particular region and efforts are done to gain GI status to such crops. Many farmers are sustaining their own seeds and farmer's varieties, the efforts are being done to recognize those seeds as local landraces under PPVFR. Some organizations of this group also are linking farmer's special crops with market links, trying to provide niche market to the efforts of conservation. One of the important features of the traditional agricultural practices is 'local seed banks'. Major focus of this group is about identifying diversity in farmer's varieties of seeds; characterization of them scientifically, thereby connecting the local farmer's efforts to the wider scientific knowledge base.

Objectives

- (i) To build up a systematic inventory of crop genetic resources of the state.
- (ii) To identify one variety in each district covered for pilot scale efforts at on farm conservation, upgradation, value addition, marketing, and registration.
- (iii) To establish district level seed banks focusing on traditional cultivars of superior quality
- (iv) To engage educational institutions in study and promotion of crop genetic resources
- (v) To plan and introduce activities for region wise in-situ and ex-situ conservation.
- (vi) Germplasm collection, characterization, evaluation and participatory seed production
- (vii) Building motivation of local communities to participate and manage the program

Organization wise Focus crops

Sr	Organization	Districts	Blocks	No of villages	Focus Crops
1	Gramin Yuva Pragtik Mangdal, Bhandara (GYPM)	Bhandara, Gondiya, Chandrapur	6	64	Rice, Linseed, Lathyrus

Sr	Organization	Districts	Blocks	No of villages	Focus Crops
2	Sanskriti Samvardhan Mandal, Sagroli, Nanded(SSM)	Nanded, Latur, Osmanabad	8	20	Chilli Safflower Sorghum
3	Lokpanchyat,Sangamner (LP)	Ahmednagar, Nashik, Pune	5	20	Rice, Pearl millet, Finger millet, Hycinth bean
4	Sheti Pariwar Kalyan Sanstha, Atpadi, Sangli	Pune, Solapur, Sangali, Kolhapur, Satar	5	15	Sorghum, Rice, Wheat
5	IIRD, Aurangabad	Aurangabad, Beed, Hingoli, Parbhani, Jalgaon, Jalna	6	69	Sorghum, Pigeon pea, Green gram, Safflower, Sesamum,Wheat
6	BAIF, Pune	Gadchiroli, Nandurbar, Ahmednagar, Pune, Palghar, Kudal	6	60	Rice, Millets, Maize, Sorghum, Hycinth bean, Cow pea, Local vegetables, Pulses
	06	23	36	248	18

Registration of Farmer varieties Under PPV & FR Act 2001

Sr	Partner	Name of group /Individual	District	Сгор	No of varieties
1	BAIF	Seed Saver Farmers Group, (2014)	Palghar	Rice	29
2	BAIF	Mr. Sunil Kamadi(2014)	Palghar	Rice	1
3	BAIF	Mr.Mavanji Pawar(2014)	Palghar	Rice	3
4	BAIF	Kalsubai parisar Sthanik biyanee savardhan sanstha , Akole(2015)	Ahmednagar	Hycinth Bean	10
5	BAIF	Yaha mogi Biyanee savarthan samiti(2015)	Nandurbar	Maize	05
6	BAIF	Yaha mogi Biyanee savarthan samiti, (2015)	Nandurbar	sorghum	05
7	LP	Kalbhat utpadak sangh & Devthan bajri utpadka sangh (2016)	Ahmednagar	Pearl millet& Rice	02
8	GYPM	Chikli,Khapa(2015)	Bhandara	Rice	02
9	GYPM	Baudh Nagar(2015)	Gondiya	Rice	01
		Total			58

95 accessions of various crops submitted by BAIF to NBPGR have been registered with IC numbers. Five sorghum lines submitted by BAIF were registered with PPV & FRA.



Participatory seed selection in Little millet, Finger millet and Rice

Morphological Characterisation



Traditional seed storage systems





Seed bank at Jawhar









Output	Achievements
Bio-resource inventory preparation	Accession database (533 accessions), ITK (Traditional food recipes, traditional cultivation practices, cropping systems, seed storage methods, festivals, traditional seed selection methods), Wild edible plants database (304), Shifting cultivation in Akole
Scientific validation	Genotyping of rice and maize (167), Morphological characterization (271 crop cultivars of 18 crops), potential yield studies (25), nutritional studies (189 land races of 6 crops), crop economics (3)
Promotion of validated bio resources	Total no. of farmers (6956),Seed production (101 MT of 18 crops, Kitchen gardens (7200), Sale of produce (199 MT), Tubers (5 MT of 2 species), Area under cultivation (1602 ha)
Conservation and safeguarding of bio-resources	In-situ conservation (996 accessions), Seed banks (community-21, cluster level-7, ex-situ-1), Safeguarded germplasm-registration with NBPGR (74), PPV & FRA (54), ex-situ conservation at CRS (473), PBR prepared (6), BMCs formed (121)
Establishment of Seed saver groups/Po's	3 FPOs, 2 Cooperatives, 179 Seed Saver Groups
Publications (Research Papers, Articles, case studies)	13 (Morphological, nutritional characterization, traditional cultivation practices, Integrated Management of Dry Root Rot in chilli s,pickel standardization ,Wild edible plant diversity), Articles (38), Newspaper articles (20)
Other publications, IEC material	Landrace catalogue, Seed saver directory, Community seed bank working manual, Wild food recipe booklet, Community seed production guidelines, Organic crop production manual, brochures, Seed conservation booklet, Calendars, e-newsletters, posters
Value addition, Branding & Marketing	Kitchen garden kit sale (5000), Product developed (Mahua, Finger Millet,Herbal Coffee,Sorghum biscuits)
Recommended practices, protocols, methodology	Participatory seed production, improved cultivation practices of maize, rice, sorghum, millets, seed storage method.
Collaboration & Linkages	NBPGR, New Delhi, PPV & FRA, New Delhi, UAS Dharwad, National Agri Biotech Institute (NABI),Mohali, Dept of Agriculture (PKVY, ATMA, Maharashtra State Biodiversity Board (MSBB), Tribal Development department (TDD), Maharashtra State rural Livelihoods Mission (MSRLM), National Seed Sovereignty Alliance, SAUs, IIMR (Indian Institute of Millet Research), IIT Bombay, NGO's(15)

Recommendations

Related to Research

- In depth research is required for identifying specific traits like stress tolerance, nutritional status, medicinal properties, any other trait that communities find useful etc. for many crop landraces.
- Genetic diversity study using molecular markers needs to be undertaken to understand diversity among the landraces.
- The approach of participatory varietal selection involving local community may be adopted for identification and genetic improvement of locally suitable crop diversity.
- Mapping of crop diversity across diverse bio-geographic regions and collection of eroding germ plasm should be important research agenda.
- Need to expand the work of *in -situ* conservation of region's agro biodiversity and crop cultivars in different crop- wise native tracts in the state and in India as a whole.

- Need to have multi stakeholder, multi partner effort in future around indigenous crops by focusing on all aspects of food production from collection of germ plasm up to storage and innovative marketing.
- Need to study in depth the role of local crops and wild food resources in vital and essential part of human's food system.
- Mandate Programme on conservation of Regional crop diversity should be given to KVK's and agriculture seed farms which will be live gene centres and demonstration centres for community awareness

Related to Livelihood Security

- Community level seed production and seed banks concept may be adopted for seed sovereignty and to facilitate self-reliance in seeds which is the soul of farming.
- Community led enterprises for production and sale of kitchen garden seeds and grains produced has good livelihood potential and also ensure less dependence on outsider agencies for important seed supply.
- Promotion of selected landraces for cultivation among the farmers through various schemes implemented by state agriculture department needs to be considered, as this can lead to further multiplication of eroding base of worthy crop cultivars.
- Inclusion of local cultivars and landraces in seed production system and food system is pertinent.
- It is important to focus on registration of traditional varieties for its commercial use.
- Government should support promotion of indigenous crop cultivars under government programmes like Pulse development Programme, Indian Agriculture development Programme etc.
- Like the National Horticulture Development Programme, subsidy should be given for conservation and promotion of Millet crops
- Long term support to genome saviors needs to be given for conservation and maintenance of unique crop diversity
- Support for production and marketing of grains produced from unique crop cultivars

Related to Food and Nutrition Security

- A relook is necessary at region's agrobiodiversity and food resources which are potential sources of nutrition including micronutrients. Even key players in agriculture research, extension and crop promotion and varietal release need to focus on promotion of nutritionally rich crop varieties for nutritional security (Ex: ICAR institutes, KVK's, State Agricultural Departments, SAUs, Experts etc.)
- Food and nutritional security by introducing perennial and seasonal, diverse vegetable crops through kitchen garden is very good intervention to ensure household level food and nutrition security. There is need to upscale and replicate this intervention through ongoing and future government programs.
- Linking region's biodiversity with school mid-day meal and other government led nutrition efforts like PDS is important.

Related to Climate Change Resilience Building

- There is need to study various crops to understand their performance under biotic and abiotic stresses..
- There is need to promote climate resilient crops and landraces for sustainable crop production under adverse climatic situations and variabilities.

Gender Dimensions

• Women are traditionally custodian of local knowledge and wisdom associated with region's crop diversity and wild food resource. It is necessary to give recognition to rural farm women and ensure their centrality in any future program around agro biodiversity.

Benefit sharing

• There should be benefit sharing mechanism for indigenous crop cultivars used for breeding purpose by research institutes, SAU's and breeders to the seed saver of that crop cultivar.

Registration of Farmer varieties

- Needs to develop simplified process for registration of farmer varieties and Authority for recommendation of application should be given to BMC's.
- Registration of farmer varieties under PPV & FR Act 2001 needs to make simple and online so that possible for quick actions.

3. Livestock Diversity and Conservation

Participating Institutes: Lokpanchayat, Sangamner; BAIF

Lokpanchayat and BAIF are members of this thematic group. Lokpanchayat is involved in understanding and conservation of Dangi cattle system raised by tribal communities in Ahmednagar district of northern Maharashtra. BAIF's work is extended in Nanded, Parbhani, Nandurbar, Gadchiroli, Ahmednagar and Wardha working on various local breeds of cattle, goats and poultry.

Focused breeds

Local breeds of Cattle (Dangi, Lal kandhari and Gaolao), goats (Sangamneri and Berari) and Satpudi local poultry

Lokpanchayat

Objectives

a) Socio- economic and ecological research to understand community conservation system of Dangi cattle

- Participatory Rural Appraisal of the Dangi system
- Role of forests in Dangi conservation
- Documentation of practical ecological knowledge related to livestock management
- Cultural practices related to the cattle feeding and nutrition of the cattle, use as a source of milk and as a source of motive power for agriculture

b) Capacity building of the tribal farmers in the context of maintaining good quality Dangi cattle.

- Awareness generation regarding simple low cost techniques that would help maintain good health of cattle
- Training programs based on local knowledge for veterinary health, fodder management,
- feed and nutrition management and importance of record keeping

c) Strengthen linkages for healthy Dangi animals

- Fodder management
- Cattle housing
- Veterinary first aid
- Government Animal Husbandry Department

d) Policy advocacy and information dissemination for the Dangi breed

- Popular articles in the local newspapers
- Coordinating a low cost monthly publication in Marathi language radio programmes

- Participating in the local programmes like weekly markets, annual fairs, exhibitions
- Participating in the state level, national and international seminar and workshops

Output of the project

a) Participatory research

- Facilitating participatory research process with selected 30_Dangi keeper families by organizing field demonstrations to diagnose cattle diseases and developing package of practices to control disease.
- Focussed on documentation of wild fodder continuously for two years. More than 200 fodder plants were documented and 53 grasses also identified.
- *Rakhanraan* (a small meadow of grassland) a unique community conserved area (CCA) for fodder newly identified in the north Western Ghats, documented for the first time.
- Comparative study of natural and artificial insemination initiated in working area.

b) Awareness and capacity building

- Awareness related to seasonal vaccination among Dangi keeper community, challenging traditional keepers have some misunderstanding and superstitions about vaccination.
- Created concrete consciousness in the keepers by using *Kala-pathak*, regular meeting, workshops, formal conversation and organized vaccination drive with state veterinary department. Lokpanchayat reached up to minimum two thousand keepers through exhibition and *Kalapathak* program.
- Artificial Insemination Service (AIS) using semen tube of Dangi, which is made by BAIF Semen Bank in the project villages, where Dangi service bull is absent. Till today total 68 AI are done. 26 calves (15 female and 11 male) were born. Lokpanchayat reached up to 26 villages (15 project villages and 11 new villages.)
- Two training workshops were held for Dangi keepers and AHW every year
- A pilot program of Livestock Insurance started in two villages, keepers got compensation after death of cattle and goat.

c) Networking

- Associated with BAIF, Dangi Research Station Igatpuri, MAFASU Nagpur, Veterinary colleges from Sh<u>i</u>raval and Paral.
- Lokpanchayat has become a member of League for Pastoral People (LPP), an international network working for strengthening pastoral community
- At closing stage of project Dangi keepers have pro-actively decided to form Dangi Breeders Association (DBA). 11 member promoters body formed to develop governance system and associated legal compliances.

Documentation and publication

- Lokpanchayat has published a small book named 'Samgra Dangi' given basic information about overall 'Dangi System' in English & Marathi language
- Detail report on Wild fodder study in 2016-17 with GIS mapping of selected grazing areas and separate survey report on *Rakhanraan*.'
- Published a paper on wild fodder and Rakhanraan. A small report on the carbon sequestration of the reservoir has been prepared.



BAIF

Approach

- Conservation of important indigenous livestock breeds by involving community
- Blending traditional and scientific knowledge in sustainable conservation program
- Scientific and technical assistance to the livestock breeders

Salient achievements

- Documented native livestock diversity and their management practices through socio-economic survey
- Under *in-situ* breed conservation program **8416** Artificial Inseminations performed through **12** cattle breeding centres and **2631** new calves born, **2340** goat breeding services through **23** elite bucks, **1680** kids born
- Elite bulls of Dangi, Lalkandhari and Gaolao procured from project areas and over 2.73 lakhs of semen doses produced for further breeding program and kept for *ex-situ* conservation.
- Milk yield potential studies undertaken by milk recording of 617 cows of focused 3 cattle breeds.
- Phenotypic characterization of 367 Dangi and Lalkandhari cattle, physical characterization of 5000 Satpudi poultry and growth measurements of 722 Sangamneri and Berari kids.
- Genotyped Dangi, Lalkandhari and Gaolao breeds using High-Density Illumina bead chip
- Community awareness through 786 events like health camp, calf rally, goat rally, deworming, vaccination, awareness meet, exhibition etc.
- Documented traditional forage resources and nutritional analysis of 107 samples completed.
- Documentation: 4 research papers, 13 articles/case studies, 4 best practices and 18 extension material.



Bahada

Shevara



Mahnera

Khaira

Para



Hayali Kukadi

Talya Kukadi



Kalyo Kukadi



Gavathi Kukadi



Kabharyo Kukadi



Phylogenetic tree of Indian Bos indicus breeds

Policy Recommendations

- The focused cattle, goat and poultry breeds under the project are well acclimatized to the native environment and each breed has its specific traits of performance under extreme agro-climatic conditions. The breed improvement and conservation measures undertaken during the project period has produced elite animals in the respective regions. The demonstrated participatory breed conservation program could be incorporated into state policies on conservation and genetic improvement of livestock resources.
- 2) The study on the genomic application in elucidating Indian cattle population structure indicated that genomic information especially the SNP (Single Nucleotide Polymorphism) marker information provides ample opportunity in understanding the genetic basis of the specific cattle population structure. Genomic tools could be used to determine effective population size that is indicative of the levels of population endangerment. Genomic tools could be useful in understanding within breed and between breed diversity levels in terms of allelic diversity, again a useful tool for designing the breeding program for a specific breed.
 - a) It can elucidate certain levels of breed ancestry, useful to breed back the specific breeds which are in endangerment.
 - b) It can provide information on the two most closely related breeds and populations, that will provide basis for breed conservation by designing specific mating program within or between breeds in a region simultaneously taking care of genetic diversity and genetic improvement.
 - c) The genetic merit of individual animal within a population could be elucidated using genomic information, that will be highly useful in selection of high genetic merit breeding stock
- 3) Conservation and promotion of local fodder and grass species, preservation through silage, utilization of tree fodder and crop residues as well as introduction of improved fodder crops and varieties to enhance fodder availability in the areas.
- 4) Promotion and market linkage of milk and milk products, value added products from cow dung, urine needs to be undertaken to enhance the income which will support in motivating the farmer in conservation of animal genetic resources.
- 5) As these animal resources are being conserved at a very remote area, migrate during scarcity period and therefore necessary breeding and animal health services should be provided by govt. departments.
- 6) Convergence of state animal husbandry and forest department regarding making available the fodder resources from the forest areas will help farmers in reducing the expenses on feeding the animals.
- 7) Promotion of artificial insemination practices in goat for assurance of quality breeding and production of elite animals.
- 8) Traditional animal management system has developed over a period of time hence breed conservation and improvement measures will be helpful for livelihood of the community. The region specific micro policy may be arrived involving breeder's association, department of Animal Husbandry, Agriculture, MAFSU and NGO's like BAIF and Lokpanchayat. This will enable farmers in participating in various govt. schemes like *Rastriya Gokul Mission*. The concept of '*Pashu Mitra*' may be adopted at village level.
- 9) Capacity building and promotion of Ethno-veterinary practices among the farmers will be helpful for availability of cost effective and timely health services locally.

4. Fish and Shellfish Diversity in Freshwater Ecosystems

Participating Institution: Bhandara Nisarg va Sanskritik Abhyas Mandal, Bhandara

Background

Aquatic biodiversity is one of the most neglected areas, from conservation and research efforts as well as economic endeavours such as potential of fishing of indigenous fishes. Eastern Vidarbha, especially the districts of Bhandara and Gondia are well-known for the large number of tanks. Documentation, conservation, sustainable use, and management plans of these tanks are crucial for people who depend on them as well as aquatic biodiversity that inhabits these tanks.

Objectives

- 1. Documentation of people's knowledge of freshwater biodiversity
- 2. Preparation and implementation of freshwater biodiversity management plans through fishing cooperative societies
- 3. Conservation and sustainable use of aquatic ecosystems and biodiversity
- 4. Advocacy for an inclusive biodiversity and fishery policy

Key Achievements

12 tanks with the water spread area of 208.94 ha. have been reserved by the Fishing cooperative societies for freshwater biodiversity conservation. Following activities have been carried out during the project duration in and around these 12 tanks:

- 1. Documentation of people's knowledge: Photo documentation of flora and fishes, preparation of formats for wetland related PBR and data collection in those formats, herbaria of aquatic flora of 12 freshwater ponds, involving 12 fishing societies.
- 2. Biodiversity management plans: Based on information of 12 freshwater tanks on catchment of tank, actual tank area, command area, land use pattern in catchment, forest and agro biodiversity in catchment and practices, livestock using the tank for water and grazing, fish diversity, bird diversity, and plant diversity, detailed management plans have been prepared for these 12 ponds. This process involved consultations and active involvement of Gram Panchayats, Biodiversity Management Committees, Fishing Cooperative Societies, the women SHGs and their Gram sangh.
- 3. Conservation and sustainable use of aquatic resources: Restoration works were carried out in 11 tanks (not only the reserved tanks, but other tanks were also included in this activity, falling under the jurisdiction of the partner fishing cooperative society), with area of 281.80 ha., which were degraded. This included *Ipomoea* extraction, planting those species which are preferred by fish and fauna. The process of conservation and sustainable use also involved regulations on fishing of local varieties.
- 4. A model of aquatic habitat restoration has been standardized, based on the work done. A step-bystep process is documented in Marathi and is available for dissemination to anybody who is interested in doing so.
- 5. Advocacy for an inclusive biodiversity and fishery policy: The major advocacy intervention includes the preparation of draft of freshwater fishery policy for the state of Maharashtra with inputs from the traditional fishing communities. The draft is prepared based on the experiences and work under MGBP and shared with the traditional fishing communities working in different regions of Maharashtra.
- 6. Developed the project ideas, based on freshwater biodiversity, with CEE, for school children. These have helped a lot to children to connect with their surrounding diversity and for teachers to interact with students and to improve on teaching methods, as per their own perception.





Recommendations

- 1. There is utmost need to differentiate between aqua culture and artisanal (traditional) fishery. Without doing this, fishery related policies, schemes and programs are being implemented by the State and Central Government departments. Without clear understanding of these two types of approaches, many voluntary organisations, CSRs and corporates are promoting aqua culture practices in the water bodies, which are part of the natural drainage system, resulting in short term gains and longterm aquatic biodiversity loss and then loss of fish production. A clear policy statement, law and programs are needed to control this situation and to conserve the freshwater biodiversity. A composite model of aqua culture and indigenous fish production needs to be evolved, based on the different agro climatic zones of Maharashtra.
- 2. The desiltation program of tanks needs to be rethinked, as currently the desiltation activity is taking place without the measurement of silt levels in selected water body. The program guidelines or the available funds decides on how much and how the silt is removed, and not the actual study of siltation. This silt needs to be managed as over siltation causes low water storage but desiltation by machines, destroys the aquatic biodiversity. This activity is very much attached with the political will also. Community level awareness is also required to stop the mechanized activities in tanks and freshwater flows.
- 3. The developed model of aquatic habitat restoration needs to be disseminated in the water bodies in Wainganga River basin. Also, this model needs to be tested in different agro climatic zones of Maharashtra for promoting sustainable fishery through biodiversity conservation.
- 4. River basin wise documentation of indigenous fish diversity, their habitat and people's knowledge, associated with it, needs to be documented. Biodiversity management committees can undertake

the work of People's Biodiversity Register (PBR) and the State Biodiversity Board should assist them in this work.

5. Public fund in freshwater biodiversity sector is exceptionally low, and no investment in production of Small Indigenous Freshwater Fish Species (SIFFS). Whereas minor carps contribute 75% to 95% of the total catch from freshwater. The study also shows that small reservoirs have the highest average yield (28.68 kg ha⁻¹), followed by the medium (14.44 kg ha⁻¹) and large (10.21 kg ha⁻¹). It is the worldwide fact that 90% workers, working in fishery sector are working in the small ponds and tanks, rivers, and streams. Therefore, fund allocation to this sector and that also for SIFFS production will make the livelihood sustainable and also contribute to conservation of freshwater biodiver

5. In-situ conservation of Grassland Biodiversity

Participating Institutions: Samvedana, Karanja Lad; Vasudha, Dhule, Ugam, Hingoli

Background

The state of Maharashtra harbours very extensive tracts of grassland, scrub, and tree savannas. They play a significant role in the economy. Ecologically, this is an important region as these grasslands are the place of origin of evolution of the legume genus *Alysicarpus* and support populations of blackbuck, chinkara, nilgai and birds like Lesser floricans and Great Indian bustards. The sustenance of communities such as Dhangars and Phasepardhis is dependent on these ecosystems. Unfortunately these ecosystems have undergone extensive degradation with the loss of productivity and replacement of palatable grasses like *Sehima* and *Diacanthium* by spiny, coarse ones like *Heteropogan*. In the last five years, the project focussed on conservation of localities that are earmarked as grasslands as well as the privately maintained grasslands.

Region like western Vidarbha has less known ecological history of grassland destruction during colonial era. Dr. Laxman Satya in his book 'Ecology Colonialism and Cattles: Central India in the Nineteenth Century elaborates the process of destruction. About 28 lakh hectors of land which was under grass cover in 17th century got converted into cotton farms. This is just to support British cotton miles in Manchester.

Objectives

- 1. In situ conservation of grassland biodiversity with special focus on indigenous grass species
- 2. Livelihood strengthening and capacity building of communities dependent on grassland/scrubland areas through eco-restoration activities
- 3. Documentation of traditional knowledge through People's Biodiversity Registers
- 4. Advocacy efforts for creation of an inclusive grassland/scrubland policy

Key Achievements

- 1. Conservation: In-situ grassland conservation in about 2000 hectares across Maharashtra. This includes conservation of abiotic resources such as soil and water as a result of increased grass cover on the area.
- 2. This also included documentation and conservation of indigenous species of grasses, about 48 grass species found in the conservation sites.
- 3. Monitoring of sites of endangered Lesser florican and its territory mapping has been done. Our project area in Akola district is the only site in Maharashtra, where Florican is sighted and there are photographic records of its breeding. These records are published in BNHS journal Mistnet.

¹Sugunan, V.V., Reservoir Fisheries of India. FAO Fisheries Technical Paper. No. 345. Rome, FAO. 1995. 423 p. Accessed online: http://www.fao.org/3/V5930E/V5930E00.htm#TOC

- 4. Community development: Livelihood strengthening efforts happened in the course of this project via activities related to fodder management. Around 2000 hectors of land is under grass species yielding about 4000 metric ton of palatable grass. This fodder availability is supporting about 3000 animal heads, which belongs to about 1000 livestock keeping families.
- 5. Capacity building workshops related to the Biodiversity Act, MREGS Act, Tribal Forest Rights Act with a specific focus on the sustainable use of grassland biodiversity and its conservation were carried out. Environment education was carried out in 30 schools in three districts.
- 6. In Laling 500 ha. and Lamkani 500 ha. of area is protected successfully & good quality grassland conservation took place with predominance of *Sehima & Crysopogon fulvus* in Lamkani while *Hydropogon, Apluda, Chloris* etc. in Laling.
- 7. PBR: PBR in 20 villages in three districts of Maharashtra, where grasslands are the dominant ecosystem, were prepared. The focus was on traditional knowledge related to grasslands and to prepare grassland/scrubland biodiversity management plans by providing a social, biological and legal backing to the efforts by the communities.
- 8. Grassland policy: A grassland/scrubland policy document was prepared in collaboration of Maharashtra Revitalizing Rain fed area Network. (MAHARRAN)
- 9. Dr. Laxman Satyas book is translated into Marathi and published by Manovikas Prakashan Pune. This publication brings forward the less known ecological and agricultural history of the area. The book known as 'कापुसकोंड्याची गोष्ट' is widely appreciated.



Kayadu river grassland

Lesser Florican habitat

6. Forest Ecorestoration and management of Non-Timber Forest Produce (NTFP)

Participating Institutions: Lokparyay, Aurangabad; Khoj, Melghat; Janartha, Shahada; Shivaji University, Kolhapur; BAIF; and Gadchiroli

Background

The Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Rights) Act 2006, popularly known as FRA implemented from 1st January 2008, presents a significant opportunity and a great challenge, not only to conservation but sustainable use and regeneration of the state's forests, as well as the crop and livestock biodiversity. The Act recognizes the rights of The Scheduled Tribes and the forest-dwelling communities including the responsibilities and authority for sustainable use, conservation of biodiversity and maintenance of ecological balance and thereby strengthens the conservation regime of the forests while ensuring the livelihood and food security for all. While community rights over the forest are likely the ideal goal, the process has started in some regions of the state from individual rights over the forests and forest produce. This project monitored the

implementation of community forest rights (CFR) and individual rights (IFR) and its effect on biodiversity conservation in 4 different eco-regions of Maharashtra, viz. north-west Maharashtra, Marathwada, Melghat and south-east Vidarbha. Another component of the project, located at the Shivaji University, Kolhapur has created an arboretum of rare, endangered and threatened (RET) species of the Western Ghats. It is crucial at this juncture to create models of how the Community Forest Resource lands can be managed to augment Maharashtra's forest biodiversity resources, while at the same time enhancing the quality of life in some of the most disadvantaged segments of the state's population.

Broad Objectives:

- 1. Biodiversity enhancement via eco-restoration activities in 4 districts of Maharashtra
- 2. Implementation with the help of Government watershed development, Afforestation and Rural Employment Guarantee Schemes (NREGA) and generation of employment for the disadvantaged communities
- 3. Documentation and validation of knowledge of ecology, propagation, utility and properties of the 150 plants and animal species selected by local communities
- 4. Policy and advocacy related interventions

Organisation	Place of Work	Focus of Work
Janarth	District: Nandurbar Tahsils: 3 Villages: 4	 Forest conservation Forest regeneration Natural resource management Biodiversity documentation Community forest rights acquisition and management People empowerment (focus on women) Livelihood generation
Lokparyay	District: Aurangabad Tahsils: 2 Villages: 2 focal; 10 peripheral	 Forest conservation Forest regeneration Natural resource management Biodiversity documentation Individual forest rights (IFR) acquisition and management People empowerment (focus on SC-ST-VJNT) Livelihood generation
Khoj	District: Amaravati Tahsils: 2 Villages: 4	 Forest conservation Forest regeneration Herbal medicines Natural resource management Community forest rights acquisition and management Sustainable and natural farming Environmental education People empowerment (focus on tribal communities) Livelihood generation via convergence of programmes and schemes
Gadchiroli Project	District: Gadchiroli Tahsils: 3 Villages: 22	Recording of "tapu" information and landscape elements

Work Area and Focus

Organisation	Place of Work	Focus of Work
Shivaji University	Focal – Kolhapur Broader – The	• Germplasm collection and conservation of rare, endangered and threatened (RET) plant species
	Western Ghats	 Research on survival, growth and propagation related research on these RET species Introduction of RET species throughout Maharashtra and India

Salient achievements

- 1. Forest management and eco-restoration activities: Although the rights to the forest land were transferred by law, it took constant handholding and follow-up by the partner agencies for the actual transfer of the forest rights. Regeneration and forest eco-restoration of 2000 Ha of lost forest across four different eco-regions in Maharashtra was achieved. This effort involved conservation of soil, water and other natural resources for sustainable forest management and conservation, protecting the forest from grazing, tree-cutting, theft and illegal possession of the land, plantation of about 150 native and endemic species, eradication of exotic and invasive species such as *Lantana* and *Hyptis*, and germplasm collection and conservation of 90 RET and endemic species from Western Ghats.
- 2. Employment generation via forest eco-restoration: Activities such as tree plantation, minor and major construction activities aiding water and soil conservation, creation and maintenance of nurseries creating year-round employment for the communities were undertaken, including agricultural activities as one of the sources for livelihood.
- 3. Documentation of biodiversity: Documentation included PBR preparation, number and names of species preserved and regenerated, the special utility of plant parts, their storage and processing methods, duration of use, names and numbers of families using the said parts of the plants, and whether the material is sold in the market, was recorded.
- 4. In Gadchiroli project in the 22 project areas the following activities were done. a. Identified various land patches as are recognized by the local people called 'tapu' (ii) Identify land elements with different Landscape Types (LSEs) (iii) Collected data on species found in the area including their uses, qualitative abundance on each tapu for 5 Gramsabhas and for all 19 gramsabhas for landscape elements. (iv) Stock mapping using Point Centered Quarter Method for 5 gramsabhas for all tapus and for all 17 Gramsabhas for landscape elements. (vi) Data is collected on RET species from people as well as by a taxonomist10. Data was collected on efforts by the people to conserve the RETs.
- 5. In places where CFR have been provided to the Gramsabhas, the responsibility of preparing a working plan for management of CFR falls on the Gramsabhas. However, the gramsabhas do not have members capable of such technical work. To address this large scale issue, the Tribal Development Department decided to create a cadre of such workers from amongst the members of Gramsabhas. A diploma course was designed and conducted by Dept. of Economics and Public Policy, Mumbai University to create such cadre. Dr. Gadgil and Dr. Edlabadkar played a key role in this endeavor. The first batch of 27 diploma holders hailing from these Gramsabhas, who are now armed with technical knowledge and have a very strong feel of the ecosystem of this area, were utilized in the present eco-restoration project. We have taken full advantage of the rapidly advancing tools of ICT to organize a collaborative process of knowledge generation. The youth involved made use of smartphones which are generally GPS enabled. Following on-line and off-line tools were used in information gathering and collation: (i) Excel sheets (ii) GPS apps for boundary demarcation (iii) Google Earth (iv) On-line data capture using Epicollect5 modules. This will serve as a model for similar exercise in other forest communities.

7. Policy and advocacy interventions: The primary advocacy intervention includes the preparation of the draft of forest policy. This includes different models on forest management, including individual forest rights, for the state of Maharashtra, with inputs from the traditional forest-dwelling communities.

Recommendations:

1. The experiences on community forest management are best compare to lonely efforts of forest dept., One of the MGB project partners Lokparyay has developed "Community Biodiversity Park" on more than 1.2 ha. barren, soft rocky, dry land at village-Parala-Junone, Aurangabad district. It has planted, protected & conserved more than 28 species which was rare in drought prone Vaijapur taluka. It has encouraged Bhil-tribal community to protect different rare tree species on the farm bunds including adjacent forest department owned barren land. They are only taking grass out the land.

In absence of CFR or with CFR the forest department along with Maharashtra State Biodiversity Board (MSBDB), community based organisations-NGOs and forest dweller community can develop "Natural Community Bio diversity Parks (NCBDP)" on hundreds of acres of barren forest land of drought prone area like Marathwada region. While developing NCBDPs, the involved community can take grass and develop their own dairy farm which will be one of assured income sources in draught prone area. It will reduce migration of tribal families as harvest area. Lokparyay study during MGB period, shows that by this way minimum 68% migration has been reduced.

Therefore, it is strongly recommended that "Natural Community Biodiversity Parks" should be developed in every forest area of villages in Maharashtra.

- 2. The small scale NTFP units like natural colour from Palas flowers alongwith agro-based processing units in a cluster of villages can be established to generate assured employment for youths. It will increase assured income source to rural community and will reduce migration towards urban centres. Therefore, government should take special initiative and drive with special committed task force and community based organisations.
- 3. NTFPs are very important considering community's dependence on this resource for meeting various social- ecological, cultural and eco system service related needs. Hence even in forestry research, there is need to have special thrust on this along with timber species.
- 4. While selecting NTFP species for conservation and multiplication, equal weightage to be given to local people's preferences as, local communities value trees not only for economic purpose but also for ecological, social, cultural uses.
- 5. The project has evolved and introduced a methodology of identification of candidate plus tree which is an important and preliminary step in tree improvement programme of a particular species. Selection of NTFPs candidate trees should be based on locals needs, social, spiritual and economic importance for the local peoples of respective regions. This will augment the community to participate in large for conservation though sustainable harvesting and with its economic benefits at local level.
- 6. There is tremendous scope to mainstream efforts of community led forestry programs. For generations, communities have conserved trees and habitats in the name of God or as a part of community practice/tradition.
- 7. There is need to introduce science and technology tools for scientific harvesting of NTFP resource. This will help balancing economic well-being with eco system wellbeing.
- 8. Need of direct role play of local bodies in marketing system: The market of NTFP is extremely imperfect and unstructured. At present forest dwellers at project area collect NTFPs and sell it to local traders which in turn sell it to the urban center and finally reach to consumers. The distribution

channel from forest collector to urban wholesaler consists of 3-5 middlemen. It was nicked that, right from gathering the NTFPs from the forests to the first level of processing them at homes, the bulk of the work is done by women. Presently, they collect NTFPs (Gums, Mahua, Charuli, Herda, Behada etc.) for sale or barter simply because of lack of alternative employment opportunities. Hence, it is important to develop a strong value chain from collector to directly processor or end user to get direct large benefit through developing institutional level of support like Community based organizations / body of Gram Panchayat etc. The state and national policy should support such local bodies to play directly in marketing of NTFPs with due approval of Forest department.

- 9. NTFP nursery entrepreneurs: The good quality NTFP species seedlings and grafts were produced by local entrepreneurs after giving initial support and training. Such many entrepreneurs could be developed and strengthened with forest department support to cater the requirement of huge quantity of seedlings in plantation programs at village level.
- 10. Value addition in NTFP's: Local community has traditional knowledge in value addition of some of the NTFP's like Mahua flowers. Various products are being prepared and utilized for their own consumptions. However, there is tremendous scope to develop many such value added products for further market linkage and commercialization so that community could get attractive remuneration. This activity needs to be strengthen through linkage with various govt. schemes. Local self-help groups (SHG) may be encouraged for NTFP value added product entrepreneurship and incorporation of local value added NTFP products in school mid-day meal scheme.
- 11. Implementation of livelihood based forestry plantation on lands claimed under FRA /CFR land could help in sustainable use and conservation of forest resources. Convergence of govt. schemes like MGNREGA may be linked for eco-restoration of private and CFR land.
- 12. The forest rights act is a very pro-people and pro-nature act. The most significant provision of this act relates to community forest resource (CFR) rights. In Gadchiroli district of Maharashtra this provision has been adequately implemented and some 1100 Gram Sabhas have been granted CFR rights. One of the M. G. B. project has been active in this district and has put together considerable evidence that the implementation of CFR rights has led to the communities undertaking good management to ensure resource sustainability and to enhance protection to nature by sitting up new sacred groves. The youth in these villages are also acquiring skills such as Minor Forest Produce assessment, processing, value addition and marketing, along with keeping accounts and paying GST. Their enhanced incomes have also meant that the communities are now less and less dependent on earning a livelihood as migrant workers. It is therefore strongly recommended that the CFR rights provisions should be implemented in letter and in spirit in all the districts of Maharashtra with significant forest cover.
- 13.Conservation and development of arboretum RET and Endemic tree species Angiosperms of Western Ghats

The Botanical Gardens are field gene banks from which germplasm of plants flow to various organizations. Considering the need of conservation the gene bank (arboretum) RET and Endemic tree species is established for generations to come (ex-situ conservation). Out of 102 targeted species of the project, 80 species are growing well in the Botanical garden (arboretum) with a 800 individuals. The saplings of 37 targeted species (5905 individuals) are distributed to various botanical, institutional, public and private gardens (857 beneficiaries). Nursery techniques of 20 RET and Endemic tree species are established.

Dept.of Botany, Shivaji University, Kolhapur is ready to provide guidelines to undertake such programs for the conservation of RET and Endemic tree species in various parts of Maharashtra. The project has set a bench mark in Ex-situ conservation of Endemic tree species. It is a torchbearer for institutes who wish to carry on such projects on endemic tree conservation.

- a) Targeting (identifying and listing) Rare, Endangered, Threatened (RET) Endemic tree species of Maharashtra is needed.
- b) Forest department should undertake the programs on collection of seeds, their germination and sapling (nursery technique) of RET and Endemic tree species of Maharashtra and further their distribution to the people and plantation in natural habitats.
- c) Local people should be trained for collection and direct sowing of seeds of RET and Endemic tree species in their natural habitats for which financial assistance and training be provided.
- d) Maharashtra Government should undertake the programme to establish arboteria of native tree species in different parts of Maharashtra which in future will serve as germplasm bank of all tree species of Maharashtra.

8. Information, Education and Communication Management

Participating Institute: Centre for Environment Education, Pune

IEC for MGB component project has consciously chosen to work in partnerships with organizations implementing various thematic projects to strengthen organizational capacities in facilitating educational activities in their work areas.

The status of biodiversity education in the state when the MGB project was started was:

- 1. Lack of state wide bench marking in status vis-a-vis National Biodiversity Target 1
- 2. Low level of subject competencies among the teachers and students to build biodiversity learnings upon them
- 3. Lack of state contextualized pedagogical strategies and programs for biodiversity learning
- 4. Neglect and systemic destruction of linguistic diversity, which is rapidly contributing to the loss of Knowledge and Practices related to biodiversity
- 5. Lack of adequate financial resources for environmental education at large and biodiversity education in particular
- 6. Lack of adequate and effective consumer awareness on biodiversity, quality of life, food & nutrition etc.
- 8. Scheme like Environment Service Scheme (ESS), supported by Environment Department, Govt. Of Maharashtra are able to provide adequate and need based inputs but are currently restricted to small number of schools (50)

Salient Achievements

- 1. Project has developed a network of grassroots biodiversity educators associated with 15 partner organizations. These have been capacity built in areas of environmental education, biodiversity mapping and studies techniques, documentation and use of multimedia. Cluster level learning resources '*Pitaras*' have been created as a common resources with reference or field guides, binoculars, cameras, weighing machines, water and soil testing kits, magnifying glasses, seed collection boxes etc.
- 2. Gotul newsletter and web portal have been developed as tools for information exchange and networking. (www.gotul.org)
- 3. Project has been able to link school-based learnings to local environment and conservation initiatives by partner organizations and try test hands on activities towards strengthening constructivist approaches.
- 4. Designing and testing of *Shivar Feri* school-based biodiversity registration ad studies handbook, and a resource kit for this process comprising 8 different resources

- 5. Secondary and higher secondary school level project ideas bank with 60 projects designed and tested in c. 150 schools. These project ideas are focused on themes of agro-biodiversity, forest, grassland and freshwater biodiversity, and also bringing cross cutting themes of gender, culture, economics and related policies as learning areas. Schools have submitted 73 school projects done by students back to CEE.
- 6. 'Anandshala Shibirs' workshop module for teachers and students- 3 days residential workshop modules were designed for teachers and students from participating schools.
- 7. In 2019-20 CEE conducted a study of food diversity among school students and across 3 generations. This study captures food diversity and intergenerational changes covering 39 different community groups with 152 families in total sample size.
- As part of IEC for the MGB project, CEE Central organized 'A Very Curious Wedding: A photo-art Exhibition on Bio-cultural Diversity of Maharashtra' at IISER, Pune campus from 10-13 October 2019.



Database Development

A major exercise during 2019-20 and till the end of the project has been to collate and curate the data collected in MGB project during the entire period and modify into a searchable and usable data for further research and documentation.

Following steps were taken to build a Relational database using Postgresql server:

- 1. Interaction with all MGB theme partners to understand different types of data collected and formats/ sheets used by them for data collection.
- 2. Identifying metadata. Deciding on organization principles for the data.
- 3. Creating schema/s and tables using postgreSQL server. The tables were structured to satisfy 3Rd Normal form.

- 4. Collection of data from all the partners in Maharashtra Gene Bank Project (MGBP) partners.
- 5. Creating EXCEL sheets similar to the structures of the tables in the schema and populating these sheets using the data from various partners.
- 6. Validating data in the EXCEL sheets for attributes which are referred in more than one table and set relations using them viz. Species names, village codes, tapu names etc. Validation for those attributes which may take certain values only.
- 7. Data Migration : EXCEL sheets \rightarrow csv files \rightarrow Postgresql server
- 8. Spatial datasets were prepared for all the components of the MGB project
- 9. Geospatial data were created and posted on PostGIS and linked to PostgresSQL and Geoserver/Mapserver for a Webmap Portal.
- 10. A user interphase was prepared for accessing the data
- 11. Standard queries have been developed for drawing information from the database and additional queries can be generated as per the user/partners' requirement

Details of data included in the database		2. Forest Ecorestoration	
1. Crop Diversity		Village Plant Diversity	4633
Village data	235	Special utility	2514
Seed bank data	34	Tapu Information	79
Accessions	873	Tapu Plant abundance	3662
Crop data	649	Tree measurement	2285
Traditional knowledge and medicine	373	3. Grassland and Savanna Diversity	
Traditional knowledge storage system	87	Тари	16
Traditional knowledge disease	89	Diversity	45
Etymology	371	Fodder product	290
Festival biodiversity	108	Fodder consumption	296
TK-pest	122	Farmland	47
TK-Reason for extinction	342	Livestock	441
Traditional knowledge		Grazing	255
TK- Food recipe	461	4. Habitat conservation	
TK-storage	174	Plant	1980
Morphology		5. Livestock	
paddy	165	Animal utility	44
linseed	2	Breeder	87
hyacinth bean	33	Migration	104
Lakhori	2	Elite animal	77
Maize	19	Milk production	201
pigeon pea	3	NTPF	
safflower	2	Utility	166
sorghum	32	Survey	1470
pearl millet	1	Plant	1980
Little millet	10	Marine Biodiversity	
Finger millet	22	Prokaryotes	1902
		Eukaryotes	

The database is available at: http://mgb.iiserpune.ac.in

Other activities

- 1. The traditional knowledge and experience of the MGB partners while working with the community have been documented in a series of 50 articles published in "Agrowan" Marathi daily under the weekly column "Jagana Aani Jeevidha". These articles have been compiled into a book form for distribution to the partner organisations for wider dissemination
- 2. A series of video films (34 in number) on the activities of MGB partners were produced. These will be hosted on YouTube.

Possible Way Forward/Forward Directions

- 1. Strengthening the local institutions to ensure long term sustainability of the project activities beyond project tenure
- 2. Continued and expanded program of Community Led conservation in other biodiversity rich areas in the state of Maharashtra and in other states in NETWORK mode
- 3. Developing linkages and partnership with MSBB to explore post project continuation and support
- 4. Exploring Possibilities of mainstreaming biodiversity conservation related key pathways and best practices with the help of ongoing and future programs of state and central government (NREGA, POCRA, CFRA, TSP, RKVY, CAMPA etc). NREGA Provisions could be used to support many innovative, locally useful works such as restoration of water bodies, regenerative plantation on CFRA lands and Grass land restoration
- 5. Exploring partnerships with agencies like, NABARD, TRIFED, Other Marketing institutions and MSRLM for Building Farmer Producer Organisations and to be able to develop a proper marketing system, brand for niche/broader markets and market linkages. There is scope to link the seed and grain producer farmers with government schemes like ATMA, Organic farming scheme, Tribal sub plans.
- 6. Advocacy for inclusive crop diversity and fishery policy, Conservation of grasslands, wetlands and forest resource is a necessity. This will facilitate wider dissemination of learnings and best practices at state and national level and for sharing with the policy makers so that appropriate biodiversity related programs could be framed and resource could be made available