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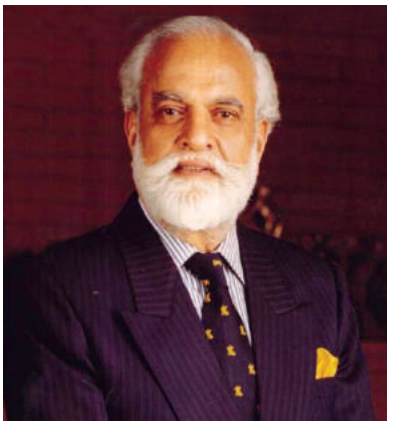

Vice Admiral Manohar Pralhad Awati
7 September 1927 – 4 November 2018

At the Ecological Society we fondly addressed him as 'Manohar-kaka', his charming personality easily disarming any trepidition we felt of his stature of 'Admiral'. He was involved with the Ecological Society for decades and even served as the Chairman of the Society for a long duration. His deep and abiding interest in nature and wildlife conservation and particularly birds led him to be involved with conservation efforts while he was still serving in the Navy and continued into his retirement from the Navy.

Upon his retirement he took up several projects in wildlife conservation with unabated passion. Accompanying the Late Shri Prakash Gole on expeditions to Ladakh and Arunachal Pradesh in search of then elusive Black Necked Cranes. His armed forces credentials bringing much aid and relief to otherwise arduous journeys into the difficult frontier terrain.

The Admiral was always very supportive and welcoming of innovative new concepts and ideas. When he was Commandant of the National Defense Academy he immediately supported the idea of conducting Nature Camps for NDA Cadets. An idea that was floated by Shri Prakash Gole. This first ever Nature Camp began a long and endearing friendship between Shri Gole and Admiral Awati culminating in his involvement with Ecological Society after retirement.

Admiral Awati's outstanding contribution is undoubtedly his work on starting and developing the "Grassland Restoration" program at Phaltan. With his tireless efforts from building fences, building the hut, to his religious daily monitoring he exemplified the perseverance and dedication required to make a project successful and prove that a wasteland can be restored to a productive grassland.

Today we the trustees, educators and students of the Ecological Society are honored to fondly remember Admiral Awati (Manohar-kaka) and express our gratitude for his constant support and guidance. May his soul rest in peace.

In search of Black Necked Crane in Arunachal Pradesh

Building hut for Grassland Restoration Project

Past issues of the Journal of Ecological Society

Volume Number	Year	Theme
1	1988	Ecological situation and Lay man
2	1989	Is our environment improved or worsened?
3	1990	Exploitation of Nature by man
4	1991	Habitat disturbance
5	1992	Threats to ecosystems
6	1993	Projects undertaken by the Society
7	1994	Turmoil for the environment
8	1995	Conservation, bird ecology
9	1996	Vasundhara is no longer Veerabhogya!
10	1997	Barheaded Goose
11	1998	Western Ghats : Sahyadri
12	1999	Eco-restoration
13 and 14	2001-2001	Biodiversity Profile of an Urban Area
15	2002	Associations in Nature and Our Future
16	2003	Sarus Crane
17 and 18	2004-2005	Ujani Reservoir Research
19 and 20	2006-2007	Conservation of Biodiversity of the West Coast between Mumbai and Goa
21	2008	The Holistic Point of View and the Riddle of Energy
22	2009	Economics of Peace and Progress
23	2010	Sustainable Green Architecture
24	2011	The Coming Organic Revolution
25	2012	Articles by Students of Ecological Society
26 and 27	2013-2014	Landscape Based Ecosystem Management
28	2015	· Rocky Plateaus · Land Use and Socioeconomic Change in the Panshet Catchment
29	2016	Man-Nature Relationship

Contents

One Year PG Diploma in Sustainable Management of Natural Resources And Nature Conservation

Program Highlights :

The Ecological Society conducts a one year program which includes class room sessions, case discussions and field experience through camps and field work. Classes are conducted every Saturday between 2:00pm to 7:00pm in the Society's office. Students have access to the Society's library which has a unique collection of books, journals and periodicals on ecology and environment. The program offers students an opportunity for intellectual interaction with experts in related fields.

The program is academically rigorous and substantial extra reading is expected from students. Assignments and field work reports require team work and extra hours of work besides the Saturday sessions.

Program Contents :

- **History of earth and man** : Time line with respect to evolution of species, Evolution of human culture and its ecological implications.
- **Study of Ecosystems** : Mountains, Tropical Forests, Grasslands, Marine ecosystem, River, Wetland, Man induced ecosystem
- **Ecosystem Management and Restoration** : Basic Principles of Management, Financial management of projects and costing, Environmental Economics, Soil Science, Restoration Theory and Practice
- **Sustainable Development** : Globalization and Sustainable Development, The new economy, New Trends in Nature Conservation, Holistic Approach in Lifestyle and Ecological Approach to Landscape Planning

Camp and fieldwork : Study of different ecosystems.

- Mountain Ecosystem – Himalaya, 7 days camp
- Grassland Ecosystem, 3 days camp
- Coastal Ecosystem, 4 days camp
- Forest Ecosystem and River Ecology, 2 days excursion
- Wetland and pond ecosystem, 1 day excursion

Eligibility : Graduate in any faculty
Duration : One year (June 2019 to March 2020)
Course Schedule :
Days : Saturday **Timing :** 2:00 pm to 7:00 pm, **Field visits** on Sunday

Admissions start from May 2019

Foreword

The word "Nature" conveys different meanings to different people. It originated from latin "natura" which means 'birth' and primarily referred to the qualities of an individual, gained by birth and hence the term, "*nature of a person*". Over the years it acquired a broader meaning that included all biotic and abiotic components, forces and their interactions on earth and even beyond, which is expressed in terms such as "*mother nature*" or "*forces of nature*". Increasingly the term is used in ways excluding or juxtaposing it with the word "human" where "natural" means without any influence of humans such as "*natural vegetation*". Social construction of "nature" as explored by sociologist and human geographers like Elizabeth Bird, Judith Gerber and David Demeritt make a fascinating reading and help us to understand the society which created the term and gave it diverse and sometimes contradictory meanings.

We, as a part of this society, need to select our own meaning from the plethora which best suits our aims of conservation and sustainable use. The vision of the Ecological Society and the mission of nature conservation take a holistic view where humans are an integral part of earth's ecosystem. And hence the *human nature* is as much a subject of our interest as the *nature* that shapes and is in turn shaped by the humans. We need to identify and promote sustainable management practices in which human activities can continue without causing imbalance in ecosystem processes. But we also must delve deeper into the processes of human mind that lead us towards conservation friendly behaviour and sustainable lifestyles.

In this issue we have a selection of papers and articles that address both. Five of the contributions discuss practices of ecological management of landscape by humans ranging from old to new and varying in scale from small private landholdings to large multi-use landscapes. One of the contributions, primarily from the field of psychology, discusses the concept of Naturalistic Intelligence that governs our interactions with the rest of the living world.

The research paper on Raakhan Ran, is the first ever documentation of grasslands conserved and harvested sustainably. It is interesting to observe how this fits into the management of agro-pastoral livelihoods by communities in the Northern Western Ghats. The next paper is from an urban landscape, and documents management of mangrove ecosystem in Mumbai by a corporate body. It assesses the carbon sequestration carried out by a patch of conserved mangroves and its potential for the mitigation of pollution in the city. The article on three dams maps and characterizes the biotic and abiotic features of the catchments of Pavana, Chaskaman and Dimbhe dams. The data is used to document restoration potential of these catchments by considering them as ecological landscapes. The article proposes a process for prioritization of restoration among multiple candidate dam catchments. This article will be useful for those working in the field of restoration as well as those discussing the policy aspects. Another article from Kodagu region of Southern Western Ghats puts forth a model using Geodesign concept which can be used to accommodate various complex factors involved in landscape planning. The Kodagu region is well known for rich biodiversity and cultural heritage, at the same time is facing increased negative interactions between humans and elephants which have inhabited the landscape for long time. The problems of this region are representative of many areas within India, where humans and wildlife occupy the same landscape and interact continuously. We hope more such studies are taken up and provide us guidelines for integrated regional planning that strengthens conservation and coexistence. As cities expand and engulf previously wild areas, biodiversity is at the risk of being wiped out locally. Maintenance of common lands such as hills, streams and parks is necessary but inadequate unless private lands between these patches can function as a support for wild species. The article on insects in a home garden describes a microcosm of wilderness that can be preserved in a heavily urbanized landscape.

The paper on Naturalistic Intelligence is included with a hope to provide a different view of environment education, which stresses more on abstract, sensorial experiences than concrete information provision and discusses ways in which nature awareness can be promoted by the society.

An article by Prof. Prakash Gole is reprinted in this

issue as it discusses the 3 Es, Engineering, Economics and Ecology that form the basis of modern life. Overemphasis on the first two and neglect of the third has led to disastrous effects, where a handful of people are strengthening their hold on resources at the cost of many lives. What is the kind of world we want? As citizens of one common planet it is time to clearly and rationally define the kind of world that we would like to leave as a legacy for future generations. The last article is a review of book that includes various authors describing their vision of alternative futures. Rather than criticizing various social, economic or cultural processes, the authors offer successful examples of alternative development efforts for all to peruse and ponder upon.

The journal has always aimed towards promoting interdisciplinary thinking and research. The selection of papers and articles in this issue continues with this tradition and we hope will be useful to readers from diverse fields of work.

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Research Paper

Unfolding the 'Raakhan Raan' a Livelihood Based Conservation Tradition of Tribals around Kalsubai Harishchandragad Wildlife Sanctuary

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Abstract

Degraded and overgrazed grasslands and meadows is a critical issue affecting productivity of open grazed animals. Traditional forest dwelling communities are known to conserve their surrounding biodiversity, mostly with cultural perspectives and this indirectly preserve the resources for future generations. Rakhan Raans are privately owned grass sanctuaries which are protected from open grazing and other disturbances like fires and harvested sustainably. This is the first study of this tradition unique to the Western Ghats. A survey was conducted in 13 hamlets belonging to 11 village panchayats in Akole taluka of Maharashtra. Fully structured interviews were conducted in all households of selected hamlets in a door-to-door manner. Using a detailed questionnaire we collected data on livestock, raakhan ran holdings and changes within last decade. The tradition is not unique to a particular community. It is a sustainable practice considering that grass is harvested after seed dispersal and some areas are left unharvested. The Raakhan Rans have been reducing over the last decade, though still maintained by large herders for fodder security. Special efforts are required to conserve the tradition and link it to the protection of grassland biodiversity and dependent livelihoods.

Introduction

Overgrazed grasslands and substandard fodder is a critical issue affecting productivity of open grazed animals (Kelkar, 2009). Overgrazing eliminates desirable plant species, decreases water infiltration into soil, increases soil erosion, reduces soil nutrients and alters the plant community composition to a less desirable state (Kgosikoma, Mojeremane and Harvie, 2013) that is poor quality fodder in the context of this study.

Ecosystem people are known to conserve their surrounding biodiversity, mostly with cultural considerations and this indirectly preserves the resources for future generations. *Devrais* or sacred groves are important community conservation practices responsible for preserving gene pools of numerous otherwise threatened flora in different parts of the world (Gadgil and Vartak, 1976). Similar to the Devrais, **Raakhan Raans (RR) are privately owned grass reserves which are protected from open grazing and other disturbances like fires. Protection enables complete undisturbed growth of grass species which are harvested systematically only after completion of their lifecycle.** But unlike the Devrais, RR is a relatively recently evolved practice with clear livelihood motivation.

This study is an effort to dig into the conservation tradition which has not been documented earlier from anywhere in the Western Ghats (Pers. Comm. Dr. Madhav Gadgil).

Raakhan Raans (RR) are sections of privately owned pastures which are protected and managed for securing fodder to be used during months of scarcity viz. February-March to July. They are protected since the past few generations by the communities in the study area. Fodder is carefully harvested after completion of its lifecycle and dispersal of seeds. This ensures healthy regeneration of local grass diversity while securing fodder for the local cattle. This is an

ecologically sustainable practice as against the modern fodder harvesting practice which recommends harvesting fodder at flowering stage for maximum nutrition. But extensive harvest of wild grasses at flowering will hamper its regeneration and availability to eventually exhaust the local fodder resources. Contrary to this unsustainable modern day approach, the age-old Raakhan Raan tradition safeguards regeneration potential of the fodder species and at the same time provides fodder security to the cattle dependant local communities. **Raakhan Raan is thus protected reserve for grass species in areas around KHWLS**.

Alongwith grasses like *Dichanthium* sp., *Ischaemum* sp., *Heteropogon* sp., *Themeda* sp., they also support the non-graminous taxa (such as *Crotalaria* sp., *Commelina benghalensis, Smithia* sp.,) and diversity of avifauna, amphibians, reptiles and lesser mammals dependant on grassland habitat for food and shelter. Thus, it is very likely that Raakhan Raans play a significant role in conservation of indigenous, rare and lesser known biodiversity.

The specific article is the first investigation about this sustainable management tradition. However the study limits itself to socio-economic perspective of these special conservation areas.

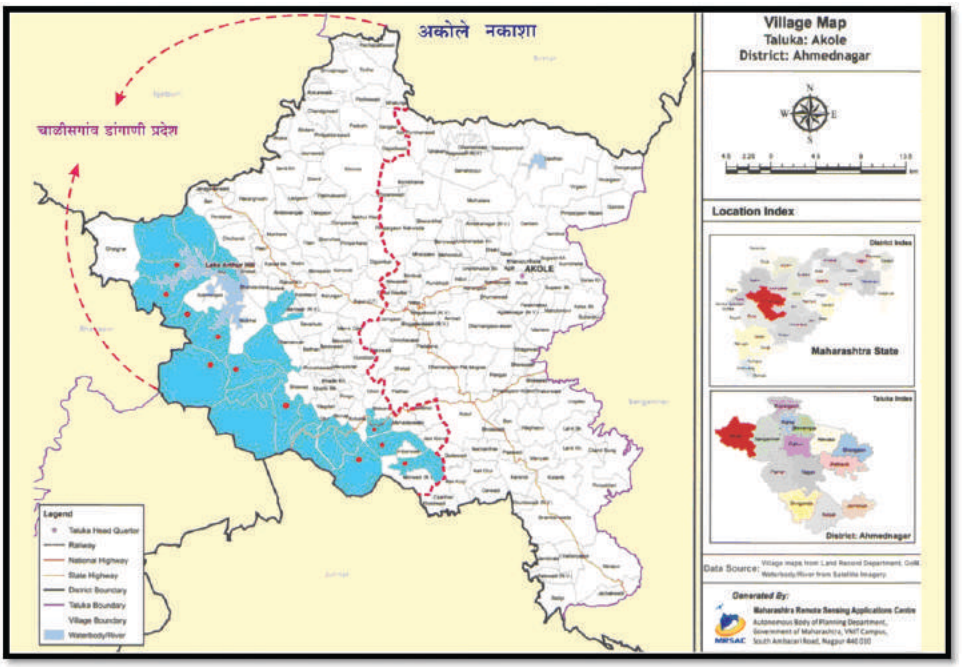
Methodology

Study Area

The project area consists of 18 villages in western part of Akole Taluka of Ahmednagar district. These villages are situated on the ridge of Western Ghats and are characterized by :

- Undulating terrain, and heterogeneous landscape including basaltic mesas, grassy slopes, cliffs, dense forest patches and human settlements.
- Torrential rains with precipitation exceeding 3000mm per year in a few places
- Semi-evergreen and moist deciduous type of vegetation (Champion and Seth,1968).

Biodiversity : The villages selected and surveyed lie in the buffer area of Kalsubai Harishchandragad Wildlife Sancturary (KHWLS). KHWLS is the northernmost protected forest in Western Ghats of Maharashtra. It harbors endemic fauna like Yellow Bulbul, Malabar Parakeet, Malabar Pied Hornbill, Indian Giant Squirrel etc. The area also supports good population of Leopards (*Panthera pardus*) with relatively less human wildlife conflict (Sambare, 2016). Many rare and endemic medicinal plants, orchids,



Map 1: Villages of the study area (marked in blue) along with villages selected for door-to-door survey (marked with red dots)

tubers etc. have been recorded by local nature enthusiasts in the region. Surprisingly, alongside a broad spectrum of diversity of wild flora and fauna, this Protected Area (PA) also supports one of the largest populations of indigenous cattle breed – 'Dangi' (Sambare, 2016) (Photo 7) National Bureau of Animal Genetic Resources, Accession Number : INDIA_CATTLE_1104_DANGI_03004). KHWLS is thus an important conservation site for its wild as well as domesticated living diversity. But except a few documentations like by Kshirsagar et al. (2012), Waman (2005) and a Flora of Ahmednagar District Pradhan and Singh (1999) by the Botanical Survey of India, the bio-cultural diversity of KHWLS has been neglected.

Demographics : The study area is inhabited mostly by Mahadev Koli and Thakar (Scheduled Tribes) along with a small population of Scheduled Castes. Farming, livestock rearing, NTFP collection are their major livelihood activities. Seasonal migration in dry period is also common. local tribal communities, Mahadev Koli and Thakar, are amongst the last communities conserving the 'Dangi' cattle. Along with caring for a rare cattle breed, they also conserve forest and grasslands through traditions such as 'Sacred Groves/Devrai' and 'Raakhan Raan'.

All the hamlets (72 hamlets from 26 village panchayats in KHWLS were surveyed to collect baseline data. The hamlets were divided into strata based on two criteria :

1. Community constitution (ST/non ST)
2. Ecological Location : Hamlets were located in varying 'Ecological Location' like mountain top, mid-slopes and valleys which have diverse microclimates affecting floral and faunal composition of the area. Thus, ecological location would affect the fodder availability, diversity, major and minor wild herbivore species dependant on them, etc.

RR is a tradition which has clear livelihood implications. Consequently, its practice can be affected by occupational profile of the household (like whether or not the HH is involved in livestock rearing) and availability of resources (like whether they own sufficient land which can be set aside as RR) Therefore, this baseline survey also recorded landholdings and occupations of the HH.

Detailed questionnaire was developed to understand the tradition of Raakhan Raan primarily including the socio-economic and distribution aspects. The questionnaire was designed to answer questions like

- What percentage of population is maintaining Rakhan Raans?
- Is there any relation between cattle rearing HH and RR conserving HH?
- What is the tenure status of RR and how much percentage of land is under RR?
- What is the temporal trend in RR practice and occupancy?
- Is RR a tradition limited to a certain community?

Trained enumerator collected information through questionnaires. When classified according to population demographics, it was found that **56** hamlets had mainly **Mahadev Koli (ST)**, **17** had **Thakar (ST)**, and **35** had **Scheduled Caste**.

Out of the studied hamlets, 41 belonged to Mountain tops, 24 to Mid-slopes and 7 to valleys. Hamlets were selected using **Stratified Random Sampling Method** to avoid over representation of a certain category and underrepresentation of other. Final door to door survey was conducted in 13 hamlets belonging to 11 village panchayats (Table 1). Structured interviews were conducted in all the households of selected hamlets in a door-to-door manner (100% households of each selected hamlet).

Detailed information was collected from households so as to explore the research questions. Data was also analyzed to look at relation between herd size (of cattle type) and RR. Cattle herds were classified into four size categories as follows : **Small** (1-5 animals), **medium** (6-15 animals), **large** (16-25 animals), **very large** (26 and above number of animals).

Results

In all 269 HH were surveyed from 13 hamlets to understand the tradition of Raakhan Raan. Eight HH (3% of total HH surveyed) belonged to SC category and 261 belonged to the ST category (97% of total HH surveyed). There were two Scheduled Tribes in the area, the dominant being Mahadev Koli which contributed as many as 199 HH in the study (76% of tribal or total population). Thakar community of Scheduled Tribes comprised of 62 HH in the current study (24% of tribal population).

Out of 269 HH 268 HH were involved in farming. A single household from Ratanwadi (Tirthachiwadi) was not farming. The number of HH involved in livestock rearing (including cattle, buffaloes and goats) was 264. HH without livestock were five and belonged to Ratanwadi (Tirthachiwadi) and Kumshet (Gavthan and Thakarwadi).

Table 1 : Classification of selected hamlets according to communities and their status

Sr	Village name	Hamlet	Total HH	Major Comm	Minor Comm	Occupation		Private land		Forest land		Landless HH
						Agri	Catt	Owner	Holding (Acres)	Occu-pier	Holding (Acres)	
1	Ambit	Payalichiwadi	16	Thk	M. Ko	16	16	15	49	1	2	0
2	Fopsandi	Fopsandi	17	M. Ko	SC	17	17	17	36	0	0	0
3	Janewadi	Bherushi	11	M. Ko	-	11	11	10	22	9	14	0
4	Koltembhe	Koltembhe	51	M. Ko	Thk	51	51	51	148	13	14	0
5	Kumshet	Gaothan	34	M. Ko	-	34	33	27	68	29	53	1
6	Kumshet	Mudhachiwadi	7	M. Ko	Thk	7	7	7	17	1	2	0
7	Kumshet	Thakarwadi	21	Thk	M. Ko	21	20	19	62	2	6	0
8	Murshet	Gavthan	18	M. Ko	Thk	18	18	18	37	0	0	0
9	Ratanwadi	Tirthachiwadi	23	M. Ko	SC	22	20	21	41	6	7	2
10	Satewadi	Jambhalewadi	15	M. Ko	-	15	15	15	35	0	0	0
11	Shingawadi	Shingawadi	22	Thk	SC	22	22	22	39	1	2	0
12	Tale	Tale	17	M. Ko	-	17	17	17	37	0	0	0
13	Vihir	Vihir	17	M. Ko	SC	17	17	17	43	0	0	0

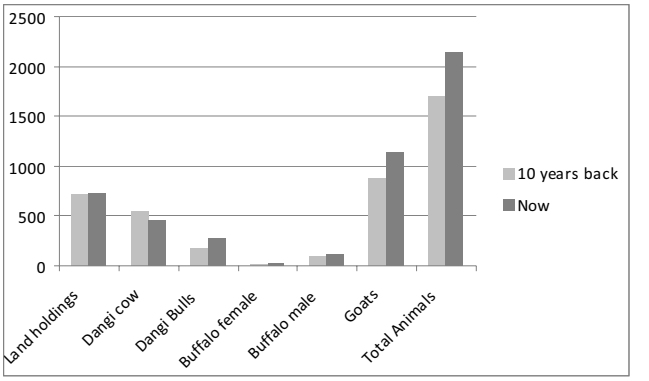
HH: Households; Major Commu: Major community in the village; Minor Comm: Minor community in the village; Occupation: Agri: Agriculture; Catt: Cattle/Livestock; Communities: Thk: Thakar (ST); M.Ko: Mahadev Koli (ST); SC: Scheduled Castes

A total of 256 HH owned private land (95.2% of total surveyed households) and they together owned as much as 634 acres of land. Koltembhe village had a largest total private land holding of 148 Acres with an average private land holding of 2.9 Acres/family. Mudhachiwadi had the smallest total private land holding reaching to 17 acres and average land holding being 2.43 acres/family. Maximum average private land holding was observed in Ambit (Payalichiwadi) (3.27 acres/family) while least was observed in Shinganwadi (1.77 acres/family).

As many as 5 hamlets out of 13 did not have any land recorded as forest land under cultivation. 62 HH (23% from total surveyed HH) from 8 hamlets were cultivating on land recorded as forest lands. The average forest land holding was 1.61 Acres Forest-land/HH. Only 3 HH from 2 different hamlets (1.1% of total surveyed households) did not have access to any land whatsoever.

Dynamics of Domesticated Animal Population

Graph 1 shows changes in agricultural assets (land holdings and reared animals) of the studied HH in the past decade. There has been minor increase in land holdings of the HH. But changes in category wise animal population are remarkable. The graph indicates clear increase in most reared animals except in Dangi cows. Especially, buffalos are seen to have doubled in the past decade with 92% increase in their number. Dangi Bulls also show increase by 63% since the past 10 years. Male buffaloes and goats have also increased by 36% and 30% respectively in the past decade.



Graph 1 : Comparison of livestock population of past (before 10 years) and present

The only category which has reduced in numbers in the past decade is the Dangi Cow. They have reduced by as much as 16% since the last decade. The main cause of this decrease may be non-salability of cows (people believe that cows should not be traded),

Table 2 : Villages and their participation in conservation

Sr. No.	Village Name	Hamlet	Ecological location	Community	Do they protect Sacred groves	RR Tradition
1	Aambit	Payalichi wadi	Valley	Thk	No	Yes
2	Fopsandi	Kondarwadi	Mid Slope	M.Ko SC	No	No
3	Janewadi	Bherushi	Mid Slope	M.Ko	Yes	Yes
4	Koltembhe	Gavthan	Top	M.Ko, Thk	No	Yes
5	Kumshet	Gavthan	Top	M.Ko	Yes	Yes
6	Kumshet	Mudachi wadi	Mid Slope	M.Ko, Thk	Yes	Yes
7	Kumshet	Thakarwadi	Top	Thk, M.Ko	No	Yes
8	Murshet	Gavthan	Top	M.Ko SC	No	Yes
9	Ratanwadi	Tirthachiwadi	Valley	M.Ko SC	No	No
10	Satewadi	Jambhlewadi	Top	M.Ko SC	No	No
11	Shinganwadi	Gavthan	Top	Thk SC	Yes	Yes
12	Tale	N/A	Top	M.Ko	Yes	No
13	Vihir	N/A	Mid Slope	M.Ko, SC	No	Yes

reduced livelihood dependence on cattle, increase in accessibility through which trade has taken up, migration to nearby cities or towns for short term alternative employment, etc.

The Raakhan Raans

Total of 56 out of 269 households practiced the tradition of Raakhan Raan. These households were distributed in nine out of 13 hamlets (five hamlets from the mountain tops, three from mid slopes and one from the valley) (Table 2) (Photo 3 and 4).

Sacred groves are known to provide benefits to local communities like better microclimates, groundwater tables, soil properties etc. It is very likely that people who practice one conservation practice (Sacred groves, in this case) and are used to the restrains which come with it, easily take up other conservation tradition (RR in this context) for clear benefits. The study tried to identify if there was any such relationship. But we found no significant relation between villages which protected the RR with village protecting the sacred groves.

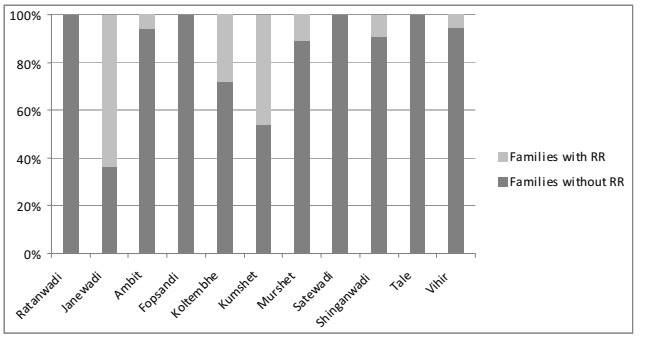
The 56 HH which were instrumental in conserving RR, protected as much as 64.5 acres of land out of the 738 acres of total cultivated land in the area around the KHWLS and allowed grass species to flourish and reproduce without disturbances like grazing, fires, invasive species etc. Even though RR is a individual practice, the entire village sees to it that each RR is protected and livestock of any family does not stray in for grazing. Traditional management strategies are yet to be documented in details, but people say that RR are protected through community effort.

The study of tenures (ownerships) of RRs revealed that 97% of the Raakhan Raans are situated in private lands and 3% on forest lands. A total of 10% of land held by households is dedicated to conserve RR while agriculture is taken up on remaining 90% land.

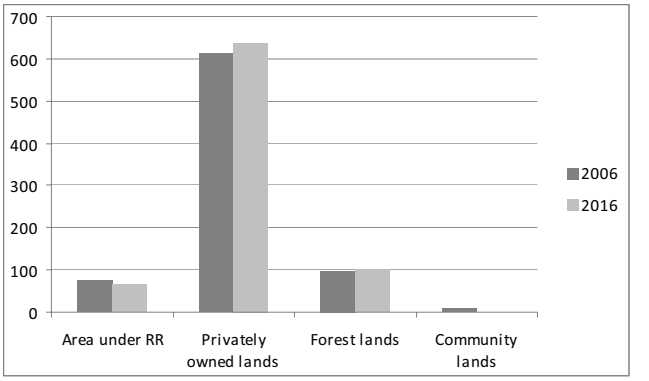
Hamletwise distribution of RRs

As seen from Graph 2, Ratanwadi (Tirthachiwadi), Tale, Satewadi (Jambhlewadi), Fopsandi (Kondarwadi) did not have any RR. Rest all the hamlets had RRs in varying percentages.

Graph 3 shows changes in RR lands within the last decade. There is a 14% decrease in RR area in the past 10 years. Pressures like land use changes, local unemployment and forced migration, changing climate and its impact on cattle health, failure of village economies to provide the much needed cash for sustenance may have caused HH to discontinue animal rearing as a livelihood option. With cattle rearing losing its significance, important conservation traditions like the RR are also losing their contexts.



Graph 2 : Village-wise distribution of HH practicing RR



Graph 3 : Change in RR area in the past 10 years.

Community wise contribution to the RR tradition

Community wise classification of the RR villages revealed that all four hamlets which had a population of Thakar community still practiced the tradition. Also 6 villages (out of 10) with Mahadev Koli community and 3 (out of 7) with Scheduled Caste population were observed to be following this RR practice.

Maximum number of HH protecting RR belonged to Mahadev Koli tribe followed by Thakars and lastly the Scheduled Caste HH. But considering percentage of households within communities, 29% of Thakar HH, 19% of Mahadev Koli and 12% of the SC households practiced this unique tradition.

The RR are protected from fires and open grazing through community regulations and mutual understanding. Open grazed lands are severely grazed (Photo 1) whereas grass density is better in raakhan rans (Photo 2 and 5, 6). Even though RR is an individual ownership entity, there are no physical barriers demarcating or excluding it from open grazing. It is through mutual understanding amongst communities

that RRs are protected. Detailed study needs to be undertaken to understand the different management/ protection strategies which communities employ for RR but it is very clear that the decision of the individual is being honoured by the entire community.

Most grasses complete their lifecycle in early winter and disperse seeds. The fodder in RR are harvested after completion of lifecycle to ensure healthy regeneration in the coming season. These areas with vigorous grass growth and high species diversity act as seed banks for this neglected diversity which provides vital support to the entire ecosystem. Depending on the soil characters grasses dry at varying rates. Harvesting at optimum moisture is essential to ensure optimum biomass recovery. Over-desiccation of fodder makes it brittle causing breakage and reducing biomass recovery. Therefore most HHs prefer harvesting Raakhan Raans in the month of November-December for optimum palatability and biomass recovery.

Size of RR

Most HH practicing the tradition preferred to protect as much as 1 acre of RR. The area conserved through this practice ranged between 0.5-3 acres. Average landholding was 1.015 acres per HH at the time of survey. Comparative study of RR landholding in the past decade shows that average land holdings have reduced from 1.36 Acres per family to 1.015 Acres per family. See Graph 4. On the background of increasing cattle population in the area reducing RR area may indicate increasing grazing pressure on surrounding forest areas.

RR and the cattle rearing livelihood

Amongst 269 interviewed HH, 238 HH were rearing animals (1 and 49 numbers). Thirty one HH did not have any animals. Amongst the 238 livestock rearing HH, 185 HH maintained larger livestock like cows, bulls, buffalos, etc.

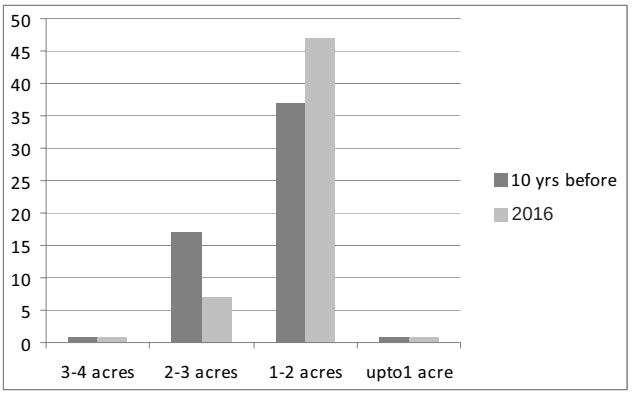
Out of 56 HH who owned RR, 54 maintained livestock while only 2 families who were not into livestock rearing maintained RR. This finding indicates that motivation behind protecting RR is closely related to whether or not the family is currently involved in livestock rearing. A total of 99 rearing goats did not practice RR while only 23 HH rearing goats practiced RR. Goats are browsers; they feed on grass along with leaves and shoots of wild plants and do not require an assured supply of fodder like the cattle.

RR assures fodder security during months of scarcity. Larger herds which are more prone to starvation due to the sheer volume of their fodder requirement can be nurtured well with a resource like RR. It is evident from the study that large herd owners prefer protecting RR more than smaller herd owners. Graph 5 shows that 40% of the "very large" herd owners depended on RR.

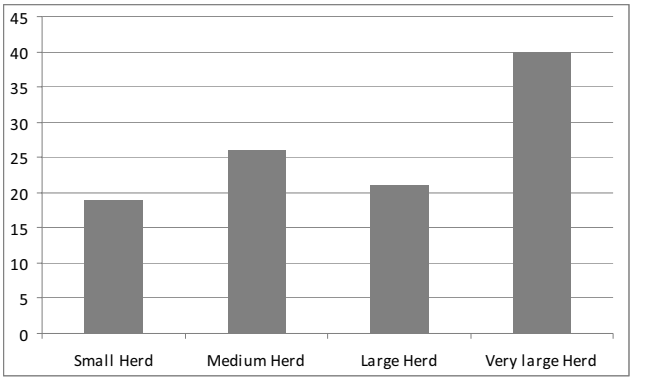
Age of this tradition

Total of 61% of the HH were practicing this conservation tradition since 75 yrs/ 3 generations. 30% were conserving since last 50 years/2 generations. 5% HH had a conservation history of 100 years/ 4 generations. Similarly only 4% had newly begun to protect RR i.e since past 25 years/1 generation.

There were 235 HH involved in selling various animal produces like milk, milk products, dung, calves, etc. 55 RR HH out of the total 56 RR HH were found to earn income out of sale of various animal products. RR thus supports livestock based income



Graph 4: Changes in area of RR/HH through past decade.



Graph 5: RR practice on the basis of herd size

X axis denotes herd size while Y axis represents % HH with RR

generation activity amongst the marginal tribal communities in the area.

Households in the study area reported cattle based income ranging from 1000 to 10000 annually. This was divided into 2 categories, 1000-4999.00 as low and 5000-10000 as high. Amongst the 56 RR HH in the studied sample, 37 RR HH (66%) earned annual income in the higher category. There were 24 Mahadev kolis, 13 Thakars amongst these higher earning HH.

Yield from RR

Initially, it was thought that RR were maintained and harvested for securing fodder alone. Survey revealed multiple applications to which these grasses were put. The grass harvested from RR provides sustenance to local cattle during the critical draught period. Besides, the grass is also used in annual maintenance of houses done before monsoon and for rouging operation in traditional rice farming. Fifty six HH reported using RR grasses as fodder, 38 for household maintenance and 31 HH used the harvested grass in farming operations. Depending on the nature of substratum, climatic exposure and protection level the yield from each RR varies considerably. Average yield per acre reported varies from 3 cartloads/acre to 20 cartloads/acre. Maximum harvest possible was found to be as much as 50 cartloads and least being 3 cartloads.

RR are not always harvested to 100% of its capacity. HH harvest the area as per their estimation of annual requirement. Only 20% RRs were completely harvested while 28% harvested only $3/4^{th}$, 36% harvested only half and 16% harvested $1/4^{th}$. Setting aside a part of unharvested RR may also be a management strategy to ensure sufficient seed numbers and soil health, but other factors such as household requirement for fodder might also play a role.

Conclusion

Fodder is an important resource for a agro-pastoral community like the ones in study area. Overgrazing and lack of suitable management strategies, have rendered community grazing areas non-productive in terms of quality and quantity. Sustainable fodder production, protection and harvesting assure long lasting resource. RR is an old practice which assures a prolonged supply of this resource.

Raakhan Raan are privately owned and traditionally conserved grassy patches in the study area. They covered a broad spectrum of landscapes and habitats. RR were located on flat lands, steep slopes, stream banks, near forested areas, in deep soils as well as in shallow soil habitats. Almost 21% of households protect and preserve RR in the current scenario underlining their dependence on animal rearing as a livelihood activity. It also indicates the significance of sufficient quality and quantity fodder for sustaining this activity. Families who rear larger livestock like cattle and buffaloes opt more for protecting RRs. Furthermore, families with larger herds depend more on RR due to higher requirement of fodder every year.

RRs are mostly found on privately owned lands. Local communities protect as much as 10% of the total private landholdings as RRs. Thus 10% of privately owned lands in the study area have been providing protection and support to many plant and animals species of grasslands habitats of Northern Western Ghats.

Improved transportation, migration for employment, change in approach towards livestock rearing, improved irrigation facilities, etc have led to reduction in RR holding HH and also area under RR per HH.

RR practice is not limited to any community as a whole. All the communities from the study area were found to protect RRs in varying proportions. RR was most common amongst Thakar communities (ST), followed by Mahadev Kolis (ST) and lastly SC. This practice is most related to livelihood and allied activities of the HH. Animal rearers and that too those who own larger animals (like cows, bulls and buffaloes) were found to be eagerly protecting RRs.

Considering today's scenario of animal husbandry as an enterprise, the enormous expenses incurred for procuring animal feed is the prime factor reducing its profitability. Reduced profitability increases incidences of malpractices and use of substandard raw material in any venture. RR practice can be a sustainable means to produce the major chunk of animal feed in a very localized and decentralized manner. Native fodder species growing in the RR will be hardy, drought and pest resistant. Production cost of these species will be negligible as no commercial seed material, fertilizer application will be necessary. It will be interesting to see how RR soils respond to land preparation and water conservation interventions also.

Besides supporting communities, RRs provide a safe and undisturbed habitat for grass species which have always been neglected from conservation perspective. The study area consists of hamlets located in buffer areas of KHWLS. Their location further increases significance of this practice by supporting greater and lesser wild herbivores.

For these multiple reasons, RR practice needs to be studied and replicated not only on individual scale

but must also be tried on community level.

Declaration

Authors take full responsibility of originality of the study conducted and article developed. They also declare no competing interests.

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Photo 1 ***:*** *Dormant Grass in open grazed area of KHWLS*

Photo 2 : Dormant ***Grass of harvested Rakhan Raan***

Photo 3 : Raakhan Raan on flat lands

Photo 4 : Raakhan Raan on slopes protecting soil from erosion

Photo 5 : Grass density in Raakhan Raan

Photo 6 : Grass harvested from Raakhan Raan

Photo 7 : Dangi cattle

Research Paper

Role of Godrej Mangroves in Climate Change Mitigation through Carbon Sequestration

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Abstract

Godrej and Boyce Mfg. Co. Ltd. is conserving thousands of acres of mangrove forest along the western bank of Thane Creek (19º03'31.12" N, 72º56'31.54" E to 19º06'31.43" N to 72º56'31.54" E) since the decade of 1940s. In this rich biodiverse forest, we have recorded 16 species of mangrove and mangrove associated plants. These forests provide ecosystem services like prevention of coastal erosion, habitat for wildlife, livelihoods for local fisherfolk, research and education avenue for academia and regulation of local climate. This paper explains material and methodology used to measure sequestered carbon using data of past 3 years. Annually this forest sequesters 6 lakh tons of CO_2 its potential annual increment value is around 50,000 tons of equivalent CO_2. This carbon sequestration service is very valuable considering high emission of CO_2 in the Mumbai Metropolitan Region and its impact on climate change. The paper also highlights importance of this project to the society and need to sensitize stakeholders for the mangrove conservation.

Key Words : *mangrove ecosystem, Thane creek, ecosystem services, carbon sequestration, climate change*

Introduction

The term mangrove is used in broad sense to refer to the highly adapted salt tolerant angiosperm plants occurring in tropical and subtropical marine coastal environments and along the banks of estuaries between lat. 30º N and 30º S. In India 65 mangrove species belonging to 31 families have been recorded. Maharashtra has about 6.41% (304km^2) of the total mangrove areas (4,740 km^2) in India (assessment by the Forest survey of India, 2017).

Mangroves form highly productive ecosystem, supporting a wide variety of organisms including commercial fishery. They not only provide wood for different purposes but also give many important products such as honey, medicines etc. It has been observed that mangroves protect the shore from storms, hurricanes, tsunamis, etc. (CAB of forestry Abstract, 1990). Mangroves supply food to marine communities via detritus food chain starting from leaf litter. The mangrove ecosystems provide a habitat for commercially important marine organisms like molluscs, prawns, crabs, fishes and act as feeding grounds for them and their juveniles. Studies have illustrated decline in fishery on loss of mangroves (Deshmukh, 1990). The mangrove swamps are known to act as natural sewage treatment plant, when conditions are favorable and the sewage is in reasonable quantity. These days, there is growing awareness regarding importance of mangroves and attempts are being made to conserve mangrove ecosystems. However, mangroves suffer damage through various anthropogenic activities like cutting for firewood, construction activities, timber reclamation, sand mining, dumping etc, animal grazing, by molluscan, insect pests, etc.

Thane creek (Long. 72º.55" E to 73º.00"E and Lat.

19°.00 N to 19°. 15″N) is important coastal ecosystem near Mumbai of which Godrej and Boyce Mfg. Co. Ltd. is conserving almost 2000 acres of mangrove forest along western bank of Thane Creek (19°03′31.12″ N, 72°56′31.54″ E to 19°06′31.43″ N to 72°56′31.54″ E) since the decade of 1940s. Thane creek extends approximately 26 km inside from the Arabian Sea and meets Ulhas river estuary by a minor connection near Thane city. As the riverine flow is less, the creek is tide dominated and experiences high salinity throughout the year except monsoon. However, due to growing urbanization in Thane- Mumbai region the creek receives significant quantity of fresh water in form of sewage. Thane creek's mangrove ecosystem has luxuriant mangroves along their banks. In past few decades, Thane creek ecosystem has been extensively studied for various aspects such as hydrology, sedimentology, mangroves, benthos, plankton, fishery and carbon footprints etc. (Deshmukh, 1990). Due to extensive urbanization and industrialization around Thane creek, this ecosystem is subjected to various damaging factors. Solid waste dumping, reclamation, pollution, cutting for the fuel are the main threats to mangroves in this region. To conserve mangrove along Thane creek, which is in-between Kanjur and Ghatkopar, Godrej is taking enormous efforts by implementing various activities focused on three pillars.

1) Education and awareness
2) Research
3) *In-situ* conservation of mangroves and development of eco-friendly infrastructure

Mumbai is one of the India's most polluted city as it experiences huge urbanization and very high levels of air pollution as a consequence. Mangroves along Mumbai act as green lungs of Mumbai and absorbs huge amount of CO_2 in their body stock in the form of cellulose. In Godrej mangroves, we are measuring this fixed CO_2 in the form of C to understand the role played by mangroves in reducing Green House Gases (GHG) and in reducing pollution in the Mumbai Metropolitan Region.

Materials and Methods

The purpose of this study was to estimate the total carbon stock in the mangrove forest at Godrej, Vikhroli. Specifically, it aimed to :

1) Determine the biomass and carbon density in the aboveground pools of the mangrove stands in the study area
2) Assess the amount of carbon sequestered in the soil.

Photo 1 : Godrej Mangrove area along Thane creek- Locations of sample collection. Area with yellow boundary- G&B, with green boundary- SPGF

The area selected for the study consists of mangrove forest located at Vikhroli, Mumbai, Maharashtra and under the control of Godrej and Boyce Mfg. Co. Ltd (G&B) and Soonabai Pirojsha Godrej Foundation (SPGF). Both of these areas are separated by a canal or creeklet which leads to Godrej jetty area (Photo1)

As far as the land cover of the study area is concerned, it includes a mixed type of classes ranging from dense vegetation, moderate vegetation, grassland area, mud flats, water body and open area. To study the land use and land cover class of study area, Remote Sensing technique has been employed from RESOURCESAT - 2, LISS IV F MX (CEED). The following are the five different land use classes obtained from the analysis :

Dense vegetation

This includes thick vegetation cover with different types of trees or plants covering land in an undefined manner. Many trees grow over only a small part of land with a dense canopy cover. The dense vegetation cover in the study area is dominated by the thick canopy cover of mangrove trees.

Moderate vegetation

This is a land use categorized under vegetation cover which represented by a land category with open type of vegetation.

This category in the study area includes mangrove trees having an open canopy cover.

Grassland

These are the areas of natural grass along with other vegetation, predominantly grasses and forbes.

Mud-flats

These are categorized under coastal wetlands that are formed when mud is deposited by tides or rivers. They are found in sheltered areas such as bays, bayous, lagoons, and estuaries. Mudflats may be viewed geologically as exposed layers of bay mud, resulting from deposition of estuarine silts, clays and marine animal detritus.

Open area

The open area within the study area comprises of open land areas with no angiosperm cover. It only had cryptogamic vegetation, mostly of algae.

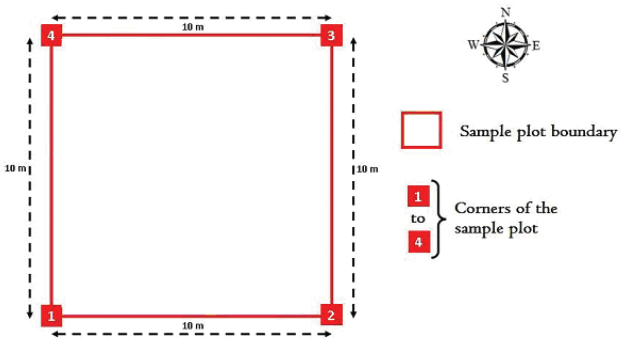

Figure 1. Layout of sample plot

For deriving the number of permanent sample plots required to estimate the carbon stock present within the project area, it was necessary to collect a standard deviation of carbon stock of each stratum. This was done through a pilot sampling carried out in each stratum. Two sample plots in each stratum were visited during the pilot sampling.

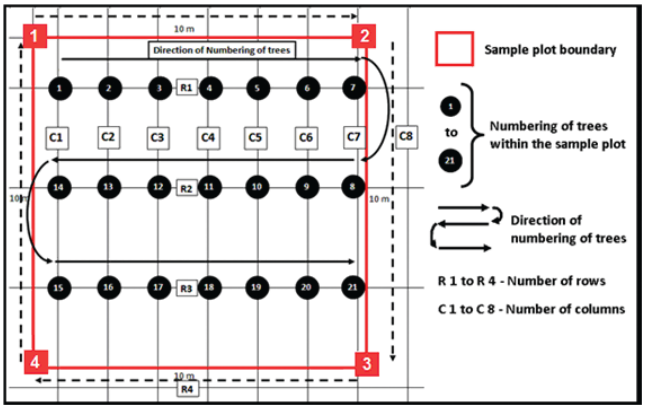

Figure 2. Numbering of trees within the sample plot

Table 1 : Number of sample plots laid in each stratum

Sr. No.	Stratum	No. of plots
1	Dense vegetation	3
2	Moderate vegetation	7
3	Grasslands	4
4	Open area	2
	Total	16

Numbering the trees within the plot

Trees were numbered from the corner of the sample plot. The tree nearest to the first corner was numbered as 1st tree. Numbering was then proceeded along the row towards the other corner of the sample plot. At the end of this, next row was covered and then starting corner of the plot was covered to end tree marking. Numbering of the trees was continued in zigzag fashion (refer Fig. 2) If there was a gap or a dead tree, its details were noted in the fieldnotes. Trees in research plots were numbered with weather resistant, white/yellow paint.

A calibrated measuring tape was used to measure the GBH of trees in sample plot. Tree height was determined using graduated bamboo sticks.

The permanent sample plot boundary was recorded using GARMIN eTrex VISTA Cx.

The carbon pools that can be considered for carbon stock estimation are defined as follows:

Above ground biomass (AGB): This pool includes all living biomass above the soil including stem, stump, branches, bark, seeds, and foliage. Where forest under storey is a relatively small component of the above-ground biomass carbon pool, this may be ignored so long as the methodology is used consistently throughout the inventory time series.

Below ground biomass (BGB): This pool includes all living biomass of live roots. Fine roots under, say, 2 mm diameter may be excluded as they often cannot be distinguished from soil organic matter or litter.

Dead wood (DW): All non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. This includes wood lying on the surface, dead roots, and stumps (usually defined as having a diameter of at least 10 cm).

Litter: All non-living biomass with a smaller diameter than that used for dead wood (say, 10 cm), lying dead, in various states of decomposition above the

mineral or organic soil. This includes the litter, fumic, and humic layers. Live fine roots (of less than the diameter limit for below-ground biomass, say 2 mm) may be included here.

Soil organic carbon (SOC): Includes organic carbon in mineral soils to a specified depth chosen by the country and applied consistently through the time series. Live fine roots (of less than the chosen diameter limit for below-ground biomass) to 30 cm depth may be included here.

The pools selected for the present study were aboveground live trees, dead trees, drowned wood, belowground plant carbon, and soil carbon. These five pools likely comprise >95% of the true ecosystem carbon stock of mangroves.

The carbon stock estimation of trees i.e. for the above ground biomass and below ground biomass carbon pool was done using the approved A/R CDM methodological tool: "*Estimation of carbon stocks and change in carbon stocks of trees and shrubs in A/R CDM project activities*" 03.0.0.

Three methods have been described in the tool. They are Stock Change method, increment method and baseline default method. In our study, Stock change method was used. In this method carbon stock in trees within the project boundary is estimated annually since 2013 at successive points of time. Change in carbon stock in trees between two successive points of time is calculated as the difference between the two estimated stocks.

Total carbon stock

The total carbon stock was estimated by adding all the five components of the carbon pool.

The equation for total carbon stock for a given project area is as follows:

$$C_{PROJECT,t}=C_{TREE.t}+C_{DW,t}+C_{LI,t}+C_{SOC,t}$$

Where,

$C_{PROJECT,t}$:*Change in the carbon stocks in project, occurring in the selected carbon pools, in* t; *t CO2-e*

$C_{TREE.t}$:*Change in carbon stock in tree biomass in project in year* t, *as estimated in the "Estimation of carbon stocks and change in carbon stocks of trees and shrubs in CDM project activities"; t CO2-e*

$C_{DW,t}$:*Change in carbon stock in dead wood in project in year* t, *as estimated in the "Estimation of carbon stocks and change in carbon stocks in dead wood and litter A/R CDM project activities"; t CO2-e*

$C_{LI,t}$:*Change in carbon stock in litter in project in year* t, *as estimated in the tool "Estimation of carbon stocks and change in carbon stocks in dead wood and litter in A/R project activities"; t CO2-e*

$C_{SOC,t}$:Change in carbon stock in SOC in project, in year t; t CO2-e

t: 1, 2, 3, … *counted from the start of the project activity*

Results

The Carbon stock in project area ($C_{PROJECT,t}$) calculated using the equation mentioned in methods is given below (Table 2).

Discussion

The estimation of carbon sequestration by Godrej mangroves provided valuable insights to their ecosystem provided by them not just to Godrej campus but significant landscape of Eastern shoreline of Mumbai Metropolitan Region (MMR). The finding offers quantifiable reason for mangrove research to Godrej and Boyce considering the organization's carbon neutrality target. The same has been mentioned in the organization's documents such as Business Excellence Report and Sustainability Report.

Godrej and Boyce has discussed this research with the Mangrove Cell of Maharashtra Forest Department with a suggestion to conduct similar research on mangroves of MMR, and perhaps state of Maharashtra. This will help the State authorities to realise importance of mangroves and convince stakeholders through an awareness campaign.

Table 2 : Carbon stock in project area

Project area	$C_{TREE,t}$ tCO2e	$C_{DW,t}$ t CO2-e	$C_{LI,t}$ t CO2-e	$C_{SOC,t}$ t CO2-e	$C_{PROJECT,t}$ t CO2-e
G&B	66284	8423	46	97221	171976
SPGF	141746	3938	21	279427	425134
Total	**208030**	**12361**	**67**	**376648**	**597110**

Conclusion

This study is first of its kind in the state of Maharashtra.

It highlighted remarkable contribution by a corporate house in mangrove conservation. The ecosystem services of carbon sequestration delivered by the Godrej mangroves benefit entire Mumbai Metropolitan Region which needs green lungs to absorb the Greenhouse Gases (GHGs) emitted by countless anthropogenic activates. Extrapolating the carbon sequestration services of Godrej mangroves to entire mangrove ecosystem of the Mumbai Metropolitan Region, this study makes clear case for wetland conservation for climate regulation.

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Research Paper

Naturalistic Intelligence (NI) : Nature and Nurture

Sujala Watve and Aparna Watve

Sujala Watve is a psychologist with the Jnana Prabodhini Institute of Psychology, Pune. She has worked on the identification of gifted children, development of Multiple Intelligences and aptitude testing for more than 30years.

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Abstract

Howard Gardener's Multiple Intelligence theory includes Naturalistic intelligence, a cognitive potential to process information regarding nature. The individuals with high NI are likely to do well in diverse nature related careers and can contribute towards sustainable management and conservation of nature.

Studies of NI in Indian context lack any insights into NI that can help to identify and nurture NI. We assessed NI in school children and its expression in naturalists. Correlation of NI with other intelligences and its use were explored.

NI had highly significant but moderate correlations with other seven intelligences. Interview results showed that expert naturalists are highly sensitive towards variety, relationships and patterns found in natural objects and make use of multiple senses, including visual, auditory, olfactory, tactile and gustatory while experiencing their surroundings. The results of both studies are used in conjunction with NI studies abroad to list characteristics that can help identify children with high NI. Activities that can help nurture NI are recommended.

Keywords: Multiple Intelligence, Naturalistic Intelligence, naturalist, education

Introduction

All species require knowledge of their natural surroundings to survive in this world. For several thousand years, humans learnt and passed on the knowledge about nature in various ways. Organized forms of this knowledge are included in life sciences and natural history. Knowledge of nature is also expressed and shared through cultural practices, art forms, songs, dance, music and literature. Hunters, farmers, shepherds, fishermen, biologists, bird-watchers, botanists are some examples of people who generate knowledge about nature through their observations of flora, fauna and natural phenomena. The knowledge is based on information through keen observations of individuals who can distinguish and find relations between plants, animals and other components in nature. The ability of certain individuals to observe and detect patterns in nature has been treated as a separate intelligence, termed, "Naturalistic Intelligence."

Identification of intelligence and its nurture have practical implications for an individual as well as for the society in which s/he resides. Psychometric approach led to creation of various tests for intelligence which led to popular term "Intelligence Quotient" (IQ) that describes scores on the tests of intelligence (Neisser et al. 1996). Spearman (1927) emphasized the importance of a general factor, g, which represents all that the psychometric tests have in common; others (e.g., Thurstone, 1938) focus on more specific group factors such as Memory, Verbal ability, Number Ability, etc.

Howard Gardener took an interdisciplinary and culturally sensitive approach to intelligence. Gardner, (1993), defined intelligence as an "ability to solve problems or fashion products that are of consequence in a particular cultural setting or community". Later, in his book, *Intelligence Reframed*, Gardner (1999) listed Multiple Intelligence (MI), each oriented to a specific type of information: linguistic, logical-mathematical, musical, spatial, bodily kinaesthetic, naturalistic, interpersonal, and intrapersonal, etc. He states that intelligence can be seen as a potential – not as something

that is fixed—and this potential is either stimulated or diminished by the cultural, environmental, and social settings a person experiences.

Naturalistic Intelligence (NI), first described by Gardener, has been comparatively less well studied than the other intelligences. NI is defined as "the potential to process information that is exhibited by naturalists" (Hayes, 2009). Gardener (1999:49) believes "the naturalist's intelligence (is) as firmly entrenched as the other intelligences" and that "(t)here are. . .core capacities to recognize instances as members of a group (more formally, a species); to distinguish among members of a species; to recognize the existence of other, neighbouring species; and to chart the relations, formally or informally, among the several species." He has explained the concept by quoting many examples of botanists, zoologists, evolution theorists, environmentalists, entomologists, etc. Poets and authors writing about nature, wildlife photographers, film-makers are some other examples who display high sensitivity towards nature, but they may not be always be able to distinguish between species and therefore may or may not be showing NI as defined by Gardener.

The MI theory of Gardener has been used to formulate variety of educational and experiential learning programmes to identify inclinations, develop intelligence profiles of individuals and to design programmes that cater to individual's personality development (Gardener and Hatch 1989; Chen, 1993; Bas, 2016). It has been seen that it leads to successful student outcomes including more interest and motivation, better recall, deeper understanding, higher attainment and improved self-esteem (Hanafin, 2014). Hayes (2009) has discussed how learning from MI theory and practice can be applied to naturalistic education and supporting (environment and biodiversity) conservation. Some MI studies that include NI are by Razmjoo (2008), Almeida et al. (2010) and Karamustafaoglu (2010).

Indian schools, with some exceptions, do not incorporate activities that can support development of diverse intelligences of an individual. Tamilselvi and Geetha (2015) have noted the importance of integrating MI activities in the teaching to aid students' learning. But only a few basic assessments of MI (including NI) have been conducted in Indian settings. Kaur and Chhikara (2008) assessed multiple intelligence levels among young adolescents and found gender related differences in the levels. Watve (2010) tested the relations among eight intelligences in MI in school children and found significant correlation. Baskaran and Babu (2014) investigated NI in Master's level students of library science and discuss need for nurture.

A very recent study from neighbouring Nepal (Neupane, et al. 2018) has shown that NI ranks first among the MI in school children in Kailali district. Other studies (Sener and Çokçaliskan 2018, Zebari et al. 2018) have assessed and ranked NI with respect to other intelligences in school and University students. The studies above have tested for presence of NI but have not described its characteristics in details. Our understanding of NI characters is mainly from studies in Europe and America such as by Armstrong (2009).

Understanding the nature of NI can help its nurture from early age. NI enhancement can help the individuals perform better in tasks that require understanding of flora, fauna and nature in general.

Aim of the present study was to understand NI, its relationship to other intelligences and its use by expert naturalists. The specific research questions posed were :

1. What is the relation between NI and other intelligences?
2. What are the ways in which nature related information is gathered and processed by individual with high NI (viz. Naturalists)?

The findings are used to describe characteristics of individuals with high NI and ways of creating supportive environment for the nurture of NI.

Biodiversity documentation, sustainable management and environmental conservation are considered national priorities in India (NBAP, 2008). Environmental education has been a compulsory component of school and university curriculum since 2003 (Almeida, and Cutter-Mackenzie, 2011). This is considered necessary to create awareness and sensitivity towards nature from early ages. Based on our study we suggest NI nurturing activities that can be incorporated in formal and informal nature education and help raise environmental awareness in the society.

Methodology

An exploratory correlational study was conducted using MI test for the eight intelligences. Data was collected using MI assessment tool, which is a behavioural checklist based on Gardener's theory of multiple intelligence developed and tested by Jnana Prabodhini Institute of Psychology (Watve, 2010). The checklist consists of 80 statements, 10 for each of the intelligences. Each statement describes behaviours (ex. Recognizes and discriminates between different textures) rated on a 5-point scale (1-5). The composite

checklist was in English and also translated in Marathi.

One hundred self-nominated students between age 11-15yrs from Pune city and suburbs were administered this checklist during the period 2005 to 2006. It included 42 girls and 58 boys. In order to check inter-rater reliability, the checklist given to students was also given to one of their parents. The scores attained by students and parents were found to be matching. Item total correlation was tested and found significantly high (ranging from 0.60- to 0.80) which indicated satisfactory internal consistency. Correlations amongst the raw scores of the sampled students were calculated.

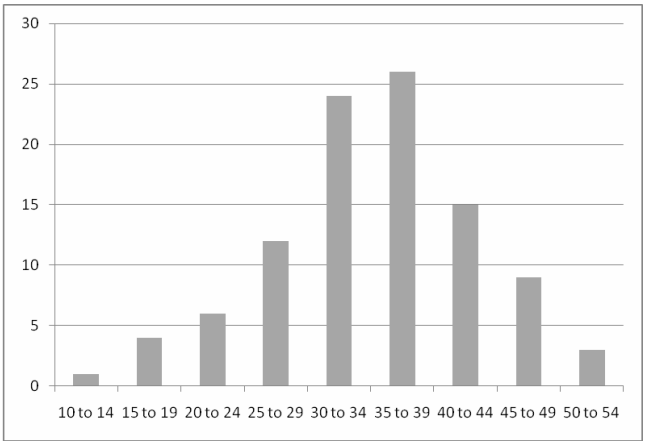
Naturalists were identified using Gardener's definition (Gardener, 1999) of naturalists as "(person who)… demonstrates expertise in the recognition and classification of the numerous species-the flora and fauna- of his or her environment. Eight naturalists (demonstrating skills for identifying plant and animal species and working full time in natural science studies) were interviewed using a semi-structured open-end interview schedule. It included questions regarding ways in which they distinguish plant and animal species, how they integrate the information about natural elements and use it in their chosen career. They were also queried regarding childhood experiences mainly to understand their interests, inclinations and influencing factors that helped them in taking up natural science studies. It helped to understand the actual process by which naturalistic individuals use their faculties in navigating through life. Information from two more naturalists was gathered through analysis of radio interviews and their own writings.

The study has limitations that the sample is culturally restricted and the nature of the tests limits analysis. But the sample is from a culturally homogenous group and showed concurrent validity. Considering this, results are fairly reliable, and can be used for further research.

Results

The raw scores on NI test were used to draw a frequency diagram (Graph 1). NI scores were normally distributed. Table 1 shows descriptive statistics of the NI scores. The sample is negatively skewed indicating more number of students are on higher end of the scores. Table 2 shows correlation of each intelligence score with the total scores on MI test. High correlations indicate high internal consistency.

The results of MI scores were used to find correlations of NI with each of the intelligences. Table 3 shows highly significant correlation between NI and other intelligences at 0.01 significance level. The values ranged from moderate to high. Most students with high NI also displayed higher scores for other intelligences. Highest correlation among the pairs is between NI and Bodily-Kinaesthetic intelligence. They are likely to have some factors more in common than the rest, perhaps related to physical and biological capacities of the individual.



Graph 1 : Distribution of NI scores

Table 1 : Naturalistic Intelligence Descriptive Statistics

Intelligences	MEAN	S.D	Skewness	Kurtosis
NATURALISTIC	34.86	8.17	-0.43	0.16

Table 2 : Area total correlation

Area of intelligence	Correlation
LINGUISTIC	0.60
INTERPERSONAL	0.71
INTRAPERSONAL	0.72
VISUO-SPATIAL	0.76
BODILY-KINESTHETIC	0.75
MUSICAL	0.76
LOGICO-MATHEMATICAL	0.65
Naturalistic	0.80

Table 3 : Correlation of NI with other intelligences for N-100

Area of intelligence	Correlation	
LINGUISTIC	0.43	Moderate
INTERPERSONAL	0.51	Moderate
INTRAPERSONAL	0.48	Moderate
VISUO-SPATIAL	0.53	Moderate
BODILY-KINESTHETIC	0.63	High
MUSICAL	0.53	Moderate
LOGICO-MATHEMATICAL	0.45	Moderate

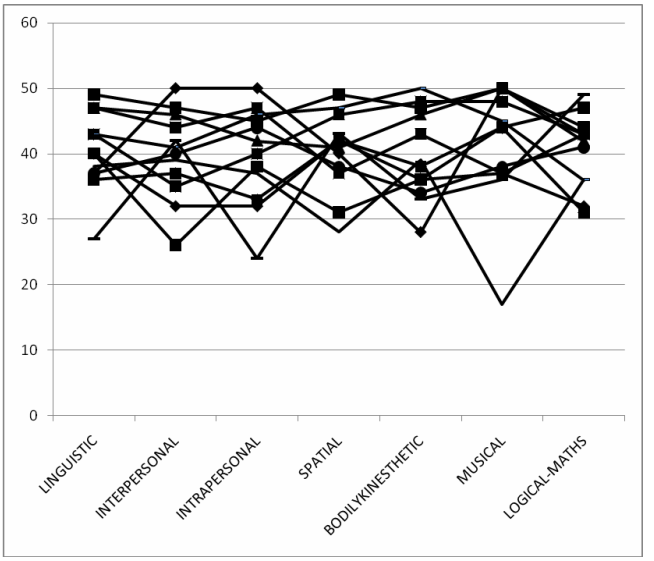
In some individuals, NI raw scores were high (45 and above) but scores on some other intelligences were lower than 30, one as low as 17 (See Graph 2). There were also students who were high on logico-mathematical, intrapersonal, visuo-spatial or linguistic intelligences but low on naturalistic intelligence. (See Graph 3). Two tailed t test revealed no significant difference in NI scores of boys and girls.

Use of NI by naturalists

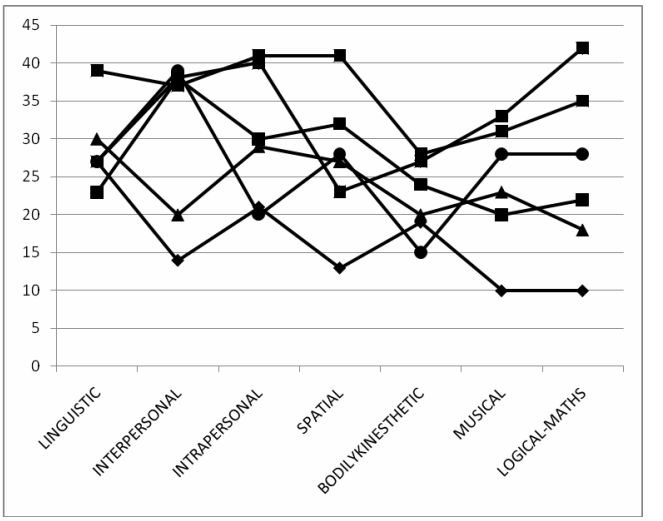
Table 4 describes naturalists interviewed for understanding their use of NI in practice. The sample included 7 males and 3 females between ages 25 and 70 at the time of interviews. They all had experience of working in wilderness areas and were mainly from two fields, taxonomy and ecological research involving plants or animals, areas which are primarily used to define naturalistic intelligence.

A psychologist measures intelligence as a 'performance' in response to the external stimuli. It was our effort to understand what kind of stimuli are received by the naturalists from the surroundings and how they perceive them. Naturalists were questioned about their childhood activities, how they identified different species or other components in the natural world, environment at home and school environment and its impact on their interests etc.

While describing how they experience nature, the naturalists described their use of multiple senses. They talked about observing patterns and shapes in examining natural elements. For example the botanists noted differences in leaf shapes, remembered the growth patterns of trees or shrubs. The zoologists noted the shapes, shades of colours, patterns of movement for ex. flight of birds or butterflies. These indicate towards the use of visual sense. The individuals also talked about use of auditory senses. They described a very high sensitivity to sounds. The expert bird watchers could hear and remember diverse bird calls, discern the different notes and some could even imitate the bird calls with high precision. Apart from the audio-visual senses, the individuals described us-



Graph 2 : Other intelligence scores of 12 individuals with NI scores above 45 (each line for one individual)



Graph 3 : Other intelligence scores of 6 individuals with NI scores 20 or less (each line for one individual)

Table 4 : Description of naturalists

Code	Qualification	Research field	Field of work
A	PhD	Plant taxonomy, Ecology	Ecology research, environment education, teaching, conservation
B	Diploma	Animal taxonomy, Wildlife biology	Wildlife studies, environment education, teaching, conservation
C	PhD	Plant taxonomy, Ecology	Ecology research, environment education,
D	MSc	Wildlife biologist Biodiversity studies	Farmer, Ecology research
E	MSc	Plant taxonomy, Ecology	Environment education, teaching, science communicator
F	MSc	Biodiversity studies	Wildlife studies, Science communicator
G	MSc	Biodiversity studies	Wildlife studies, Farmer, entrepreneur
H	MCom, Diploma	Wildlife biology, ornithology	Environment educator, science communicator, conservation
I	PhD	Microbial taxonomy, Biosciences	Biological research, teaching, science communicator
J	PhD	Wildlife biologist	Wildlife studies, teaching

ing olfactory and tactile senses. They talked about different smells as an aid to identification of species. The natural world was described as full of various smells that become part of memory which is useful in identification of species. Some described detecting the presence of certain animals, (as diverse as ants and tigers) through their characteristic smells. Texture of natural things was also considered very important. Different barks, leaves, flowers, fruits have distinctive textures which are imprinted in a naturalists' memory and useful in remembering the species. The touch of animal and sensing its response to touch are important in handling animals, such as snakes. Although taste is an equally important sense, it is used with discretion in experiencing nature as it can be potentially dangerous to taste unknown things. But for some plants or fruits, taste was considered a very important quality to remember the species. Most respondents showed keen interest in food and testing diversity of foods which could be related to the high sensitivity to taste.

Although the naturalists described individual senses and how they use it to identify specific plants or animals, they all emphasized that, in practice, it is an 'integrated experience', where they remember plants or animals or natural phenomenon as a composite of different sensory experiences. There are no fixed or pre-determined categories in which these experiences can be categorized. However, for the purpose of documentation, the plant and animal taxonomy disciplines have created several technical terms that describe colour, texture and smell etc. which are not part of colloquial language. For ex. the terms scabrid, coriaceous, hirsute describe texture of a leaf. Those who undergo formal training in the discipline learn to apply the terms in describing their sensory perceptions.

Interestingly, three of the naturalists, formally trained in the science of taxonomy said that their ability to discern types and patterns was limited to natural entities alone. Gardener (1999) supposes that "naturalists' capacity is brought to bear on artificial items", such that a child that can discriminate among plants and animals is using the same skills when she classifies sneakers, cars, marbles etc. But the respondents said that they never observe or remember the types of man-made objects like cars because they are not at all interested in them. However, on further probing, half of the naturalists remembered collecting natural as well as man-made things as children. They had collected stamps, coins, matchboxes, candy wrappers, bottle caps in childhood along with feathers,

rocks, leaves and shells. Perhaps it's not the skill set but interest that made some prefer remembering natural objects rather than man-made objects.

Apart from the sensory aspects, the individuals described seeing relations among the different components in nature. They described observing interdependence among the naturally occurring living and nonliving things. E.g. finding a certain group of plants near moist areas in a forest, listening to the alarm calls of different animals and birds to deduce movement of a large predator, seasonal cycles in habitats.

All the individuals had started observing nature since childhood. They had experienced nature in unstructured manner initially, observing nature around their homes, visiting natural areas like forest, rivers, farms in rural areas etc. But this was also followed by partially structured experience of nature through environment education programmes, environmental camps, trekking etc. Collecting different natural and non natural things (stamps, leaves, coins, stones etc.) was commonly practiced. Eight of them had followed this with formal training in natural sciences as part of graduate and post-graduate studies. One had practiced farming and livestock rearing, while one has chosen to be into agri-horticulture as a full-time profession. They had acquired their information on nature through direct experience as well as indirectly through books, audio-visual media (mainly television and films before the internet era) and expert talks on nature. Most of them remembered influence of other accomplished naturalists who directly or indirectly helped them in observing and documenting natural phenomenon.

According to Gardener and Moran (2006) "Naturalist(ic) intelligence processes information related to distinguishing among natural and manmade objects, which is evolutionarily derived from the hominid capacity to recognize, group, and label distinctions among natural phenomena". This is supported by the responses of the naturalists in present study. It was seen that they perceive and categorize information related to flora, fauna and also abiotic components of nature such as temperature, moisture, wind, light etc. and can recognize patterns and relations between them. They use all five senses which aids in receiving information that is not gained by simple observations or listening.

In the case of high NI individuals, their mind is processing over the Content 'Nature', gathered through sensory organs and then processed to abstract form. In other intelligences stated by Gardener the content of thinking are different. Language in Linguistic intelligence, sound in Musical intelligence, Visual matter in Visuo-spatial intelligence, symbolic material in Logico-mathematical intelligence, bodily and kinesthetic sensations in Bodily-kinesthetic intelligence, relations in Interpersonal intelligence and within self experiences in Intrapersonal intelligence. Likewise sensory-motor experiences seem to be material to be processed in Naturalistic intelligence (NI).

Some of the common processes that emerged through the discussion are as follows :

The individuals displayed **curiosity about nature** as indicated by questions, seeking information from various sources, experimenting on natural phenomena.

They had **selective attention** towards things in nature, comparatively extended attention span and successful concentration towards living and nonliving things in nature in their natural form.

They **grasped various aspects** of natural things, their sizes, shapes, contours, designs, patterns, colours, texture, temperature and vibrations, odors and taste through audio-visual, tactile, olfactory senses and occasionally through taste.

They had a **rich memory of past experiences** regarding natural things, as an integrated experience of in the form of visual, auditory, tactile and olfactory representations, could note distinction amongst them, their interconnections, their naturally occurring patterns, alterations and forecasting further variations.

They showed **divergent thinking patterns** on the gathered information. Continuous processing over the acquired information to see relations amongst them and find out causal relationships is generally done.

They **logically compiled** and did **critical evaluation** of the data to give meaning to this linking and deductive as well as inductive reasoning

Though naturalistic intelligence was dominant and common in this chosen group, they differed with respect to other potentials and performed activities related to linguistic intelligence (writing, reading literature), musical intelligence (singing, mimicking), logico-mathematical intelligence (conducting research), spatial (drawing), bodily-kinesthetic (outdoor sports, trekking) etc. Interestingly, all of them had ability to communicate this knowledge to others, but had chosen various forms of expressions that included giving talks, formal teaching, informal outdoor communication, writing and in case of two individuals by writing poetry and through drawings. Some had chosen to express their learning of nature through scientific papers, while others through more popular writings and talks. Their academic performance in

school had varied from moderate to poor and at least three expressed difficulties in adjusting to the standard schooling and education.

Discussion

The study revealed many facts about NI, its relationship with other intelligences and processes involved in use of NI. Moderate correlation shown by NI with remaining Intelligences indicates that some intelligence factor is common to all. But the fact that the correlation is not perfect, in any pair, supports the idea of Gardener that NI is a separate intelligence. The adolescents in the sample varied with respect to NI and other intelligences. Home and school environment could be responsible for these variations in addition to hereditary factors.

MI theory states that all intelligences are needed by an individual to productively function in society. Karamustafaoglu (2010) has shown that individuals with different levels of intelligence have different learning characteristics and each student can learn and succeed when the teaching activities are organized by taking the students' intelligence types into consideration. Kornhaber, Fierros and Veenema (2004) studied 41 schools that had used MI-inspired practices for several years. They document numerous ways in which these schools and their students have benefited. MI approach offers suggestions for providing a more reasonable and practical approach to schooling.

School education especially in India, does not address needs for nurture of multiple intelligences. Considering the variation in the intelligence profiles, a standard educational content, as delivered in Indian schools may not benefit all in the same way. For ex. Some of the students in the sample had high scores in Linguistic or Logico-mathematical intelligence (Graph 3). They would do well in languages, logical and mathematical tasks, which are valued potentials in Indian education system. But the same students had low levels of naturalistic intelligence which could lead to poor understanding of subjects such as life sciences and biology. One of the students, who had high NI score, had lower scores on Linguistics and Intrapersonal intelligence (Graph 2). Linguistic intelligence is useful in communicating while Intrapersonal intelligence can help in knowing and learning about own self. Teaching activities based on MI can help such individuals overcome their weaknesses and use their potential to the fullest. Understanding intelligence profile of a student can then be followed by developing skills that are required in adult life, for ex. in choosing a career based on his/her dominant intelligence/s.

According to Gardener and Moran (2006) Intelligence and skill are separate. Intelligence is an individual's biopsychological information processing capacity, while skill is a cognitive performance that includes the supports and the constraints of the environment (See Fischer, 1980). In many fields people with skills for identification of natural elements, or understanding of natural phenomenon are needed. For ex. the field of organismal and conservation biology does need "scientific naturalists" (Futuyma 1998:2) to study or learn about nature. Fostering of NI is also required for undergraduate biology students (Hayes, 2009).

The intelligence profile of individual is a potential which can develop into a skill in later years if supportive environment is available. The school children in this study displayed NI as a potential, while the naturalists showed necessary skills for making a career in nature related subjects.

Adult naturalists in our study listed many activities they had engaged in at young age, which match those listed in the MI test used in this survey. This suggests that they had displayed NI characteristics at young age. However, at least half of them felt that school environment was not very supportive to their potential. The schools had focused on more conventional skills such as reading, writing, calculations etc. and had not included outdoor activities or experimentation that enhance nature related skills (identifying species, handling animals etc.) . Their skills grew through their interactions at home with family, and outside of home, with friends having similar interests and by interactions with experienced naturalists. These individuals developed into adult naturalists due to the support through various means. But it is possible that for several others naturalistic potential remained underdeveloped and underutilized due to various social, cultural, physical constraints. To avoid this, early identification of NI, followed by nurturing through activities in home, schools and outside of school can prove beneficial. Armstrong (2009) lists activities that indicate high Naturalistic Intelligence and suggests that children with high NI think through nature and natural forms and need access to nature and opportunities and tools for investigating nature. Thinking through nature and natural forms could be used innovatively in teaching methodology as well, especially so if the individual shows less interest in some subjects. Gerald Durrell, a renowned wildlife biologist, has described early education by his tutor,

George, who incorporated natural history, (Durrell's favourite subject) into teaching of all subjects, including mathematics, history and geography which were otherwise taxing for the young naturalist (Durrell, 2006).

We suggest following characteristics that can help parents and educators to assess NI levels in children, adding to those suggested by Armstrong (2009)

- Perceiving and distinguishing different tastes, textures and smells in addition to audio-visual memory
- Urge to handle, smell, taste unfamiliar objects
- Interest in playing with sand, mud, water and other natural objects
- Good memory of experiences in nature and with plants and animals
- Talking a lot about favourite pets and animals,
- Interest in tasting diversity of foods and cooking
- Liking field trips in nature, zoo, natural history museums
- Enthusiastic participation in activities that involve natural objects (mehendi, rangoli, decorations etc.) even when NOT proficient in it
- Keenly observing nature (clouds, water, hills) etc., getting excited about nature
- Keenly observing plants and animals in zoos, aquariums, terrariums, gardens
- Collecting various natural objects (rocks, leaves, feathers, insects etc.)
- Effortless understanding of animal and plant classification, evolution etc.
- Easily grasping the natural groups of animals and plants (ex. sharks, whales, mosses etc.)
- Interest in knowing about nature through films, internet, books etc.

Assessment can then be followed up by efforts to nurture the intelligence. This should not be limited to only ranking high on NI assessment. It is necessary to remember cautioning by Armstrong (2009) and many others against pigeonholing a student into one intelligence, as each can have many strengths. Overcoming weaknesses in a certain intelligence aspects is equally important.

NI enhancing activities need not be limited to children alone. Many adults, from all walks of life, are now seen participating in nature related activities, environment information collection, conservation action etc. Growing participation in taught courses in Ecological Restoration, Field Botany, Ornithology, Herpetology, Entomology, Wildlife photography, Animal psychology indicates that people are interested in learning about nature. Career options for individuals with dominant NI have become available in horticulture, environmental restoration, field biology, tourism, sustainable agriculture. The NI skills might be useful even in other fields such as food industry. Very recently Government of India has launched green skill development courses which train individuals in practical nature related services, such as garden maintenance, documenting biodiversity, bird watching. Individuals in such courses can benefit through activities that can nurture NI.

We suggest following division of NI nurturing activities

a. those encouraging use of multiple senses
b. those providing information about diversity of natural elements
c. those encouraging organization of information

a. those encouraging use of multiple senses

Vardin (2003) has compared the human development theories proposed by Maria Montessory and Gardener, showing how both emphasize importance of environment (used in a sense broader than natural environment) on human development. Montessori curriculum, especially the sensorial exercises (For details See Vardin 2003) are a good way for encouraging use of various senses.

In recent years, schools encourage activities such as nature visits, plantations, vermiculture as part of environment education. This can provide an opportunity for children to interact with nature. Nature education courses can give similar opportunities to adults. But for development of NI, special efforts will be required to ensure that the individuals actually use all their senses with hands-on experience of nature rather than just seeing a natural area, listening to talks, demonstrations, presentations or through taking photographs. Walking through a natural area, touching, smelling different things on the way, camping, building and maintaining a compost pit provide an enriching sensory experience.

In the past, elements of nature could be easily experienced in immediate surroundings even in a city. Most cities had hills, gardens, wetlands and parks which were easily accessible and safe for exploring. With growing urbanization, many of the natural elements are lost or are inaccessible. Public gardens are limited to a few cities and are changing towards visually appealing gardens rather than stimulating senses. In most gardens, wading in pools, touching or cutting flowers, digging in the sand is not allowed or is frowned upon by parents or garden authorities. Zoos are good places to see wild animals, but cannot

allow hands-on experience of wild animals. These rules are required for safety of the plants and animals but they do deprive visitors from sensory stimuli. The exposure to nature is definitely much more in rural areas as compared to city. But considering the rapid urbanization of villages, it is possible that rural population is also deprived or will be deprived of nature experience, unless actually engaged in farming, livestock rearing etc.

Developing and/or maintaining public wilderness areas such as town forests, riversides, natural ponds, wild gardens etc. are some actions that society can take for nurturing Naturalistic Intelligence in the citizens.

b. those providing information about diversity of natural elements

Formal school curricula of state and central boards include biology and environmental sciences. Since 2003, Environment Education has also become a compulsory subject at undergraduate level for all faculties. Both include information about flora, fauna and natural phenomena, but mainly as text or figures. Teaching of these subjects in class does not require actually engaging with natural objects/phenomenon and using various senses. Biology teaching in school and college includes detailed information about plants and animals, but it needs to be accompanied by practical lessons in interacting with the species in natural state, not only in laboratories. Knowing the characters of a taxon (for ex. An insect/ plants) from text is possible but inadequate for being able to actually identify it. A naturalist is not only required to learn and apply whatever is already documented, but to detect new patterns and linkages. For this s/he requires opportunities to explore natural objects and formulate her /his own concepts and patterns.

Information on nature is now easily available through books, TV, Films and Internet. But it is entirely targeted at visual and auditory senses. The other senses described, emphasized by naturalists, are not used while gaining information on nature from media alone. Outdoor exposure through visits to parks, field trips to diverse natural areas are by far the best way of experiencing nature, especially so if it includes opportunities to explore nature through multiple senses.

c. those encouraging organization of information

Organizing observed information is an important part of developing NI. Keeping a field diary, notes, recordings, sharing and comparing with observations of others, conducting experiments, developing projects are also important part of NI nurture. Observing and drawing natural objects can be taken up as part of recording.

In the table 5 we have listed different activities that can be part of NI nurturing at home and school. But maintaining natural areas which allow outdoor activities is equally important and needs to be ensured by nature-aware society. These expand on suggestions by Hammerman (2006) and Armstrong (2009). Though divided into three groups the activities have many overlapping features.

NI and environmental conservation

Morris (2004) had criticized Gardener's idea of naturalistic intelligence and had argued that considering large scale environmental degradation, sensitivity (rather than intelligence) towards environment is required. Tirri and Nokelainen (2008) included "Environmental intelligence" in their Multiple Intelligences Profiling Questionnaire rather than Naturalistic Intelligence. They based this on Environmental Sensitivity Scale (EnSS) influenced by the work of Gardner (1999), Morris (2004) and Wilson (1998). It included following three categories: 1) Love for nature; 2) Nature conservation; 3) Environment-friendly consumer habits.

These are different objectives than the nurture of NI. Gardener and Moran (2006) have clearly asserted that naturalist intelligence does not include empathy for natural things. They consider empathy as an emotional capacity whereas NI is an information processing capacity. Thus, individuals may have high NI, but not have sensitivity towards nature or participate in nature conservation and vice versa. For ex. a plant or animal taxonomist may not wish to involve in conserving plant or animal species. Animal or plant collection, taxidermy are integral part of natural science studies but are considered environmentally unfriendly and insensitive by many.

Nature conservation requires much information from natural science fields, and hence nurturing NI will indirectly help in conservation. However, for involving naturalists in nature conservation, NI enhancing activities need to be coupled with those that create empathy and sensitivity towards nature. Recent studies by Priyankara and Fan (2017) indicate that NI can be a predictor of eco-initiatives, eco-civic engagement in managers and executives of an industry. Further research can focus on assessment of NI and Environmental Sensitivity as separate but linked factors. The insights from these studies can provide valuable help in developing a nature sensitive society.

Table 5 : Activities to encourage nurture of NI

	Exploring with senses	Collecting information on nature	Organizing information through projects
Home	Free play with natural objects (mud, soil, grains, leaves etc.) Kitchen exploration Interacting with pets	Collections of various objects Exposure to books, media on natural science	Raising caterpillars, butterflies, maintaining garden, terrarium or aquarium Cooking, experimenting with different food items Making photo-video documentation
Schools	Use of sensorial exercises Making smelling boxes, sets of ringing bells/chimes Exploratory for natural textures, smells. (ex. collection of natural perfumes/ ittar bottles, collections of different fabrics etc.).	Collective learning- seed/leaf collections, School fieldtrips to different habitats in different seasons, visit to bioscience laboratories, interactions with biologists Use of TV, Internet, Films etc.	Developing school garden, pet section Using microscopes, binoculars, telescope leaf/ seed rangoli, jewellery making, nature poetry, reading nature literature, nature quests Project activity such as monitoring biodiversity, seasonal changes etc.
Outdoor	Development of sensory gardens (garden of fragrant flowers, food plants, aromatic plants and butterfly gardens, etc.) Experiencing of public natural spaces, wilderness areas, natural ponds, natural riverb anks, etc. Nature camps with hands-on activities	Nature information centres Visit to different ecosystems Botanical gardens, zoos, etc. Interactions with expert naturalists	Working in animal rescue centres, Community farms, gardens, nature parks and butterfly gardens Experience in natural science projects Report writing and scientific documentation exercises

Finally, it is the responsibility all, citizens, civil society organizations, schools and government agencies to ensure natural as well as social environment that encourages nurture of Naturalistic Intelligence.

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Article

Assessment of Restoration Potential in the Catchments of Pavana, Chaskaman and Dimbhe Dams in Northern Western Ghats

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Abstract

Dam catchment regions in Western Ghats, a biodiversity hotspot, have special significance for its ecology and sustainable development. As a part of the Western Ghats mountain range, they host unique biodiversity that needs to be conserved. The study area viz. Pavana, Chaskaman and Dimbhe catchments are part of the Northern Western Ghats. These dams have been built on rivers that supply water to several large cities and to a large part of Maharashtra's agriculture in the Deccan Plateau. Conserving forest cover in these regions has a direct impact on water security. Considering the above factors the study of land use and vegetation was conducted in the catchments of Pavana, Chaskaman and Dimbhe. This study involved classification and identification of land use classes supported by ground truthing in the catchment areas.

For areas having degraded vegetation cover, the recommended approach was ecological restoration (Gole, 1990) (Gole, 2007). Based on this study we developed and tested a method to compare relative restoration potential and prioritization across multiple dam catchments. Restoration guidelines, both general and catchment-specific, were developed to guide an implementation program.

Background and Scope of the Study

In the years 2014-15, Global Forest Watch, under its Small Grants Program provided an opportunity to the Ecological Society, Pune, India to perform ecological surveys and assess the restoration potential in Northern Western Ghats at select dam catchments Pavana, Chaskaman and Dimbhe (Ecological Society, 2014).

These catchments are characterised by changes in land use after the construction of dams. The reasons for land use changes are as follows :

1. Ring-roads built around the dam catchment, resulting in housing development for urbanites
2. Displacement of villages on the valley floor due to the reservoir, resulting in re-settlement on upper slopes, shifting cultivation, etc. (Gole, 1985)
3. Modern and more intense agriculture
4. Quarrying, various small-scale industries, hotels and spa development, hill stations, townships, all followed by further road construction (Ecological Society, 2014).

The above activities have resulted in loss of forest cover and other forms of degradation of natural vegetation. Development, especially roads through the forest, has resulted in fragmentation of forest areas which are essential for the movement of the biodiversity.

Northern Western Ghats are the source region of

major rivers like Krishna, Bhima, and Godavari. Hence water security of Maharashtra and other states like Karnataka, Andhra Pradesh and Telangana depends on the Western Ghats.

Due to the above reasons and their criticality, large-scale conservation and ecological restoration of Northern Western Ghats has become absolutely necessary.

Objectives

This article documents the results of our study of natural vegetation cover, land use and ecological status of the catchment areas of three dams in the Western Ghats. The methodology employed was to classify the natural vegetation cover and assess the human use of land. The ecological status of the classified natural vegetation cover areas was evaluated to ascertain their restoration potential. The study area was the catchment areas of Pavana, Chaskaman and Dimbhe dams which lie on the eastern side of the Western Ghats, in Pune district.

The "Western Ghats" region is not only globally important for its biodiversity but locally it harbours very special biodiversity. However now it is developing fast and large areas within the region are being converted to second homes and farm houses. Modern poly-house agriculture is also practiced to a large extent. All these changes cause degradation of natural vegetation. As major rivers Krishna, Koyana, Bhima, etc. originate in Western Ghats, it is important to conserve their source region for water security. Restoration of the forests and other natural vegetation types holds an enormous potential for the revival of these rivers. Importance of restoration in the conservation of these areas is explained by Prof. Prakash Gole. In his book, 'The Restoration of Nature', he has highlighted why ecological restoration should receive a strategic importance :

"Can natural eco-systems ever be restored to their original form and functions? The answer appears to be a resounding 'no'. Yet 'Restoration', i.e. restoring eco-systems to viable forms and functions is undoubtedly important today."

"Restoration of degraded eco-systems to a viable form and substance should therefore, receive the highest priority in any plan of economic and social development. Unfortunately its importance and urgency are not recognized by anyone in India."

In this article, we also provide guidelines/recommendations that could be useful in restoration planning in the Northern Western Ghats. These recommendations can also be useful for researchers and restoration practitioners in the Western Ghats in general and dam catchments in particular. Finally, we aimed to develop a method for selecting restoration candidates by prioritizing and choosing from multiple such catchments.

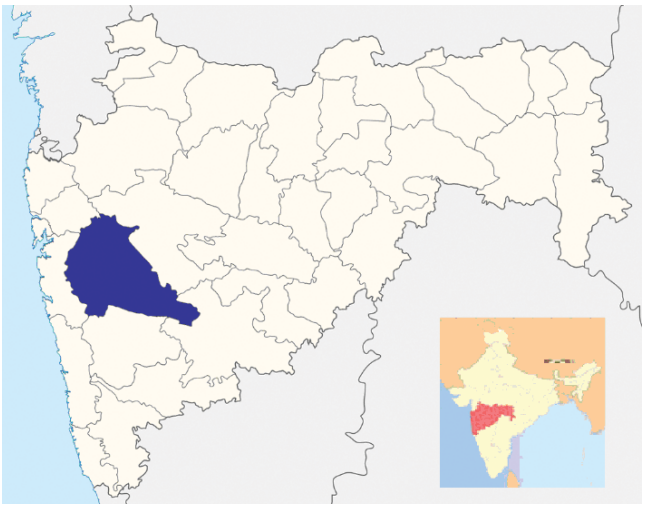

Figure 1 : Location map of the state of Maharashtra and Pune district

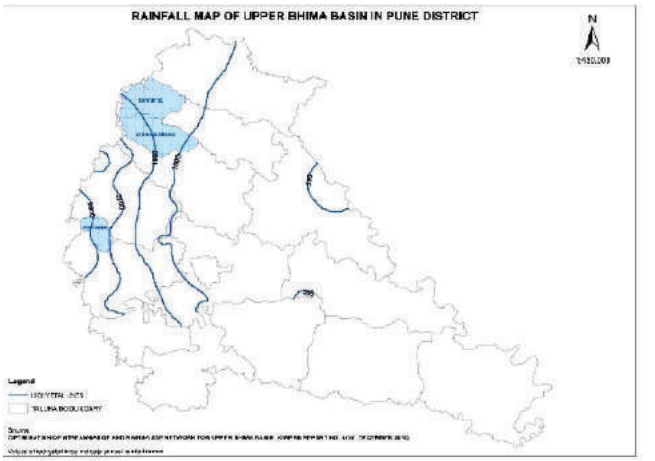

Figure 2 : Position of the three catchments.

Dimbhe Dam Catchment *Tehsil Ambegaon, District Pune, Lat-Long: 19º 6'38.08"N, 73º43'28.68"E*
Chaskaman Dam Catchment *Tehsil Khed, District Pune, Lat-Long: 18º58'36.75"N, 73º45'25.05"E*
Pavana Dam Catchment *Tehsil Maval, District Pune, Lat-Long: 18º40'14.44"N, 73º29'28.99"E*

Table 1 : Key details of the catchments of Pavana, Chaskaman, and Dimbhe(WRIS, 2018)(CWPRS, 2010)

	Pavana	Chaskaman	Dimbhe
River	Pavana	Bhima	Ghod
District	Pune	Pune	Pune
Tehsil	Maval	Khed	Ambegaon
Nearest City	Lonavala	Khed	Khed
Completion Year	1972	1999	2000
Purpose	Hydroelectric, Irrigation	Hydroelectric, Irrigation	Hydroelectric, Irrigation
Villages resettled due to the dam	17	28	13
Catchment Area (Sq. km)	115.03	308.88	277.43
Temperature	Pune District: 20 to 42° C (Summer), 8 to 32° C (Winter)		
Rainfall Zones	I II III IV V	I II III IV V	I II III IV V
Rainfall (mm)	Greater than 2500	Between 1500 and 2000	Between 1500 and 2000
	Between 2000 and 2500	Between 1000 and 1500	Between 1000 and 1500
	Between 1500 to 2000	Between 500 and 1000	
Seismic Zone	III	III	III
Drainage Density	2.947/ km	3.177 / km	2.981/ km
Order of Main Streams	4^{th} and 5^{th}	5^{th} and 6^{th}	5^{th} and 6^{th}
# villages and towns	32 villages	80 villages and 2 towns	80 villages
Population in catchment (Population data : Census 2011)	9647 across 1721 households in 21 villages where data is available	< est. 25000, across the 21 villages where data is available	10425 across the 20 villages where data is available

Note : The maps with rainfall zones, drainage map, and drainage density calculations for each catchment are given as part of online supplementary data.

Study Process

The study area i.e. the three catchments lie in the north and west of Pune district (Figure 1 and 2). Table 1 provides the key details for the three catchments.

For the selected three dam catchments, we performed the following process :

1. Satellite images were obtained and the dam catchment region was marked for study with the help of topographic sheets.
2. With the help of a GIS consultant and assigning vegetation class signatures, a mapping of the dam catchment by vegetation class and land-usewas prepared (software: ArcGIS).
3. Field trips of the dam catchments were conducted to do ground truthing of vegetation classes.
4. Restoration potential was estimated and restoration guidelines are provided across dam catchments and specific to dam catchments.
5. Developed a method to prioritize and select when one has to choose from multiple such catchments.

As part of Step 4 above, we also developed a general-purpose restoration framework and detailed guidelines for restoration in the Western Ghats. This article mainly summarizes work done in Steps 1-3 and 5 with key results from step 4.

Physical and social character of catchments

Pavana

The physical character of the Pavana catchment shows steep slopes and narrow valleys near the crest line of the Sahyadri (Northern Western Ghats). The high drainage density indicates landscape made up of innumerable small sub-basins. The nature of the landscape is young, immature, and dissected.

The valley becomes broad in its middle and lower part. Basalt is the major underlying rock. The soil near the crest-line where heavy rainfall occurs is red while the soil in the valley is typical black cotton soil with silt- loam texture.

The Pavana dam catchment is located close to the cities of Pune, Lonavala and Mumbai. Its natural beauty and proximity to cities make it a favourite location for second homes of urbanites. The hills in the catchment are dotted with such farm-house development projects.

The forest patches are seen on the hill tops of the catchment however they are rapidly getting degraded due to residential construction. Junnar Division Working Plan of the Maharashtra Forest Department mentions that "Various detrimental agencies like fire, grazing, illicit cutting, encroachments, poaching etc. have a deleterious effect on the health and growth of the forest." (Gov. of Maharashtra, Forest Department, 2006)

In the valley, agriculture is predominant. Shifting cultivation, though on a small scale, is still practised on the hill slopes. Deviation from the traditional agriculture in the form of floriculture in poly-houses occupies a significant area.

This is not a densely populated area. Looking at the number of farm-houses, it is likely that this area has a floating population from the near-by cities of Lonavala, Pune and Mumbai.

Chaskaman

Steep slopes and high drainage density makes the North–western parts of Chaskaman catchment more rugged. Southern slopes of Bhimashankar form part of the Chaskaman catchment. Therefore nature of the landscape is young, immature, and dissected in the upper part of the valley. The middle part of the valley is relatively broad as significant Arala tributary with its sub-catchment joins the river Ghod, creating a terrain more complex.

In the Chaskaman dam catchment, traditional agriculture is observed. It does have human-induced stresses like clearing of mature forest for agriculture on privately-owned area. In-stream agriculture is practiced all over the catchment. Diverting the streams and creating terraces for cultivation alters the character of the stream and the drainage pattern. Modern development is also insignificant.

In spite of hilly and dissected character of the catchment, the number of human settlements is considerably high.

Dimbhe

The River Ghod originates on the Bhimashankar plateau. Here the plateau is extremely rugged as it is criss-crossed by several deep gorges of River Ghod and its tributaries. Thus physiography of the upper part of the Dimbhe catchment is very complex. (See Figure 3 for representative cross-section of Dimbhe catchment)

Physiography in the middle and the lower part of

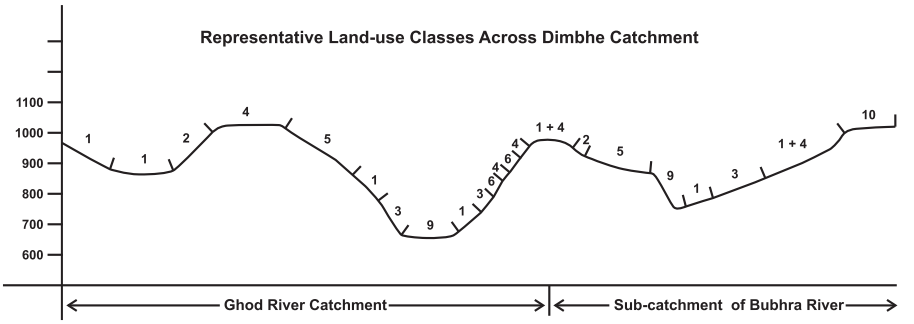

Figure 3 : Representative cross section of the Dimbhe catchment and the land use classes-
Y axis: Altitude in meters; Scale: 1 cm = 100 meters, X axis: Ground distance in meters Scale: 1 cm = 500 meters,
Index of land use/land classes: 1: Agriculture (Paddy), 2. Dense Shrubbery, 3. Plantation, 4. Scrub, 5. Mature Forest, 6. Cliff, 7. Reserved forest, 8. Agriculture - Shifting Cultivation patches, 9. River Channel, 10. Barren Land

the catchment is very similar to the upper part i.e. rugged because spurs from the crest of the Western Ghats extends right up to the dam wall.

The Dimbhe catchment has predominantly tribal population in the hilly part. The local population is engaged in agriculture but is also dependent on the forest produce. The forest quality is good since it is adjoining the Bhimashankar wildlife sanctuary. In the valley, the main activity is subsistence agriculture.

It is observed that Bhimashankar shrine has become very popular for religious tourism. This has resulted in commercial and modern development in the catchment area.

Methodology of the Study

We adopted the methodology developed during the previous experience of forest analysis, vegetation assessment, and ecological restoration in the Ecological Society's research project which is described below-

Reconnaissance Survey

A preliminary survey of the catchment area was done torelate to the wider landscape. The main objectives were to understand

- the physiography of the catchment : whether its major part is hilly or moderately hilly or has larger proportion of plains, nature of the slopes, etc.
- general assessment of the vegetation cover and forest type
- presence of Devrai (Sacred Groves) which could be used as a reference ecosystem
- water resources and their status (whether they areperennial) etc.
- general density of village settlements
- area under agriculture, type of agriculture
- any other major human interventions.

Acquisition of the Topo-sheets and Google Images

Topographical-maps for the dam catchments were obtained from the Survey of India. The catchment area was identified by taking into account the water-divide. It also helped us in understanding the character of the slope, drainage and extent of forest.

We used the Google image of the catchments along with the topographical-maps. Marking of the water divide to demarcate the dam catchment was a combination of GIS work and close manual observations of topographical-maps. The catchment boundaries delineated on the topographical-maps were superimposed on the Google image.

Mapping Process

The project team worked with a GIS consulting team for the actual mapping of the defined vegetation and land-use classes on the Google image, using ArcGIS software. This identification was done based on the team's domain expertise, observations from the reconnaissance survey, and past projects done by Ecological Society. On an average, each image comprised of about 3000 such polygons.

Polygons where there was *uncertain identification of vegetation* were added to a "Query List". These polygons were confirmed by ground truthing in the actual field. The landscape is represented as an assemblage of polygons of various vegetation and land-use classes.

Vegetation and Land Use Class Mapping

The landscape is a mosaic ofnatural vegetation, plantation, agriculture and interventions like roads, quarries, other constructions etc. (Figure 4) Due to various human interventions, the landscape is further fragmented. This landscapewas then classified as Vegetation/Land Cover classes which refers to natural vegetation types like grassland, canopy forest etc. whereas the Land Use class refers to anthropogenic use like agriculture, roads, and settlements. The Vegetation and Land Use Classes used in this study are defined below. A detailed description, satellite image, and sample photo of each class is available in online supplementary data.

- Mature Forest : The vegetation class, 'Mature Forest' is defined as the area characterized by old-growth forest. It has a good percentage of old-growth trees and lianas.
- Dense Shrubbery : The vegetation class 'Dense Shrubbery' is defined as the area that is mostly

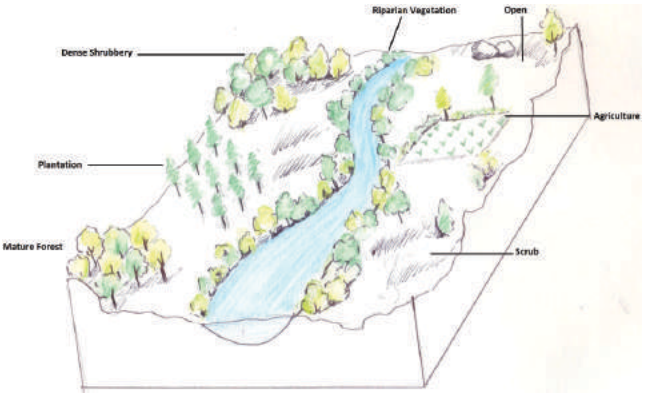

Figure 4 : Landscape as a mosaic of habitats

covered with shrubs. It may have some tall trees or some sporadic open patches.

- Scrub : 'Scrub' is an area dominated with grassy under-growth, inter-mixed with shrubby clusters and dwarf canopy trees.
- Open Land : Open land with exposed rock, vertical cliffs and rocky outcrops are included in this vegetation class. In this study, we also included grasslands in Open Land.
- Karvi : Many of the highersteep slopes in the catchments are covered with Karvi (*Strobilanthes callosus*). These are pure stands without any other tree species. They cover very steep slopes with shallow substratum where survival of any other vegetation is difficult. Therefore Karvi becomes a distinct vegetation class.
- Riparian Habitat : A River and stream bank with riparian vegetation is covered in this vegetation class.
- Agriculture/ Horticulture : The dominant feature in this human land use class is agriculture and horticulture.
- In-stream Agriculture : This is an agricultural practice in the feeder stream of the river. It may often change the natural drainage flow of streams.
- *Gaalper* (Agriculture on reservoir bank) : When the water level in the dam reservoir recedes, the land on the reservoir bank is exposed where agriculture is practiced.
- Plantation : Many times plantation is a monoculture and that too of non-native. It is manmade hence marked as a human land use class and not included under natural vegetation.
- Village Settlement : It is a village/hamlet with residential area. It may have housing built with traditional material and architecture or it may have modern housing.
- Modern Development : Any construction like greenhouse, farmhouse built using modern materials and architecture, windmills, industry, multistory buildings, business establishments like hotels, Resorts, were all categorized as Modern Development.
- Road : Only the tar/concrete roads were considered under this class.
- Quarry : Any quarry, whether working or abandoned, was considered under this class.

Socio-economic conditions

As a foundation for restoration planning, a detailed socio-economic analysis of the region is essential i.e. the people residing in the area, their resource needs, the local economy and its integration with the national economy, and fulfilment of their needs through local natural resources. Secondary data collected on socio-economic conditions is being analyzed separately and not covered in this article.

Management information from government agencies

A major stakeholder is the government, i.e. departments like Forest Department, Department of Social Forestry and Water Resources Department (formerly, the irrigation department). To find out their land use and utilization and management of natural resources in the catchment, the project team visited the respective departments and got an understanding of their policies and working.

Forest resources of these catchments are managed by the Forest Department. Its role is to protect, conserve and enhance the forest resource. Pavana and Dimbhe contain a significant area under forest department's ownership (~21% and ~16% respectively per our estimates), while Chaskaman has relatively less area under forest department (estimated to be around 5-6%).

Forests are cut mainly for timber and fire-wood by local people. The department of Social Forestry came into existence to help locals and fulfil their needs by energy plantation on their own land, thereby reducing stress on the government-owned forest. This Department does not own any land by itself. Methods of operation of Social Forestry Department are summarized in online supplementary data.

The Water Resource Department is another major stakeholder as water resources from the catchment area are managed by this department by storing water behind the dam and redistributing it through canals.

To better understand the government stakeholders, the following were studied :

- 10-year working plans by the Forest Department for Junnar division (2004-05 to 2013-14) and Pune division (2012-13 to 2021-22). (Gov. of Maharashtra, Forest Department, 2006), (Gov. of Maharashtra, Forest Department, 2011)
- Various schemes by the department of Social Forestry
- The detailed draft plan for the Upper Bhima basin by the Water Resources Department (Gov. of Maharashtra, Water Resources Department, (n.d.).)

We tried to relate the secondary data from the Forest Department and Water Resource Department to understand resource distribution among local communities and people outside the catchment.

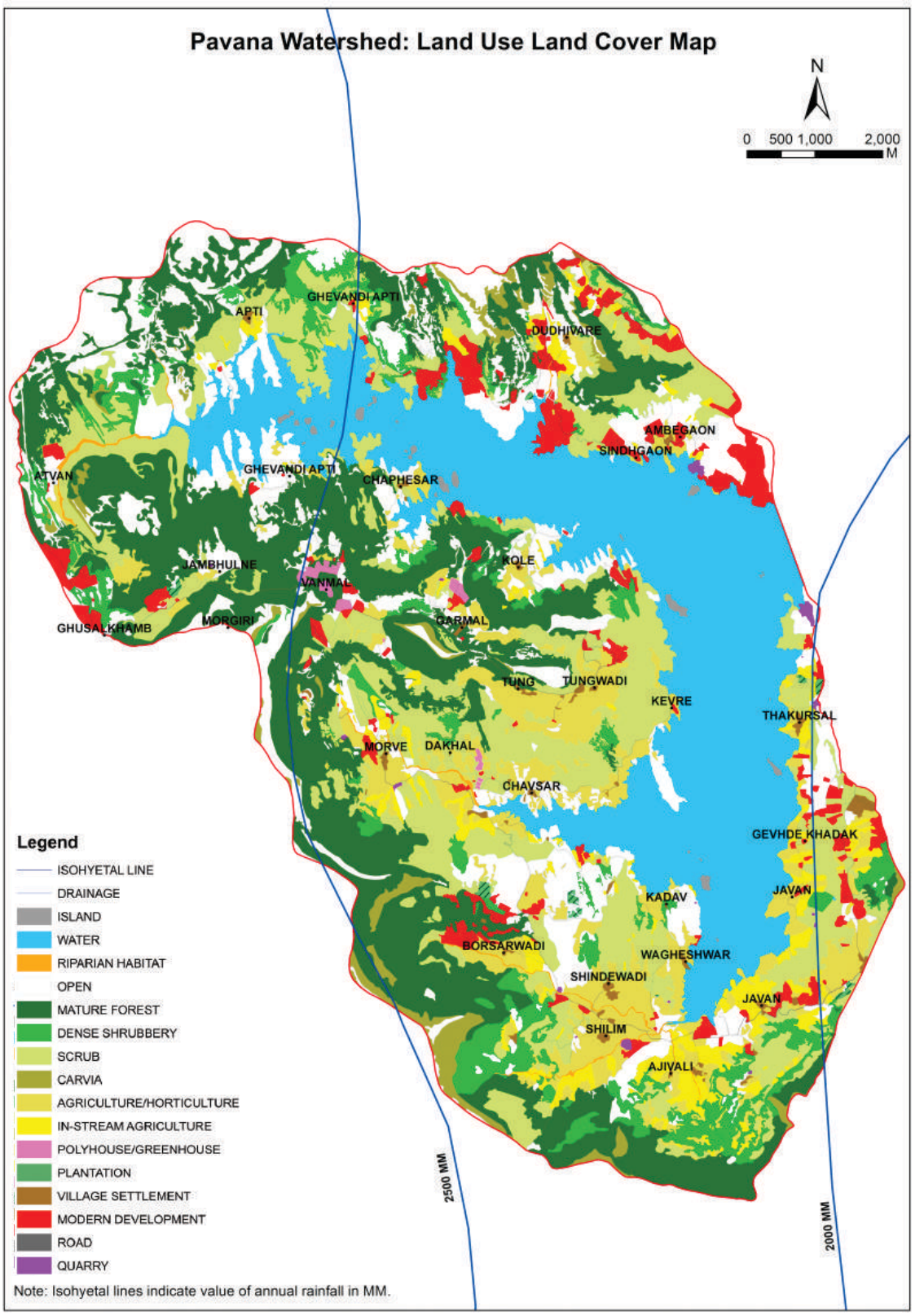

Figure 5 : Pavana Catchment : Vegetation and Land Use Map

Results

The analysis and interpretation of the Land-use classes in each catchment is given below.

Pavana : Vegetation classes and Composition

Figure 5 shows the vegetation and land use map of Pavana catchment. Table 2 shows area statement by vegetation and landuse and Table 3 shows vegetation composition.

Pavana : Observations and Comments

- The western part of the catchment, near crest-line, has high rainfall (2500 mm). Semi-evergreen forest is observed in this area having composition of *Memecylon-Actinodaphane-Syzygium* associated with *Olea dioica, Atlantia racemosa, Glochidion ellpticum,* etc.
- Moist deciduous type of forest was observed in the zone with the rainfall between 1500 mm and 2500 mm which includes *Terminalia sps.-Bombax ceiba, Ficus racemosa*, associated with *Meyna laxiflora, Albizzia chinensis,* etc.
- Mature Forest is mainly observed at the mountain tops, base of vertical cliffs, slopes and ravines, near the crest-line.
- In zone III, with rainfall less than 1500 mm, dry deciduous forest type was observed with *Acacia sps., Bombax ceiba, Boswellia serrata, Cassine glauca,* etc.
- A Sacred Grove is present at the base of Fort Tung (18º 39.862" N, 73º 27.447" E) and is named after the goddess Waghjai. Its area is 0.34 acres. It is surrounded by agricultural land. Dense patch of unique vegetation of *Pandanus sp.* is an indicator of high ground water level which was validated by the flowing perennial well. Old growth trees like *Caryota urens, Syzygium cuminii, Mangifera indica, Olea dioica, Ficus racemosa, Atlantia racemosa* associated with climbers like *Elaeagnus conferta, Dalbergia horrida, Tylophora dalzelii, Jasminum malabaricum* are found in this sacred grove.
- The Pavana catchment also consists of a few more sacred groves. The Ajivali sacred grove is a known example for its commercial management by local community.
- The Pavana catchment has lot of modern development, having resorts, farm houses and spas. Road construction through thick forest near village Dudhivare pass has fragmented the forest, and resulted in soil erosion. (Figure 6)
- Dwarf canopy forests with composition of *Memecylon-Syzygium-Actinodaphane* associated with *Canthium dicoccum, Careya arborea, Macaranga peltata,* etc. which is a typical montane forest composition near the crest line was also observed in Pavana catchment.
- Dense Shrubbery was observed with intermittent trees on gradual slopes found in all rainfall zones. As the rainfall zone changes, tree species in the dense shrubbery also changes. E.g. *Memecylon, Actinodaphane* in high rainfall zone area and *Terminalia, Bombax* in low and medium rainfall zone.
- At places Karvi patches dotted with trees like *Olea dioica, Memecylon umbellatum* near crest-line were observed on the steep slopes.
- Abundant shifting cultivation patches with good shrubby growth were observed on the higher slopes.
- In dwarf canopy forest, the composition is more or less similar to dense shrubbery with increased tree density.
- Dense shrubbery patches are termed as regenerating patches because vegetation structure is in regenerating state due to presence of root stocks. These areas have a good potential for restoration as these are moderately degraded areas compared to scrublands
- Observed intermittent coppiced trees of *Dillenia pentagyna, Terminalia elliptica, Syzygium cuminii, Carrisa congesta* in land patches used for *Rab* (It is an age-old practice in which farmers burn the piece of land before cultivation). Farmers also cut standing trees on the plot where they want to cultivate. These patches indicate earlier canopy forest.

Figure 6 : Example of soil erosion

Table 2 : Pavana Catchment : Area Statement as per Vegetation and Land Use

Vegetation and Land Use Class	Area under the each Class (sq. km)	Percentage Area w.r.t. Total Catchment Area (%)
Mature Forest	25.337	22.02
Dense Shrubbery	7.000	6.08
Scrub	18.807	16.34
Open Land	17.634	15.33
Karvi	2.096	1.82
Riparian Habitat	0.329	0.28
Islands	0.282	0.24
Waterbody	23.993	20.85
Agriculture/ Horticulture	9.794	8.51
In-Stream Agriculture	3.602	3.13
Plantation	0.182	0.15
Village Settlement	0.551	0.47
Modern Development	4.468	4.1
Road	0.556	0.48
Quarry	0.145	0.12
Total Area	**115.03**	**100**

- Scrub vegetation includes woody, hard, thorny vegetation along with weeds like *Lantana camara* and indicates significant degradation. This class was observed throughout the catchment especially near settlements and lower slopes near valley floor and near the main water-body.
- Areas recently created for shifting cultivation are very similar to scrub areas.
- Scrubland supports pioneer species of flora and fauna i.e. habitat-generalist species. Excessive cutting of trees for fuel wood, grazing, and fire may lead these areas towards more and more degradation. Protection, management and restoration is required to improve its ecological value.
- Open area is observed at places like mountain tops, vertical cliffs, exposed rocky area, rocky plateaus and is scattered throughout the catchment.
- Land use in the open areas is related to soil cover. Open areas with good soil cover are used for cultivation by the locals while open areas with shallow soil are used for grazing. At places we observed quarries indicating degradation of landscape.
- Open land bordering the main water body is barren and does not support any vegetation because these areas are submerged for a long period of time during the year.
- Vertical cliffs support lithophytic vegetation with high desiccation tolerance to withstand harsh conditions.
- Part of the Open vegetation class, **Rocky Outcrops** are a special habitat in the Northern Western Ghats. They support habitat specific flora and fauna with many endemic, rare and endangered species and provide refuge to small as well as medium animals in harsh weather. The rocky outcrops have high biological value. However, they are treated as wasteland due to lack of knowledge and poor scientific understanding. Many of them are being made open for development, which is a serious threat.
- Practice of *Gaalper* agriculture is common when water recedes during non-rainy season.
- Steep scree-covered slopes, often just below the

Table 3 : Pavana Catchment : Vegetation Classes and Composition

Vegetation class	Species Composition
Mature forest	**Semi evergreen :** *Memecylon-Actinodaphane-Syzygium* associated with *Olea dioica, Ficus racemosa, Atlantia racemosa, Terminalia chebula,* etc. with understorey of trees like *Meyna laxiflora, Macaranga peltata, Callicarpa tomentosa, Glochidion ellipticum* and *Mallotus philippensis,* etc. The ground flora includes *Asystasia dalzellina, Desmodium triquetrum,* etc.
	Moist deciduous : *Terminalia tomentosa- Bombax ceiba - Ficus racemosa* associated with trees like *Bridelia retusa, Careya arborea, Albizzia chinensis, Wrightia tinctoria, Garuga pinnata, Emblica officinalis, Grewia tiliifolia, Meyna laxiflora, Kydia calycina, Dillenia pentagyna* and climbers like *Elaeagnus conferta, Jasminum malabaricum, Stephania japonica, Cocculus hirsutus, Dalbergia horrida,* etc.
	Deciduous forest : *Terminalia bellirica, Acacia chundra, Acacia ferruginea, Lannea coromandelica, Bombax ceiba, Boswellia serrata, Cassine gluca, Bauhinia racemosa, Woodfordia fruiticosa, Clerodendrum serratum, Asparagus racemosus,* etc.
Dense shrubbery	*Carrissa congesta, Gnidia gluca, Lantana camara, Woodfordia fruticosa, Casearia graveolens, Pavetta crassicaulis, Holarrhena pubescens, Leea indica, Pogostemon benghalensis, Calotropis gigantea, Strobilanthes callosa* with intermittent trees like *Terminalia elliptica, Bridelia retusa, Flacourtia indica, Bombax ceiba, Syzygium cuminii, Ficus hispida, Emblica officinalis, Wrightia tinctoria, Memecylon umbellatum,* etc. **Dwarf canopy forests** with composition of *Memecylon-Syzygium-Actinodaphne* associated with *Canthium dicoccum, Careya arborea, Macaranga peltata, Xantolis tomentosa,* etc.
Scrub	*Themeda quadrivalis, Apluda mutica, Heteropogon contortus* intermixed with clusters of *Lantana camara, Carrisa congesta, Woodfordia fruticosa, Gnidia gluca, Calotropis gigantea, Euphorbia nerifolia*. The clusters also included dwarf trees like *Bombax ceiba, Meyna laxifora, Terminalia elliptica, Syzygium cuminii, Grewia tillifolia*
Open area	Typical rocky plateaus during monsoon become green with herbaceous vegetation; species like *Utricularia, Eirocaulon, Smithia, Impatiens, Crotalaria, Indigofera, Swertia minor, Sopubiadelphinifolia* decorate these rocky plateaus. Orchids like *Habenaria grandifloriformis* observed associated in grassy patches associated with *Heteropogon contortus, Themeda, Apluda, Andropogon* and shrubby clusters of *Carrisa congesta, Gnidia gluaca, Meyna laxiflora,* etc. Vertical cliffs supports typical vegetation of species like *Ensete superbum* (Wild Banana), *Ficus arnottiana, Hymeodyction obovatum, Tripogon lisboe, Euphorbia ligularia,* etc.
Karvi	*Strobilanthes callosa, Strobilanthes reticulata* are associated with climbers like *Dioscorea spp, Tylophora dalzelii,* etc.
Riparian	*Ficus racemosa, Syzygium cumini, Pongamia pinnata, Syzygium zeylanicum, Homonoia riparia* along with other terrestrial species like *Bombax ceiba, Lannea coromandellica, Xantolis tomentosa,* Cyperaceae members and some grasses like *Saccharum spontaneaum,* herbs and shrubs like *Ludwigia octovalvis, Phyllanthus reticulatus,* etc.
Plantation	*Gliricidia sepium, Eucalyptus globules, Leucaena latisiliqua, Casuarina equisetifolia, Acacia auriculiformis, Cocos nucifera*

cliffs, support Karvi vegetation. On such steep slopes, usually nothing other than Karvi grows.

- Karvi patches were also observed on steep and moderate slopes of the historic forts Tung, Tikona and Lohagad. A few patches were observed along the road and near crest-line. e.g. Lions Point at Lonavala.
- Though the area under Karvi is not significant, it needs to be protected since it plays a major role in preventing soil erosion on the slopes and provides a habitat for wild fauna. This function is especially important in dam catchments, since soil erosion causes siltation of the dam reservoirs.
- Karvi stems are used by local people for building houses and agricultural and also in 'Rab' practices. Thus, managing its extraction in a sustainable way is recommended and this is a challenge in management in the catchment.
- The riparian species composition is special because these species tolerate water level changes. The species mentioned in composition are found in most riparian habitats in Western Ghats and also found in the catchments in this study.
- Riparian vegetation is precious and must be maintained and protected. Its ecological value is very high for reasons below :
  - It creates additional habitat diversity and adds to the mosaic of habitats in the landscape.
  - It acts as an interface between the river/ stream and land.
  - It filters the sediments and thus reduces the sediment load in the river. It can control rate of siltation in dam reservoirs.
  - Riparian areas with good vegetation serve as corridors for movements of materials and organism and work as breeding grounds of many faunal species.
  - It also helps to maintain micro climate and in reducing bank erosion.
  - This habitat needs to be protected, restored and enhanced with proper methods.
- Considering the entire catchment, the area under plantation is not significant in percentage. It is especially found near modern development and open areas. Species like Subabhul and *Gliricidia* have traditionally been preferred in plantations in W. Ghats in spite of being exotic. Indigenous species are recommended for plantation for ecological integrity.
- Area under modern development is 4.1% which includes farm-houses (individual plots and schemes), polyhouses, etc. This area, due to its proximity to the cities like Pune, Mumbai and Lonavala is a favourite place for a 'second home' for the city-dwellers. Another activity of modern agriculture is floriculture in polyhouses. The spread of polyhouses is significant. (Figure 7)
- We saw some abandoned stone quarries in the catchment. e.g. near Thakursai village adjacent to the dam wall. In the quarries, there is no substratum, but completely exposed rock. Such areas are difficult to restore ecologically as there is no soil left. However such areas, if protected and restored, will provide refuge to a variety of biodiversity. (Figure 8) (Bradshaw et. al., 1980)

Chaskaman **:** *Vegetation Classes and Composition*

Figure 9 shows the vegetation and land use map of Chaskaman catchment. Table 4 shows area statement by vegetation and landuse and Table 5 shows vegetation composition.

Chaskaman : Observations and Comments

- Natural vegetation classes comprise of 60.68% of the total catchment area.
- The area under open land and scrub land together is above 35% indicating long-term degradation.
- Part of the Bhimashankar wildlife sanctuary is in this catchment. Mature forest is observed only near Bhimashankar, Nigdale and Bhorgiri area.
- Evergreen forest was observed at Guptbhima and near the Forest Department's rest-house area of Bhimashankar Wildlife Sanctuary. Protection and less human disturbance will ensure conservation of this good forest cover.
- As rainfall decreases from the west to the east, vegetation composition accordingly changes from evergreen species to semi evergreen and moist deciduous.
- The Bhimashankar Wildlife Sanctuary is protected for the Malabar Giant Squirrel (Shekaru), i.e. *Ratufa indica* which is a keystone species and endemic to the Western Ghats.
- On the way to Taleghar from Bhorgiri, observed newly created agricultural plots by clearing of good vegetation cover on Forest Department land.
- All the mature forest is mostly found in protected area, near crest-line.
- There are many open areas adjacent to the mature forest patches. On inquiry, we found out that they are privately owned. Owners may purposely clear forest on their land to assert their right on that land and to practice agriculture there. Such instances are highly detrimental to natural forests.

Figure 7 : Road building for modern development

Figure 8 : Stone quarries

- The surrounding area of Kalmodi has tribal settlements. This area has rolling hill slopes with flat mountain tops. This area should support moist deciduous forest. But most of the area is highly degraded and barren. This might be due to shifting cultivation, exploitation of forest for timber, firewood and grazing etc.
- Scrub areas in Chaskaman catchment is mostly observed near dam wall and near settlements.
- There is no specific composition of species in open area, but observed the following :
  - *Euphorbia sp.* (Nivdung) appearing in open patches, associated with woody and hardy vegetationindicating xerophitic condition.
  - Rocky outcrops : Many of the open land habitat are rocky outcrops. They have specific vegetation during monsoon.
  - At places there is dominant grassy vegetation dotted with clusters of stunted trees, shrubs, herbs and climbers.
- This study observed cattle tracks on the hill slopes. The extent of the cattle tracks indicated intensive grazing. The rainfall in this area indicates it should have a good forest cover but this is not seen, leading to the conclusion that the area is overgrazed.
- Karvi patches were observed at the end of the catchment near Bhorgiri.
- High altitude, high rainfall, steep slopes and rubble strata support Karvi vegetation.
- Though small in percentage, Karvi is very important in reducing soil erosion on the slopes. This function is especially important in dam catchments, since soil erosion causes siltation of the dam reservoirs.
- Teak (*Tectona grandis*) is the most widely planted species in the catchment.
- From the Dam wall, we observed Teak plantation till the village Mandoshi, which formed the dominant floral feature in the landscape. Such plantation is done on forest department land as well as on private lands through Social Forestry initiative. Hence, natural vegetation could be observed from Mandoshi onwards in the western part of the catchment.
- Nilgiri plantation was also observed near Dehane village.
- Modern development has not yet emerged as a significant threat to the landscape, but this may change in future. At a few places, we saw roads being constructed right on the hill for proposed projects. (Figure 10)

Dimbhe : Vegetation Classes and Composition

Figure 11 shows the vegetation and land use map of Dimbhe catchment. Table 6 shows areastatement by vegetation and landuse and Table 7 shows vegetation composition.

Dimbhe : Observations and comments

- Natural vegetation classes comprises of 64.96% of the total catchment area.
- Mature forest is higher as compared to Chaskaman in Dimbhe
- Open area is maximum (19.39%) of all the vegetation classes indicating high level of degradation.
- The area occupied by plantation is significantly low.

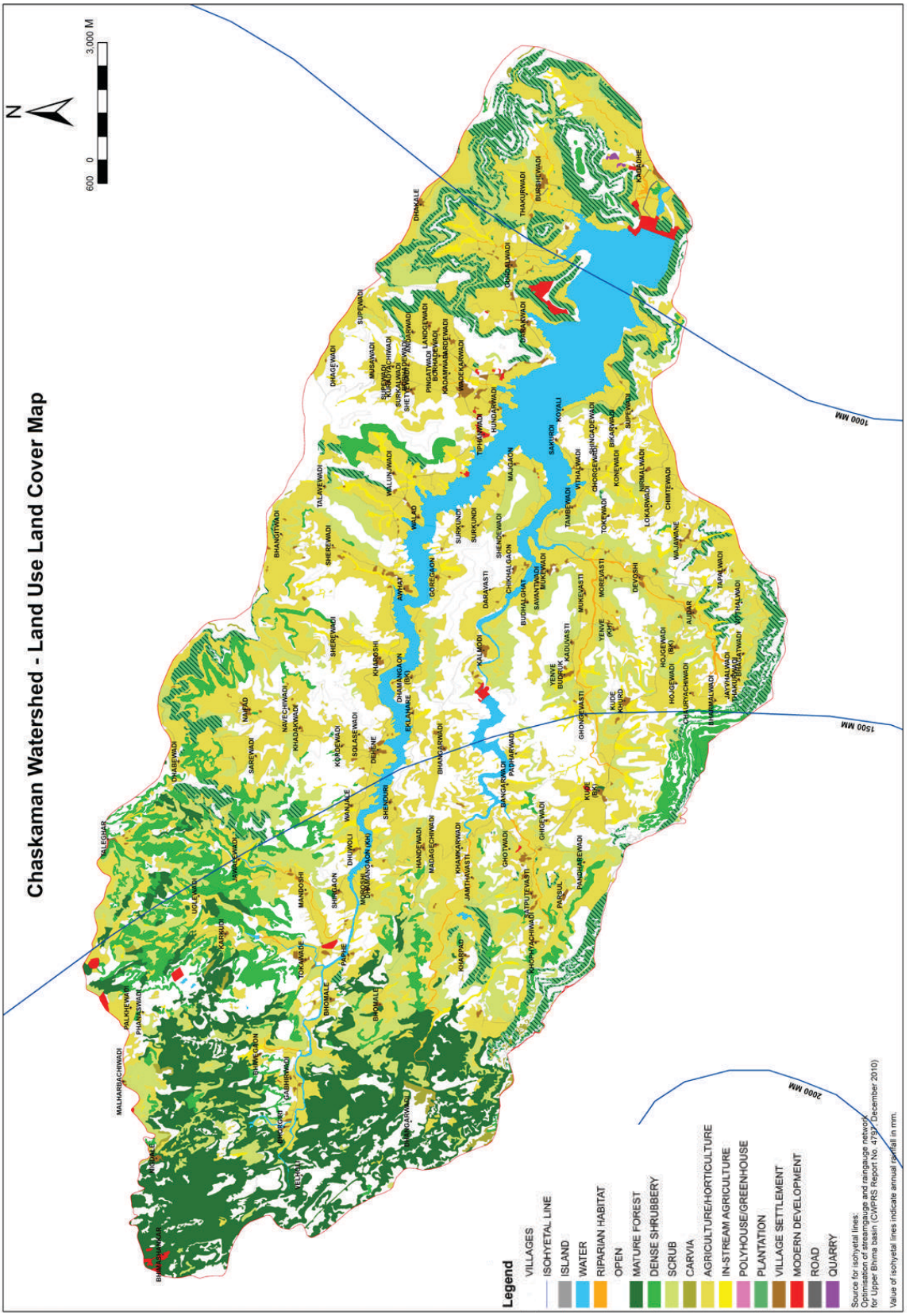

Figure 9 : Chaskaman Catchment : Vegetation and Land Use Map

Table 4 : Chaskaman Catchment : Area Statement as per Vegetation and Land Use

Vegetation and Land Use Class	Area under each Class (sq. km)	Percentage Area w.r.t. Total Catchment Area (%)
Mature Forest	29.947	9.69
Dense Shrubbery	17.716	5.76
Scrub	37.300	12.07
Open	81.083	26.25
Karvi	0.820	0.265
Riparian Habitat	1.149	0.37
Islands	0.000	0
Waterbody	19.591	6.34
Agriculture/ Horticulture	91.132	29.50
In-Stream Agriculture	5.276	1.70
Plantation	19.407	6.28
Village Settlement	2.611	0.84
Modern Development	1.178	0.38
Road	1.621	0.52
Quarry	0.050	0.016
Total	**308.88 sq. km**	**100**

- The Dimbhe catchment receives rainfall of less than 2000 mm, hence it is unable to support species of evergreen forest. In the Western part of the catchment, semi-evergreen forest is present. The second important forest type seen here is the moist deciduous forest.
- The Sacred grove (*Devarai*) near village Phalode is devoted to the deity named Marideo. It has old growth trees like *Ficus amplissima* (Piparani), *Terminalia chebula* (Hirada) associated with *Syzygium cuminii* (Jambhul), *Atalantia racemosa* (Makadlimbu), *Mangifera indica* (Amba), *Casearia graveolens* (Bokhada), *Actinodaphane angustifolia* (Pisa), etc.
  The Devrai is located near the main road and surrounded by agricultural land with a few settlements. Therefore, it has become isolated and lost connection with other forest patches. Prominent edge-effect could be observed with weeds and hardy species like *Lantana camara* (Tantani), *Crotalaria pallida* (Khulkhula).
- The Ahupe sacred grove is fragmented by road. It has many old growth trees and lianas. It is an ideal habitat for *Ratufa Indica*, the Indian giant squirrel which is a key-stone species and endemic to the Western Ghats.
- Community conserved Hirada trees are present in Phalode and in many other villages in the catchment area. Collection and sale of Hirada fruits is one of the income sources for the locals in this catchment.
- Mature forest was also observed at the end of the west side of the catchment which includes area of Kondhwal and Ahupe located near the crest-line.
- Good forest patches were seen near 1st order stream niches which are almost inaccessible for the humans and have higher availability of moisture.
- The composition of dense shrubbery in this catchment is more diverse, with relatively larger number of species. Please see vegetation composition in tabular format given in Table 7.
- The opportunity to improve the status of dense shrubbery to mature forest by restoration is significant.

Table 5 : Chaskaman Catchment : Vegetation Classes and Composition

Vegetation class	Species Composition
Mature forest	**Evergreen** : *Memecylon-Garcinia-Dimorphocalyx-Litsea* are associated with *Mallotus stenanthus, Mallotus aureopunctatus, Knema attenuata, Drypetes venusta, Mangifera indica, Syzyzium cumini, Ficus nervosa, Garcinia spp.*
	Semi-evergreen : *Memecylon-Actinodaphne-Olea* community is associated with *Mangifera indica, Heterophragma quadriloculare, Diospyros silvatica, Atalantia racemosa, Mallotus phillipensis, Murraya koenigi, Bridelia retusa, Xantolis tomentosa*. Ground flora includes shrubs like *Ixora brachiata, Gnidia gluca, Pavetta indica,* etc.
	Moist Deciduous forest : *Terminalia spp.-Dalbergia spp.-Bombax ceiba, Erythrina stricta, Ficus racemosa, Lagerstromia parviflora, Zanthoxylum rhetsa, Grewia tiliifolia, Careya arborea, Meyna laxiflora* are asociated with climbers like *Dioscorea bulbifera, Paracalyx scariosus, Teramnus labialis, Tylophora dalzeli, Smilax ovalifolia*.
Dense shrubbery	*Strobilanthes callosa, Woodfordia fruticosa, Carrisa congesta, Pavetta sp, Gnidia glauca, Thespecia lampas, Grewia serrulata, Casearia graveolens, Holarrhena pubescens, Meyna laxiflora, Catunaregum spinosa* and trees like *Terminalia elliptica, Bridelia retusa, Flacourtia latifolia, Bombax ceiba, Syzygium cuminii, Ficus hispida, Emblica officinalis, Wrightia tinctoria, Acacia feruginea, Tectona grandis*
Scrub	*Acacia nilotica, Azadiracta indica,* etc. associated with shrubs like *Fluggea leucopyrus, Calotropis gigantea, Lantana camara, Euphorbia sp., Woodfordia fruticosa, Gymnosporia sp.,* etc.
Open area	There is no specific composition of species but we observed the following : At places observed *Euphorbia spp.* associated with *Artemisia nilagirica* indicating xerophytic condition. Many of the open land habitat are rocky outcrops. They have specific vegetation during monsoon and following are some of the species seen : *Eriocaulon-Utricularia-Smithia-Senecio* associated with *Nanothamnus sericeous, Cythocline lutea, Cythocline purpurea, Hygrophilla serpyllum, Smithia purpurea,* grasses, sedges associated with shrubby clusters of *Gnidia glauca, Catunaregum spinosa, Crotalaria retusa* and *Carissa spinarum,* etc.
Karvi	*Strobilanthes callosa* associated with climbers like *Dioscorea spp., Tylophora dalzelii,* etc.
Riparian	*Acacia nilotica, Ficus racemosa, Syzyzium cumini, Pongamia pinnata, Syzygium zeylanicum, Ficus arnottiana, Homonoia riparia* along with other terrestrial species like *Bombax ceiba, Lannea coromandellica, Xantolis tomentosa; Cyperaceae* members and grasses like *Saccharum spontaneaum;* herbs and shrubs like *Ludwigia octovalvis, Phyllanthus reticulatus, Crinum viviparum,* etc.
Plantation	*Tectona grandis* associated with *Terminalia elliptica, Bombax ceiba, Lannea coromandellica, Madhuca latifolia, Grewia tilifolia*. Teak (Sag) plantation is also dominated by weedy undergrowth of *Lantana camara* with other shrubby vegetation like *Carrisa caranda, Woodfordia fruticosa, Gymnosporia senegalensis, Jasminam malabaricum,* etc.

- The species diversity is also high in case of scrub vegetation class. (Please see vegetation composition)
- Among Open land areas, rocky plateaus have typical vegetation in Monsoon season. Rocky plateaus are not level lands. By removing boulders of rocks, depressions are created on the plateau. We have seen paddy fields on such depressions.
- Inspite of heavy rainfall, we came across *Euphorbia sp* (Nivdung) associated with *Artemisia nilagirica* (Dhordavana), *Woodfordia fruticosa*, etc. indicating seasonally dry conditions. These conditions exist due to steep slopes which cannot hold soil and moisture.
- On the crest-line near Ahupe, the forest is bordered by *Strobilanthes callosa* (Karvi) vegetation. It is also found in patches on steep slopes.
- Plantation mainly consists of teak and few non-indigenous species like *Gliricidia*, Subabhul, planted on a fairly large area in the Dimbhe catchment.

Discussion

Catchment Restoration Potential and Recommendations

This study defines Restoration Potential of a dam catchment as the total area of land in the catchment underthe four main natural vegetation classes (Mature Forest, Dense Shrubbery, Scrub, Open land) and plantation**.** These classes can benefit from protection and restoration and lead to an improvement in nature's services and biodiversity. (Urbanska, 1997)

The overall region can be seen as a mosaic of habitats. Finding restoration potential in a specific part of it requires us to evaluate *forest patches, corridors* that connect patches, and *matrices*, which are arrays of various land uses and habitats around a forest patch, dotted with vegetation (Forman et. al. 1996). The ecological quality of the matrix (and it's variation over seasons) are important when restoring overall ecological health of a fragmented landscape (Jules et. al. 2003).

The central theme of our restoration recommendations is to protect good forest patches, restore degraded patches, connect patches using new or existing corridors where possible, and protect matrices (as they provide nature's services to surrounding forest patches).

Pavana : Restoration Potential and Recommendations

Restoration potential of the Pavana catchment is 68.96 sq. km. Please refer to the Figure 5 when reviewing the recommendations below.

1. In the high and middle rainfall zone, we observed a lot of scrub. Ideally, there should be good forest cover, considering the rainfall in this area. Hence the large extent of scrub land here is unacceptable and indicates a high degree of degradation. We recommend this area (patches of scrub) as a top contender for restoration.
2. A lot of modern development including polyhouses is observed in the midst of mature forest. Such development and roads leading to them can cause further forest erosion, introduction of waste in natural ecosystems, and long term impact on nature's services. Such projects should not be allowed in mature forest areasin future. For already existing projects, the owners should be involved in landscape level restoration programs. The local councils and state government should consider restrictions on further development in/near mature forest.
3. In-stream agriculture is relatively high. It should be discouraged or sustainable alternatives should be provided.
4. Towards the North-West of the dam catchment, in the land-area between the villages Atvan, Ghusalkhamb, Morgiri and Jambhulne, there are large patches of mature forest fragmented by relatively small patches of modern development and agriculture. If a trade-land programcan be devised so that agriculture is shifted to other open areas, then the mature forest cover in this area can be increased. Successful examples of relocation of villages include Dhain (2004-05) and

Figure 10 : Road construction on hills in Chaskaman catchment

Table 6 : Dimbhe Catchment : Area Statement as per Vegetation and Land Use

Vegetation and Land use class	Area under each Class (sq. km)((%)	Percentage Area w.r.t. Total Catchment Area (%)
Mature Forest	36.879	13.29
Dense Shrubbery	41.408	14.92
Scrub	45.325	16.33
Open	53.817	19.39
Karvi	1.245	0.44
Riparian Habitat	1.664	0.59
Islands	0.000	0
Waterbody	15.831	5.70
Agriculture/ Horticulture	74.436	26.83
In-Stream Agriculture	3.525	1.27
Plantation	0.569	0.20
Village Settlement	1.698	0.61
Modern Development	0.074	0.02
Road	0.918	0.33
Quarry	0.044	0.01
Total	**277.43**	**100**

Bori (2009-10) by NTCA/Project Tiger in the Satpura National Park as well as relocation of seven villages in the Melghat Tiger Reserve (2012-15). Similarly, owners of the land where modern development exists can be integrated in the restoration program. With proper protection, the patches of scrub and dense shrubbery adjacent to mature forest would automatically upgrade so as to form a continuous, large stretch of mature forest.

5. Similar condition is observed to the west of Shilimb, where there are large stretches of dense shrubbery in the midst of mature forest. Similar program to increase the extent of mature forest should be considered here.

Chaskaman : Restoration Potential and Recommendations

Restoration potential of the Chaskaman catchment is 185.45 sq. km. Please refer to Figure 9 when reviewing the recommendations below.

1. In the high rainfall zone, towards the west, near crest-line of Western Ghats, village settlements are few. Mature forest areas are surrounded by dense shrubbery area. With simply more protection mainly from human interference, these areas can be restored to a continuous stretch of mature forest. Some of the area within this zone belongs to forest department and may be effectively protected by preventing grazing and agriculture.
2. In the mid rainfall area of the catchment, dense shrubbery is present to the north of the reservoir. However, it is absent to the south of the reservoir. Logically, with same rainfall, even this area should support dense shrubbery vegetation. To make this possible, restoration programs should be devised including trading of land. The land owners can be given a substitute land in open areas identified in this study to practice agriculture.
3. There are a lot of open areas in the midst of dense shrubbery. In these areas, restoration should be practiced since it can evolve to the next stage in progression, i.e. mature forest.
4. The history and present trends in land ownership

Table 7 : Dimbhe Catchment : Vegetation Composition and species composition

Vegetation class	Species Composition
Mature forest	**Semi-evergreen :** *Memecylon-Actinodaphne-Olea* community is associated with *Mangifera indica, Xantolis tomentosa, Lepisanthes tetraphylla, Heterophragma quadriloculare, Diospyros silvatica, Atalantia racemosa, Cryptocarya wightiana, Symplocos racemosa, Mallotus phillipensis, Murraya koenigii, Bridelia retusa* with shruby under growth of *Ixora brachiata, Mallotus stenanthus, Mallotus aureopunctatus, Gymnosporia rothiana, Pavetta crassicaulis, Raulvaolfia verticillata* and climber likes *Rubia cordifolia, Oxyceros rugulosus, Eleagnus conferta, Ancistrocladus heyneanus, Ventilago bombaiensis,* etc.
	Moist Deciduous forest : *Mangifera indica-Syziygium cuminii-Terminalia elliptica* with *Careya arborea, Dalbergia spp.-Bombax ceiba, Erythrina stricta, Ficus racemosa, Lagerstromia parviflora, Xanthoxylum rhetsa, Terminalia chebula,* etc. are associated with shrubs and climbers like *Carrisa congesta, Pavetta sp., Dioscorea bulbifera, Paracalyx scariosus, Teramnus labialis, Tylophora dalzeli, Smilax ovalifolia,* etc.
Dense shrubbery	*Strobilanthes callosa, Woodfordia fruticosa, Carrisa congesta, Pavetta sp., Gnidia glauca, Thespecia lampas, Grewia serrulata, Casearia graveolens, Holarrhena pubescens* and trees like *Meyna laxiflora, Catunaregum spinosa, Terminalia elliptica, Bridelia retusa, Flacourtia latifolia, Bombax ceiba, Syzygium cuminii, Ficus hispida, Emblica officinalis, Wrightia tinctoria, Acacia ferruginea, Tectona grandis*
Scrub	*Acacia nilotica, Azadiracta indica, Fluggea leucopyrus, Calotropis gigantea, Lantana camara, Euphorbia sps., Woodfordia fruticosa, Gnidia gluca, Maytenu ssp., Bridelia retusa, Memecylon umbellatum, Flacaurtia latifolia, Ziziphus mauritiana,* etc.
Open area	Among Open land areas, rocky plateaus have typical vegetation in Monsoon season. Herbaceous species like *Utricularia, Eriocaulon, Smithia, Impatiens, Crotalaria, Indigofera, Swertia minor, Nanothamnus sericeous, Cythocline lutea, Hygrophilla serpyllum, Smithiapurpurea* grow on these plateaus. Orchids like *Habenariagrandifloriformis,* etc. are associated with grass community like *Heteropogon contortus, Themeda quadrivalis, Apluda mutica, Andropogon sp.* and shrubby clusters of *Carrisa congesta, Gnidia gluaca, Meyna laxiflora,* etc. These grow on rocky plateaus occupying their own niche.
Karvi	On the crest-line near Ahupe, the forest is bordered by *Strobilanthes callosa* (Karvi) vegetation. It is also found in patches on steep slopes.
Riparian	*Acacia nilotica, Ficus racemosa, Syzyzium cumini, Pongamia pinnata, Syzygium zeylanicum, Ficus arnottiana, Homonoia riparia Vitex nigundo,* along with other terres trial species like *Bombax ceiba, Lannea coromandellica, Xantolis tomentosa* and *Cyperaceae* members; grasses like *Saccharum spontaneaum* with herbs and shrubs like *Ludwigia octovalvis, Phyllanthus reticulatus.*
Plantation	*Tectona grandis, Gliricidia sepium, Lysiloma latisiliquum, Acacia auriculiformis, Eucalyptus globosus,* etc.

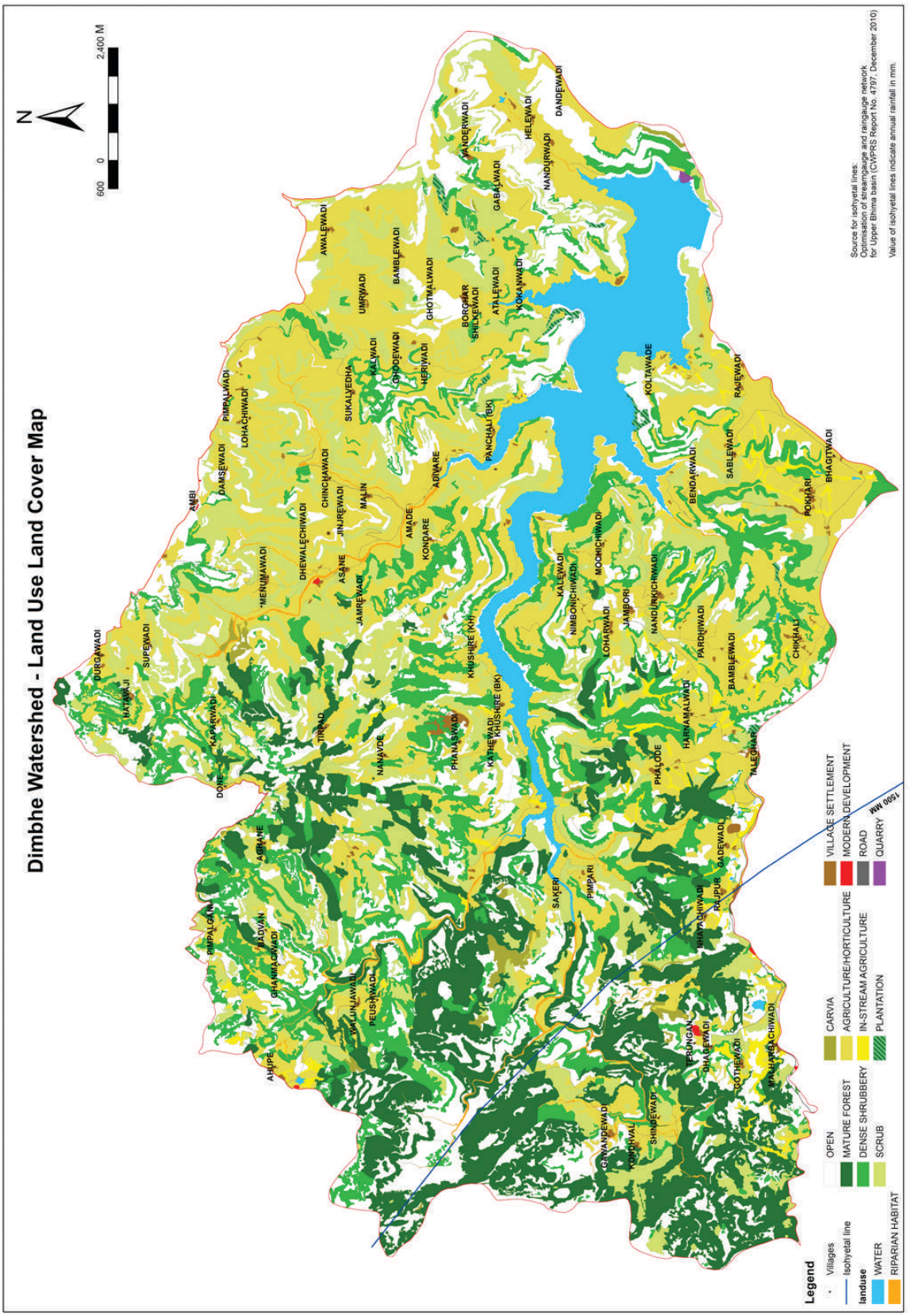

Figure 11 : Vegetation and Land Use Map of Dimbhe catchment

of tribals and other locals as well as their aspirations should be taken into account when planning restoration.

5. Regarding private owners asserting land rights by clearing mature forest on their own land, we suggest a land trade program be worked out with the owners. Owners can be offered subsidy or an alternative piece of land in open vegetation areas in the catchment.
6. Dense Shrubbery throughout the catchment should be provided protection.Protection can be provided by
   a. Forest department if its within their reserved forest area
   b. Land trade programs to bring more land under reserved forest, subject to socio-economic feasibility
   c. By convincing private landowners for more protection and restoration. Suggested ideas could be
      i. Private sanctuaries
      ii. Landowner-conservator's collective (Pathak, 2015)
      iii. Model Eco-sensitive Zones (Pathak, 2015)

Dimbhe : Restoration Potential and Recommendations

Restoration potential of the Dimbhe catchment is 177.99 sq. km. Please refer to the Figure 11 when reviewing the recommendations below.

1. To the west of the catchment, between Walunjwadi and Kondhwal, there are fragmented patches of mature forest and dense shrubbery. This area belongs to Bhimashankar Wildlife Sanctuary. A restoration program can be implemented by Forest Department to create continuous green cover.
2. There is a large extent of dense shrubbery throughout this catchment which should be provided protection. There is a need to educate the local community to know the benefits of protecting this vegentation type.
3. Continuity of mature forest and dense shrubbery areas should be a top priority. Both, currently are highly fragmented. Restoration programs should focus on creating corridors connecting these patches of dense shrubbery to increase available habitat for various kinds of biodiversity.
4. Agriculture in the hilly areas with steep slopes is difficult. Often it is subsistence agriculture, as is the case here, to the north-east of the catchment in the vicinity of villages Chinchawadi, Jinjrewadi, Shindewadi, Ghotmalwadi etc. A substitute land in the open areas could be offered to the owners and hilly areas could be provided complete protection for natural vegetation to grow.
5. Drainage density of this catchment is high indicating a large number of streams. However, compared to these number of streams, riparian vegetation is negligible. Creation of riparian zone along these streams will add ecological value to the catchment.

Recommendations Applicable Across Catchments

A few additional recommendations and ideas that could be applicable to any of the three catchments are given below :

1. At the policy level, absolute protection to the source regions of the rivers is recommended. Modern development should not be allowed in these areas.
2. Subsequent to the climate change talks in Paris in 2015, there is a renewed thrust on renewable energy in India. This may result in multi-fold increase in windmill installations in India over the next 1-2 decades. Over the past decade, we have already seen many new windmill projects coming up in the vicinity of Western Ghats. Chaskaman and Dimbhe catchments are likely to see more windmill activity, in addition to what is already seen. Wind-mills are generally preceded and followed by construction of roads. Accessibility brings about various secondary and tertiary changes in the landscape and can change land use rapidly.
   Due to these concerns, we recommend that windmills should not be allowed near mature forest, dense shrubbery, forest corridors, biodiversity-rich areas, or any other areas we have listed in this report as ideal for restoration. Windmill projects should also not be allowed to modify or change existing drainage and watershed structure in the catchment.
3. Considering the large number of village settlements in some of the catchments (e.g. Chaskaman or Dimbhe), Forest department, communities, and NGOs should work closely to create an equivalent of a sacred grove (*devrai*) in each village to increase green cover. This could be a novel program by the Social Forestry Dept or other parts of the Forest Department, in association with NGOs and local village councils. Each village could demarcate a patch of land for a Devrai and vouch not to touch it for many decadesto come**.** Being a devrai, even forest pro-

duce or timber should not be taken from this area, or if taken, there should be high restrictions, enforced by the community. The location of this patch should be such that it adds to nature's services in the area e.g. pollination, water retention, soil conservation, erosion control, etc. This initiative could get plants of indigenous species from the forest department/social forestry department and ongoing inspection and consulting from NGOs. They should also get government grants and awards for improving the forest.
In the state of Maharashtra, the *Jalayukta Shivar* (farm pond) scheme was given top priority and rapid implementation by the government from 2014. A similar thrust could be put behind the "Sacred Grove in every village" scheme.

4. Karvi, especially on the steep slopes plays an important role in preventing soil erosion. Also at that gradient, nothing else than Karvi flourishes. The local communities extract Karvi for their livelihood. Exploitation of Karvi in such areas should be sustainably managed along with the community.
5. Communities in these catchments are dependent on local resources like fish. Small bunds across the streams and fish ladders can be introduced in the streams to increase fish yield. In a prior demonstration study done by Ecological Society in the Chaskaman dam catchment during 1997-98, it was observed that villagers caught fish during monsoon season, by utilizing a cloth as net across stream. It was observed that fish go up-hill for laying eggs. In this study, very low bunds were constructed in the catchment and the resulting habitat was useful to both fish and local community of fishermen.

Restoration Prioritization across Catchments : A framework

The study also attempts to address the possibility that a funding agency, an NGO, or a government department may be faced with the decision of selecting a given dam catchment for restoration from among multiple such candidates. This could happen due to budget and time constraints, interest in relative restoration potential, and so on.

The framework below tries to answer the above question, on an experimental basis.Itis based on our limited analysis and not on any focused or empirical studies. It is an intuitive framework based on our general experience with restoration in the Western Ghats.

Disclaimer : For selecting a given catchment among multiple such candidates for restoration, several aspects are pertinent. We only cover a subset of these below. Moreover, most of the scoring methods we provide below are simple and could be refined. Further analysis and enhancement of this framework is needed.

Extent of vegetation cover

For our purposes, this is the percentageof land in the catchment under the four natural vegetation classes: mature forest, dense shrubbery, scrub, and open land. The higher the extent, the more the potential for protecting vegetation and improving natural forest. On the other hand, it could be argued that the lower this number, the more the need for restoration, since this area is eroded and is in need of restoration. While both these arguments are true, we recommend the "higher" extent as a driver for determining potential, simply because the more the vegetation, more the nature's services that can be counted upon from this area.

A simple scoring scheme for this parameter could be as : 1 (<25%), 2 (25-50%), 3 (50-75%), 4 (75-100%). Extent of vegetation cover and scores for our three dam catchments are given in Table 8.

Overall amount of fragmentation of natural vegetation

Fragmentation is the effect of land use changes due to human intervention of all types, gradual natural processes including land erosion, climatic conditions over the years, or calamities (e.g. landslides or diseases on plants). The more the fragmentation of vegetation, the longer the time, and more the effort and costs that will be needed to restore a landscape.

Fragmentation could be measured using sophisticated GIS analysis techniques (e.g. statistical analysis of vegetation class polygons in an average unit area of a landscape), however we could not attempt this during the course ofthis project.

For now, we have a simple scoring scheme, based on a subjective assessment of the LULC maps, as below : Fragmentation score for our three dam catchments are given in Table 8.

Conduciveness of natural conditions

This is an important dimension for restoration and we can think of sub-dimensions as below.

a. Rainfall

The more the rainfall, more is the water availability

Table 8 : Comparative Scoring across Dam Catchments for Restoration Potential

Catchment Scores and Values	Extent of Vegeta-tion Cover	Extent of Fragmen-tation	Rainfall	Drainage Density (Compu-ted in bracket)	Soil Quality	Shape of catchment	Extent of human land use	Vicinity to cities	Total Score
Pavana	3 (65%)	3 Low	3	3 (2.9)	2	1 Circular	4 (16%)	1	20
Chaskaman	3 (60%)	2 medium	1	3 (3.1)	3	2 Elongated	3 (39%)	2	19
Dimbhe	3 (62%)	1 High	2	3 (2.9)	2	2 Elongated	3 (29%)	3	19

in a catchment on an annual basis. Nature's response to higher rainfall is faster growth of forests. The scoring for scale for rainfall should not be absolute, but should be determined in a relative way, among the candidate catchments. In our case, all three catchments are in the Western Ghats, but Pavana gets relatively more rainfall while Dimbhe and Chaskaman get relative less. The relative scoring is provided in Table 8.

b. Drainage Density

The higher the drainage density, the more the length of drainage paths in a unit geographic area. Hence higher drainage density will mean relatively more water availability, making a catchment more conducive for restoration. More drainage density also results in higher habitat diversity and supports diverse platforms.This too should be a relative measure among the available candidates with some kind of indexation applied.

Since the drainage densities of the three catchments are close to each other, we assign the same and arbitrary score of 3 to all. If any of them was to have a significantly lower drainage density, say < 1 or between 1-2, a lower score like 1 or 2 could be assigned.

c. Soil Quality

Richer the soil quality in a given landscape, higher will be chances of success of restoration since less effort will need to be spent in enriching the soil. Soil Quality measures could be elaborate and will need detailed sampling and analysis methodologies. Also it may not be entirely correct or easy to assign a single soil quality measure across the landscape. Rather, a basket of soil measures may need to be worked out. In the absence of all this, we have assigned subjective scores to the soil quality in the three catchments based on our general observations.

d. Shape of catchment

The more elongated a catchment, the higher the probability that multiple, varying "rainfall instances" will happen across the length of the catchment. This means more rain will be retained and drainage will be gradual. On the other hand, the more circular a catchment, the faster will be runoffout of the catchment. Thus the shape of the catchment has an impact on the extent of moisture retention, which in turn affects restoration potential. Scoring across catchments on this parameter will be relative. A rigorous quantitative model for shapes can be done using measurement of long and short axes, further spatial analysis, etc. For now, simple scores for our three catchments, based on our assessment of their shape is provided in Table 8.

<u>Conduciveness of human conditions and interference</u>

Restoration programs cannot be successful without the involvement of stakeholders. It may be important to develop a variety of measures to express how conducive the general human conditions in a catchment are, for restoration. Below are two sample measures.

a. Degree of human land use

We have simplified this measure to take the sum total of percent land under all human use. This could be fine-tuned further to consider the varying impact each of them may have on restoration efforts. E.g. Roads bisect forests and affect habitat development,

while in-stream agriculture modifies drainage in the system. Grazing and fire have a direct impact on soil. Village settlements and modern dwellings may be sources of waste that choke up natural ecosystem flows. All these impact ecosystem health and hence restoration success.

For now, we will simply add up all human land use and assign a score as 4 (<25%), 3 (25-50%), 2 (50-75%) and 1 (75-100%). Extent of human land use and scores for our three dam catchments are given in Table 8

b. Vicinity to cities

Particularly in a densely populated, developing country like India, the more the vicinity of a forest to a major metro area, higher the chances that human land use in future may suffer from "urban effects", including urbanites buying land, developers building farm house schemes, large companies choosing these areas for townships and private hill stations, tourism, and so on.

Thus simply being near a city can affect the potential for restoration. The farther an area from a city, relatively less will be the urban interference. This could also be modelled quantitatively though actual distances and road connectivity to nearby metros. For now, we observe that Pavana is very near to Mumbai, Pune and Lonavala, while Dimbhe and Chaskaman have only Pune as a nearby city, but not as close as in case of Pavana. The scoring is given in Table 8.

Composite Scores of the Three Catchments

After developing such basic measures, we could consider arriving at a composite score to provide a more definitive answer as to how to prioritize across catchments based on their restoration potential. For this, various weighted average or other such formulae could be considered. For now, we will do a simple addition of the above scores.

Thus, in this case, the simple model developed above does not provide a distinctly attractive candidate for restoration. Rather all three catchments score close to each other and have similar restoration potential.

In such a case, a decision could be made based on the total sq. km. of restoration potential in the catchment. In our case, the highest potential is with the Chaskaman catchment, of 185.45 sq. km.

In conclusion, our study of vegetation cover, land use and ecological status of the Pavana, Chaskaman, and Dimbhe catchments points to the significant restoration potential of such regions and how restoration can contribute to the larger objective of conserving the Western Ghats biodiversity hotspot. A landscape ecological approach, with restoration potential as a basis for discussion, can help develop a constructive dialog between all the stakeholders i.e. government departments, local communities, ecological and socio-economic experts and NGOs. We hope this study and similar such studies provide useful data for such dialogs and prioritization of restoration.

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Note

The online supplementary data for this article is available at following link or by writing to the lead author. https://bit.ly/2BhP5uc

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Article

Reverse Extraction – Resource Sharing; Participatory Planning in Kodagu, India

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Abstract

Traditionally, people have depended on forests for their livelihood and a process of sustainable resource extraction was in place, which typically did not result in major degradation of forested landscapes. With the increase in human population, per capita consumption and commodity exports there have been substantial changes in land use patterns, and depletion of forest cover and habitat for wildlife. In response to shrinking habitat, a new phenomenon of "reverse extraction" is now increasingly visible, where wildlife such as elephants, leopards, wild boar, and several other species are increasingly coming out of their habitat that has resulted in crop raiding, livestock killing, and causing human deaths as well. This paper makes a case for anintegrated conservation planning at a regional scale takes advantage of indigenous knowledge, advances in geospatial technologies, and inclusive, participatory planning as a way forward that would create a people's plan fulfilling human and wildlife needs.

Keywords : Western Ghats, Kodagu, biodiversity conservation, geodesign, regional planning, community participation

Introduction

Historically in India and several parts of the world, forest communities have lived in and have depended on the forests for their livelihood through a continued process of resource extraction. Guha defines "forest communities" as people whose existence depends on a close and ecologically sustainable relationship with the forest they inhabit (Guha 1983). According to one source, it is estimated that about five million people in India lived inside of protected areas, 147 million people live in and around forested areas, and an estimated 275 million people depend on forests for their livelihood (Kutty and Kothari 2001). But the degradation and loss of forest cover, particularly from timber operations, in the pre-colonial period, was much less compared to a scale that began during the British Raj and continued post-independence (Gadgil and Guha 1993; Guha 1983). The main drivers of resource extraction until mechanized timber extraction came around were grazing, collection of fuel wood, and other non-timber forest produce (NTFP) by the forest communities. During the period 1890-1970 more than 30 million hectares of land was transformed from forest and grassland to agriculture and settlements in India before and after independence

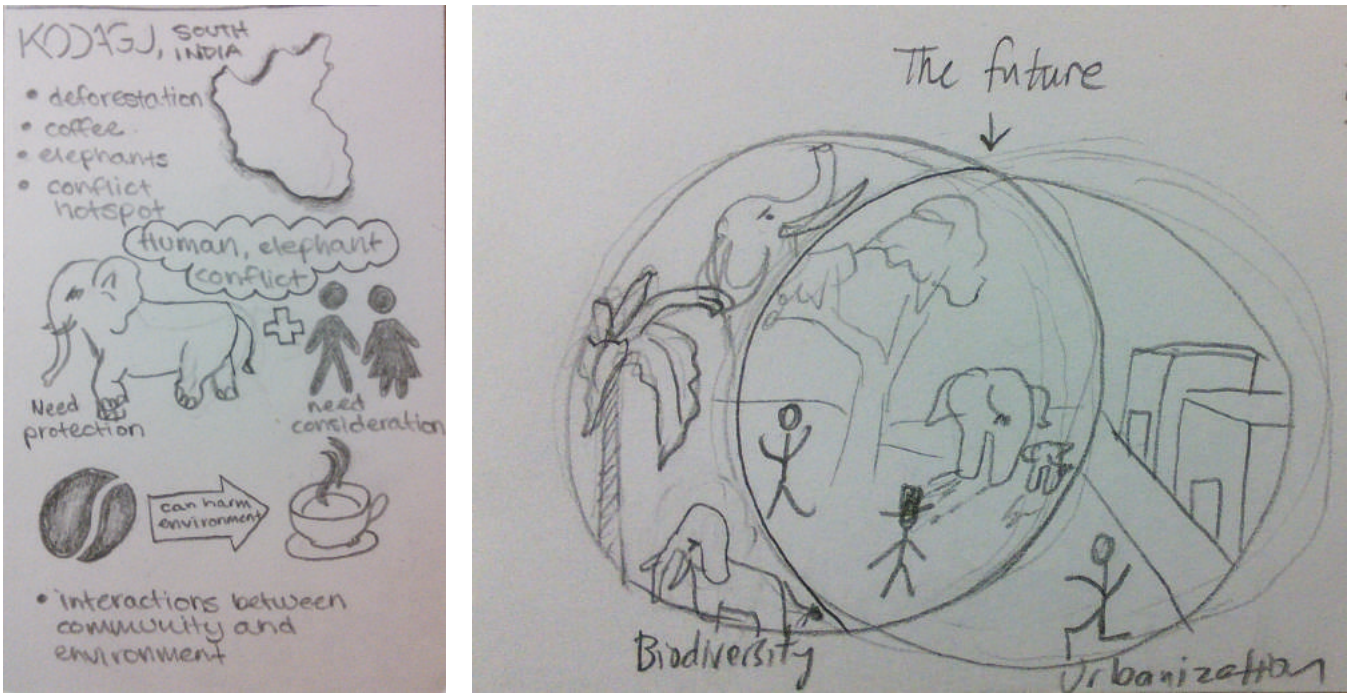

Figure 1 : PROBLEM and the SOLUTION. Sketches by landscape architecture students – Hannah Hughes and Sinead Santich (LDA 01, UC Davis), 2015

(Tucker 1988).

With the increase in human population since independence and with the advent of heavy machinery, more land was converted for agriculture, mining, hydroelectric projects, infrastructure, industries, and settlements. From a population of 345 million in 1947 when India became independent, the population is now over 1.2 billion ("Census of India Website - Office of the Registrar General and Census Commissioner, India" 2011; Srinivasan 2004). The increase in per capita consumption and exports of commodities such as coffee and tea cultivated on erstwhile forested land has also increased the need for more resources, and has had an impact in the form of increased human activities on the landscape.

These problems at regional scale need a serious consideration in the context of nature conservation because most planning problems at this scale tend to be"wicked problems". (Rittel and Webber 1973). It refers to problems that are difficult to clearly define and are inherently unsolvable because of nature of the problem, they are social problems that involve a number of different stakeholders with different views. These could include poverty, urban renewal, environmental and natural resources policy. This paper makes a case for understanding the role of resource extraction by people and "reverse extraction" by nature. Concept of reverse extraction is applicable to a wide variety of resource types. For example, the spread of deer tick virus (DTV) that now affects human brain in the north-central United States as a result of humans overlapping with deer habitat (Ebel et al. 1999), flooding in major cities in India such as Chennai (2015) and Mumbai (2005) (Gupta 2007; Revi 2005; Sengupta 2016), where natural water systems have been destroyed to allow construction for human uses, and caving-in of land in Philadelphia that was earlier a stream but was filled-in to build housing (Finkel 2013). We look at this in a framework of integrated conservation planning at a regional scale that takes advantage of indigenous knowledge, advances in geospatial technologies, and inclusive, participatory planning as a way forward that would create a people's plan fulfilling human and wildlife needs. It looks at Kodagu district in the southern Indian state of Karnataka which is part of a global biodiversity hotspot the Western Ghats (R. A. Mittermeier et al. 1999; Russell A. Mittermeier et al. 1998; Myers 1988, 1990). features in the World Wildlife Fund's Global 200 high priority ecoregions for conservation (Olson and Dinerstein 1998). See location map below (Figure 2). Apart from being part of global

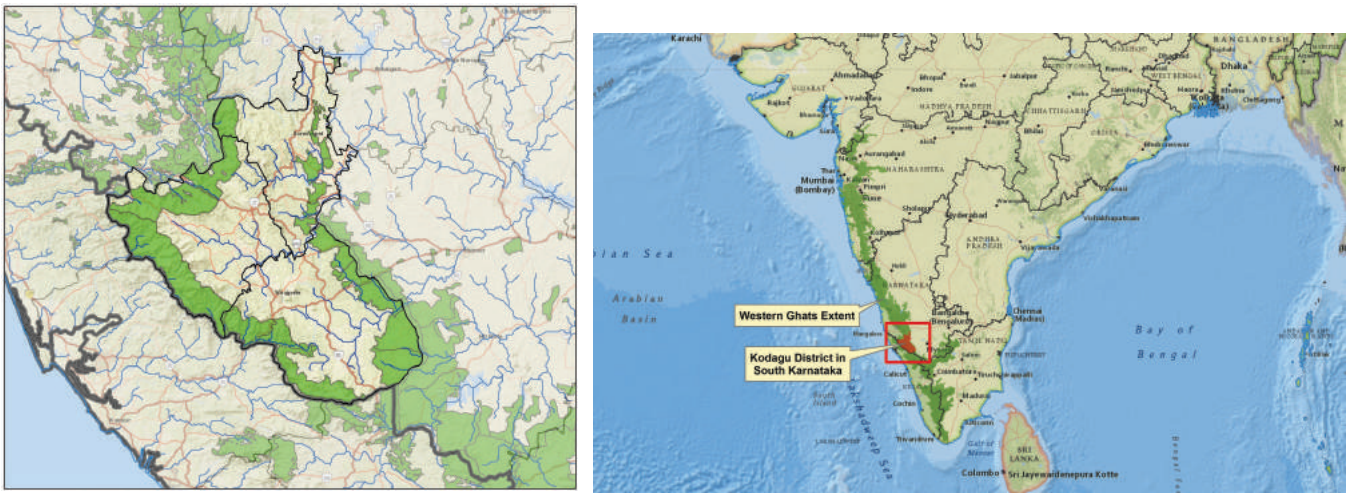

Figure 2 : Location of Kodagu and the Western Ghats

biodiversity hotspot, Kodagu is also a major coffee producing region of India.

The future of resource sharing by humans will depend on planning these areas where humans and wildlife could co-exist through employing strategies such as large-scale landscape planning integrating protected areas, protecting biological corridors, and restoring degraded habitats. This is also important because ecological health of surrounding areas has an impact on the protected areas (Laurance et al. 2012)

Context – Kodagu District in South India

Kodagu district, formerly known as Coorg as named by the British, has an area of 4,102 km^2 (1,585 miles^2) and is located in the southern Indian state of Karnataka. (Figure 2)

Kodagu is the largest coffee growing district in India and produces almost 40% of the total coffee grown in the country ("Coffee Board of India" 2015; Upendranath and Subbaiah 2012). Apart from coffee, there is also the cultivation of spices such as black pepper, arecanut, cardamom, ginger and other cereal crops such as paddy (rice). Almost all coffee commercially grown here is shade grown, and therefore, the coffee estates have a good tree canopy cover and resemble a forest (Figure 3).

Historical policy developments have surrounded Kodagu with a network of protected areas and reserve forests that support rich biodiversity including "charismatic" large mammals such as Asian elephant, tiger, leopard, gaur, and sambhar deer (Bhagwat et al. 2005a, 2005b; Garcia et al. 2010a). Elephants frequently move through the coffee estates of Kodagu from the surrounding forests, resulting in serious elephant-human conflicts through crop damages and human deaths – mostly of cultivators and laborers working in the fields (Rangarajan et al. 2010).

Increased per capita consumption of the population, has also increased the need for more resources, and has led to increased human activities, such as expansion of area under agriculture and plantations, industrial areas, rural and urban areas and transportation networks. There has been a slow growth in the human population in Kodagu district in the past, especially in the 1960s through 1990s at about 1% (decadal), except between 1991 and 2001 when it was about 12%. Growth stabilized during the last census period of 2001-2011, but future pressures are inevitable.

Resource extraction, especially timber, at a very

Figure 3 : View of a coffee estate

large scale in India started during the British period (Gadgil and Guha 1993; Guha 1983; Roy et al. 2015). There were commercial plantations of teak (*Tectona grandis*) and eucalyptus (*Eucalyptus globulus*) across the landscape in India. Remnants of these plantations can still be seen in Kodagu in Nagarhole National Park, which is now also a Tiger Reserve. Nagarhole still has about 107 km^2 of the forest as mixed teak and eucalyptus plantation and about 87 km^2 of purely teak plantation (Hannam 2005; Mahanty 2003).

In Kodagu over the years, large tracts of forest land have been converted into coffee estates thus shrinking the natural forest cover. Between 1977 to 1997 there was 30% loss of forest cover in Kodagu while the area under coffee cultivation doubled (Garcia et al. 2010b; Leroy et al. 2011) (Figure 4).

Elephant Human Conflict (EHC)

With all these changes in the land use, there has been an increase in wildlife-human conflicts, and large mammals such as elephants venture into agricultural and settled areas for food; reversing human extraction processes in response to the shrinking and fragmentation of their habitat. According to the Ministry of Environment and Forests (MoEF), annually about 400 people and 100 elephants lose their lives because of elephant-human conflict throughout India (Rangarajan et al. 2010).

Kodagu district has enjoyed some successful conservation initiatives through designation of Nagarhole as a national park (1983) and Tiger Reserve (1999) and its incorporation into the Nilgiri Biosphere Reserve (NBR) in 1986. It was declared as the Project Elephant reserve in 1992, thereby creating a large contiguous wildlife habitat with interlinked protected areas spanning across three states. These initiatives have stabilized, the elephant population in southern Karnataka Sukumar et al. (2012). Habitats have been shrinking and are more fragmented, but successful conservation efforts such as better protection, has resulted in an increase in the elephant numbers (Project Elephant Division, MoEFCC, Govt of India 2017). This has resulted in the elephants going far beyond the forested and protected area boundaries into agricultural areas, and in some cases even close to urban areas. Thus, the success of conservation efforts has greatly increased the risk of conflict (Gubbi et al. 2014; Madhusudan et al. 2015; Sukumar 1994; Sukumar et al. 2012).

The Elephant Task Force set up by the Karnataka

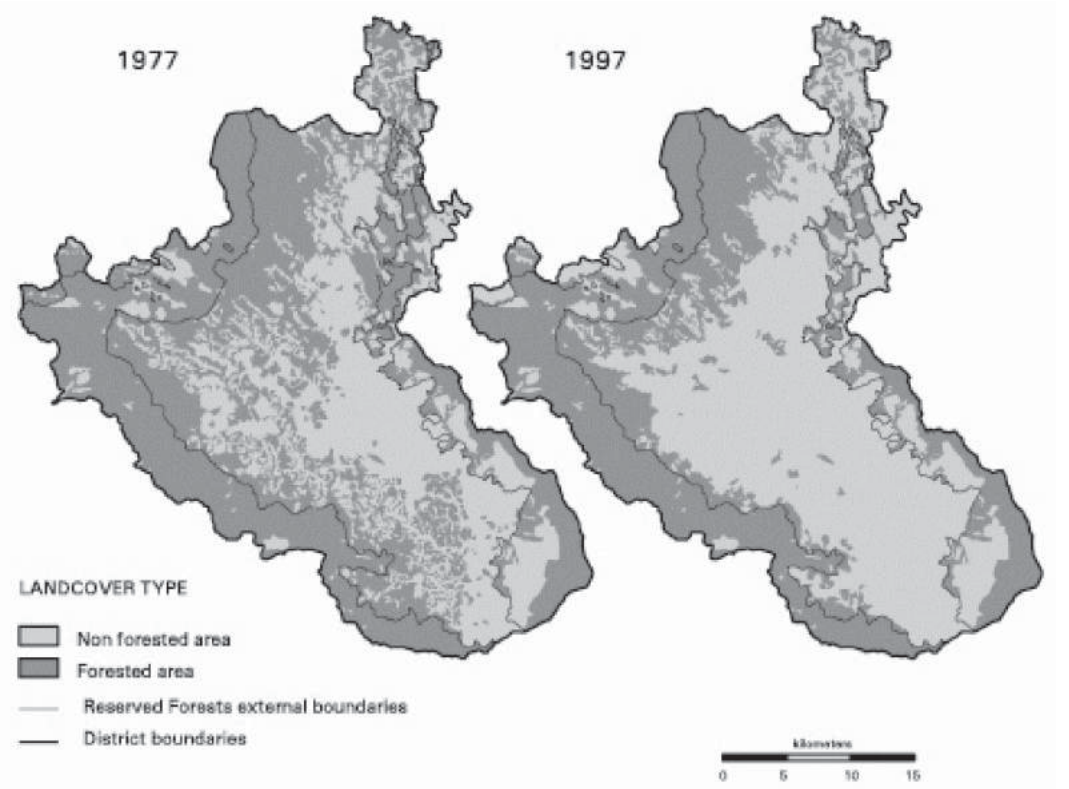

Figure 4 : A comparison of % forest area between 1977 and 1997 (Source: The French Institute)

High Court on how to deal with this conflict in its report of 2013 mentions the causes of the increased EHC as follows–

"The ecological basis of such conflicts is rooted in a set of complex factors including loss, fragmentation and degradation of the natural habitat, regional changes in land-use pattern, attraction from the superior palatability and nutritional properties of cultivated plants as compared to the natural forage of the elephant, social organization of the elephant with adult males generally becoming more persistent raiders, and adverse climatic events such as droughts causing elephant groups to disperse from their native habitats."

The Elephant Task Force identifies three zones of elephant and human interface –

Elephant Conservation Zone : This would encompass the landscape/s of the larger and more viable population/s of wild elephants, with emphasis on maintaining habitat integrity through protection of existing corridors, this zone could also include a certain number of human settlements within, depending on how the boundaries of the zone are drawn.

Elephant-human Co-existence Zone : Intermediate zones between the larger, integral habitats and small, fragmented forest patches would be regions for implementing the coexistence model through negotiated sharing of space between elephants and people. Future management of this zone, and its reclassification if needed, would depend on the success or otherwise in implementing the co-existence model.

Elephant Removal Zone : These would be regions where elephants would have to be captured from small, isolated patches of forests or human-dominated areas with unacceptably high levels of elephant-human conflicts, and/or the viability of the elephant groups in serious doubt." (Sukumar et al., 2012)

This research uses the proposed planning framework for an "Elephant-human Co-existence Zone" as a model for Kodagu district in order to propose an inclusive, participatory planning approach for sharing of natural resource as opposed to the current reality of resource extraction only by people that is resulting in reverse extraction by wildlife, especially elephants.

Other Pressures – Tourism, Urbanization, New Infrastructure

Urbanization

The urban population of Kodagu is very small compared to the rest of Karnataka state and the national averages. According to the 2011 national census, out of a total population of 554,519 for Kodagu only 14.61% (38.67% for Karnataka State, 31.16% for India) lives in the largely urban settlements of Madikeri (district headquarters), Virajpet and Somvarpet (Directorate of Census Operations, Karnataka 2011). The urban population of Kodagu is unlikely to grow (Pani and Iyer 2013), though other pressures will increase overall human impacts. The district is getting a new transient population that is buying property here as a second home for visits from cities such as Bengaluru and Mysore. A growing number of native Kodavas has moved to these larger cities but their estates continue to be actively farmed by hired managers.

Tourism

Unlike the population of Kodagu, tourism is on the rise and is expected to exert more pressure on the natural resources. Kodagu is famous for its salubrious climate, scenic values, temples, historical places and wildlife parks. According to the Karnataka tourism department, in 2015, 3,500,000 tourists were expected to visit Kodagu, a big jump from just 587,216 in 2010 (Times News Network (TNN) 2014). Most of the tourists come from nearby cities of Bengaluru, Mysore and Mangalore. A significant number come from other parts of India, and abroad as well. As there is no direct rail connection to Kodagu, most people come by private cars, buses, and taxis. The nearest airports are in Mysore, Bengaluru and Mangalore and the nearest railheads are in Kannur (Kerala), Mangalore, Bengaluru and Mysore. The government and the business community has proposed a new international airport near Kannur in Kerala, which is about 58 km from Virajpet and about 90 km from the district headquarters of Madikeri. This airport is expected to be functional soon, and is expected to increase the number of tourists visiting Kodagu. Also, with an increase in the size of the middle class in India and the increase in disposable income in that class, these tourism rates are certain to continue to rise (Beinhocker, Farrell, and Zainulbhai 2007; Saxena, Lanzeni, and Mayer 2010)

Most of the tourists visiting Kodagu stay at hotels, small resorts, and home stays in coffee estates. Home stays are becoming more popular because they give the visitor an opportunity to experience an operational coffee estate, get to know the local Kodava culture by staying with a Kodava family and enjoy their traditional home-cooked food. Homestays also bring additional income to farmers which can be very helpful especially during years when coffee prices are low. Currently, according to the Kodagu district ad-

ministration tourism department, there are 477 registered home stay providers in Kodagu and more than 1500 unregistered home stay providers doing brisk business. As tourism goes up in the district, the number of hotels and resorts are expected to increase.

Infrastructure

Infrastructure projects such as power lines, railway lines, roads, power projects, dams, will have an impact on landscapes, communities, and wildlife habitat. In 2015 a 400kv high tension power line project was completed through the eastern part of the district. This 120km long power line (55 km passing through Kodagu) has resulted in the removal of about 50,000 trees from forested areas and private coffee estates. There was a long-standing opposition to this power line passing through the district. It will result in further disturbance and reduction of forest cover, although the Power Grid Corporation of India has taken adequate measures by minimizing the length cutting through forested areas, and making it safe for elephants crossing by raising the height of power lines to 15 meters.

There is also a railway line currently in the planning stages. This line will connect Mysore with Kushalnagar in the eastern edge of Kodagu and will eventually be cutting through the district and connecting with the neighboring state of Kerala.

There are several roads that pass through protected areas and reserved forests that are also elephant habitats. The major road running east to west from Mysore to Virajpet onwards to Kannur in Kerala is proposed to be widened and is expected to provide the main connectivity in this region between the two states, as well as a connection to the coast increasing the pressure for further commercial development (Reilly, O'Mara, and Seto 2009).

Strip developments along roads are very common, and one can already see that development happening all along these roads. This development will certainly have an impact on the forests and result in both further fragmentation of elephant habitat and hindrance in their movement corridors. Unless the traffic on these roads is regulated, it could result in accidents with wildlife crossing the roads, as well as disturbance to crossing animals.

Traditional Knowledge of Local Communities

An important source of information or data on land, water, climate, and biodiversity is the "traditional knowledge" that resides with the community. This traditional knowledge comes from the community's long relationship with the geography of the land where they have lived for many generations (Robbins 2003). Traditional knowledge is valuable information that usually cannot be obtained from any other source other than the community itself.

Urbanization is a fast happening globally. Since 2008 for the first time more than half the world's population has started living in urban areas, a figure that continues to rise. By 2030 in Africa and Asia the urban population is expected to make up 80% of the world's urban population (United Nations Population Fund (UNPF) 2007). Therefore, rapidly urbanizing countries such as India need to record this traditional knowledge because this knowledge will certainly be lost with migration from rural to urban areas. The beginning of the loss of traditional knowledge is very much visible in Kodagu as fewer people from the younger generation are continuing to manage and work in their family coffee estates, and many have moved on to urban areas of Mysore, Bengaluru, other Indian cities and even to the United States and the United Kingdom. The status of being a farmer and a land owner in a rural area is not enough to establish sustainable self-sufficiency and the benefits that go with it, including marriage, family, and economic stability. It is important that this traditional knowledge is preserved and incorporated into the conservation planning process of the region.

As custodians or owners of the traditional knowledge, the local community or the stakeholders should be involved in the integrated regional planning process. This is the only way to make it a people's plan with their aspirations incorporated in it. They should own it and if they do that should ensure its implementation.

Case for an Inclusive Integrated Regional Planning

The natural resources and the land that are currently available should be shared by the local community for economic use and conservation. This balance calls for a co-existence model recommended by the authors of the Elephant Task Force report to the Karnataka High Court as the "co-existence zone"(Sukumar et al. 2012). Research has already happened in Kodagu that has studied local communities, demographic changes, the economics of coffee, elephant habitats, barriers put in place by the forest department to reduce elephant-human conflict, foraging habits of elephants and several similar areas of research.

The communities' traditional knowledge should be integrated with this completed scientific research, and

combined with latest developments in, spatial analysis technologies, and planning in a visioning exercise that brings together human, physical and political geographies into an inclusive, participatory planning process (Treves, Wallace, and White, 2009). This is now also legally mandated of all districts in India with the passing of the 73rdand 74thamendment to the Constitution in 1993 (Singh, 1994; Mukarji, 1993). This requires the districts to implement decentralized planning down to district level by forming a District Planning Committee which would compile all village and taluk plans and come with a holistic district level regional plan. In Kodagu the planning comes under the purview of Chief Planning Officer (CPO) under the Rural Development and Panchayati Raj Department. The CPO is responsible for compiling the needs and requirements of the district from the panchayats and taluks and come up with a district level regional plan.

There is a new emerging field Geodesign, which involves bringing in spatial information for various disciplines into a Geographic Information Systems (GIS) framework, where the planners take the GIS analyses and use it in design and planning (Dangermond, 2010a, 2010b; McElvaney, 2012; Miller, 2012; Steinitz, 2012). Geodesign is a method which according to Dana Tomlin is geographic decision making that is a combination of rational and non-rational thought that is more typically associated with matters such as designing a building, sculpting a landscape, composing a song, or crafting a work of art (Tomlin, 2011). Flaxman defines Geodesign as a design and planning method which tightly couples the creation of a design proposal with impact simulations informed by geographic context (Flaxman, 2010). The most extensive work done in this field is by Carl Steinitz, who explains that Geodesign is based on and shaped by a set of questions and methods necessary to solve large, complicated and significant design problems, often at geographic scales ranging from a neighborhood to a city, landscape region or river basin. He further explains that the practice of Geodesign requires collaboration among design professions, geographical sciences, information technologies, and people of the place (Steinitz, 2012)

Geodesign-like methods have been successfully deployed to help both regional planning authorities and the general public, envision alternative future landscapes generated by computing for policy scenarios. Generating geographic representations of expanded future communities, forces proponents to specify their assumptions and map their footprints. Maps and 3-D images of the results make it easy for those impacted to specify which they value or oppose, and to vote on their preferences on how to balance the inevitable tradeoffs.

Influential U.S. examples include Salt Lake City and Sacramento regions (Benner and Pastor, 2015), San Joaquin Valley (Beardsley et al., 2009; McCoy and Steelman, 2005), while one example from elsewhere is Kajiado District, Kenya (Beardsley, 2009). These are thought to have both led policy elites toward favoring "smart-growth" solutions that preserve wildlife and low-density working agricultural landscapes, and concentrating higher densities of residences, services, and community sustainability in more compact, contiguous, and strategically-placed priority zones for community development. Results of these experiments have been encouraging, but the question remains as to whether they can be exported to work in the rich social-historic-environmental context of India.

Recent advancements in computing, spatial technologies and evolution of participatory planning as against a top-down approach to regional planning has given the planner a unique opportunity to organize information from a variety of sources on various geographies in a digital form. This information is interactive and can be overlayed within all these geographies, such as road layers overlayed with surface water layers, together with economic and cultural information, to understand the interactions of choices made for roads and all of the other variables of concern to the community. Today all this information along with aspirations of local communities can be accommodated in an interactive process that allows real-time correction and input to data, real-time understanding of interaction effects, and real-time opportunities to try alternatives. Largely the stepwise process of geodesign is best explained in Figure 5 (Steinitz, 2012). (Figure 5)

Several new GIS-based tools have been developed that support this interactive approach. Four representative tools that planning practitioners have had some success with in bringing all this together are considered in this paper. They are :

- Geodesign framework by Carl Steinitz (Steinitz, 2012)
- GeodesignHub, an interactive web-based collaborative planning tool based on Carl Steinitz's Geodesign framework (Ballal, 2015; Ballal and Steinitz, 2015)
- UPlan : Urban Growth Model, developed by Information Center for the Environment (ICE) at University of California at Davis (Roth, 2012).

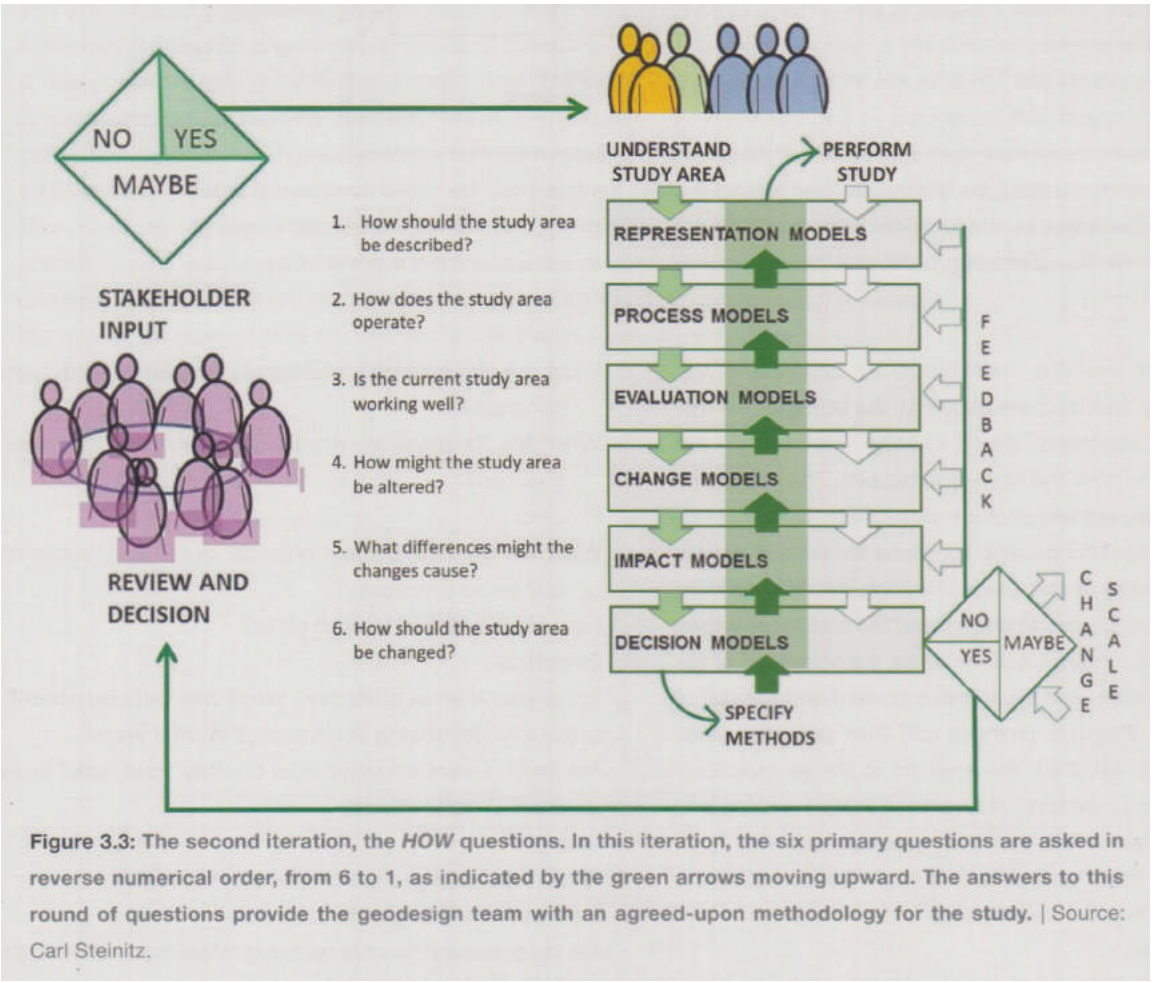

Figure 3.3: The second iteration, the *HOW* questions. In this iteration, the six primary questions are asked in reverse numerical order, from 6 to 1, as indicated by the green arrows moving upward. The answers to this round of questions provide the geodesign team with an agreed-upon methodology for the study. | Source: Carl Steinitz.

Figure 5 : Geodesign step (Source: Carl Steinitz)

· GeoPlanner for ArcGIS, developed by Esri, Inc the largest GIS software company is used to logically manage a geo-planning activity and its associated scenario (Esri, Inc. 2014)

By making the best use of these tools to bring together geospatial data, traditional knowledge of the communities and using interactive process, the planner is creating a platform that is useful in initiating a dialog between various stakeholders to achieve both conservation and development.

Conclusions

The future of conservation will depend on how best we plan areas where people and wildlife could co-exist, such as working agricultural landscapes adjoining protected areas, biodiversity migration corridors, and degraded habitats. A determination of how communities can share resources with the wildlife in areas where human use is inevitable and unavoidable must be made. Sustainability is defined not only by the changes in amounts of landscape elements (e.g., hectares devoted to various uses) but also geographic design, clustering compatible uses, maintaining contiguous corridors for moving wildlife and resilient waterways, and minimizing travel distances for human communities to meet their critical needs.

Clearly society must provide an opportunity for appropriate, economically useful, human extraction, but it must also guard against taking landscape conversion to the point of creating reverse extraction. This challenge of land use conflict highlights the importance of the role of the planner. The planner must go beyond bringing all physical, human and political geography data together for technical analysis and instead become a "master planner". The master planner must serve as knowledgeable and expert facilita-

tor supported by new technology and community engagement in a design process. As such a "planner as facilitator" will be required to bring together the local community, the scientific community, the government and the planning profession in a process that allows for constructive interaction that reflects the views of all parties.

The success of inclusive, participatory planning facilitated by technology, data, and able planners has been demonstrated in some North American settings. The economic pressures for development and the sensitivity of the environment to development are however not unique to the North American setting. It seems reasonable to hypothesize that inclusive, participatory planning, using similar geospatial visualization tools, would succeed to bring about a better balance of extraction and conservation in the Kodagu region of India and by extension, in other areas of the forested tropics where wildlife conservation will necessarily be concentrated in complex working landscapes. Appropriate government bodies, NGOs, and citizen organizations sufficient to test this hypothesis are available in Kodagu and the authors recommend that this research be supported before resource conflicts lead to irrevocable destruction of both natural resources, and through reverse extraction, the human habitat as well. As mentioned earlier participatory planning process using geospatial technologies or geodesign can be applied in other areas. The community and stakeholders, physical geography, important issues and adminstrative structure and policies will be different but the planning framework can still be applied. Although in this case this process has been used in conservation planning, but it can be applied in non-conservation regional planning areas as well.

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Article

Home Insects : Important Representatives of the Diversity around us

Swati Gole and Aditi Kale

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Introduction

Observations and sporadic photographic data gathering of insects and the garden around my house inspired me to write this note, "Home Insects". However since I don't have a background of formal Biological science, major contribution in interpreting and analyzing data is by co-author Aditi Kale.

Why Study Insect Diversity?

Significant insect diversity was encountered around the house. Documentation of this diversity was started and photographic data generated whenever possible. While documenting, I tried to identify insects and read more about the taxa.

Insects (Class Insecta) are one of the most diverse group on earth. They have successfully adapted to various landscapes and habitats and also have various important ecological roles like pollinators, prey and predators. They utilize various resources in their surroundings to complete their life-cycle successfully. Hence, species richness and abundance of insect diversity are strongly related to the ecological balance in the areas they occupy.

There is a general consensus that there is a decline in insect population all over the world. Given the important role they play in ecology, research regarding causes of decline in insect population is also a priority subject. (Ref: Yale Environment, http://e360yale.edu) The common causes of insect population decline are intense agriculture, urbanization and fragmentation of ecosystems.

Original ecosystem is fragmented into dispersed wilderness patches due to urban development. The space between these wilderness patches is called a matrix. This situation calls for examining the effect of urbanization by gathering insect data in this urban matrix area.

There are studies regarding matrix area in the urban landscape and agricultural landscape. These studies give guideline for the documentation of insects in the matrix area of urban as well as agricultural landscape.

"Much of the focus on biodiversity within agricultural landscapes has been on the conservation of rare species. But recently another issue has become equally prominent, namely whether or not increased biodiversity or species richness enhances ecosystem functions such as primary productivity and nutrient retention or ecosystem services such as pollination and biological control." (Daily, 1997; Tilman, 1997; Hector et al., 1999; Kaiser, 2000; Loreau, 2000)

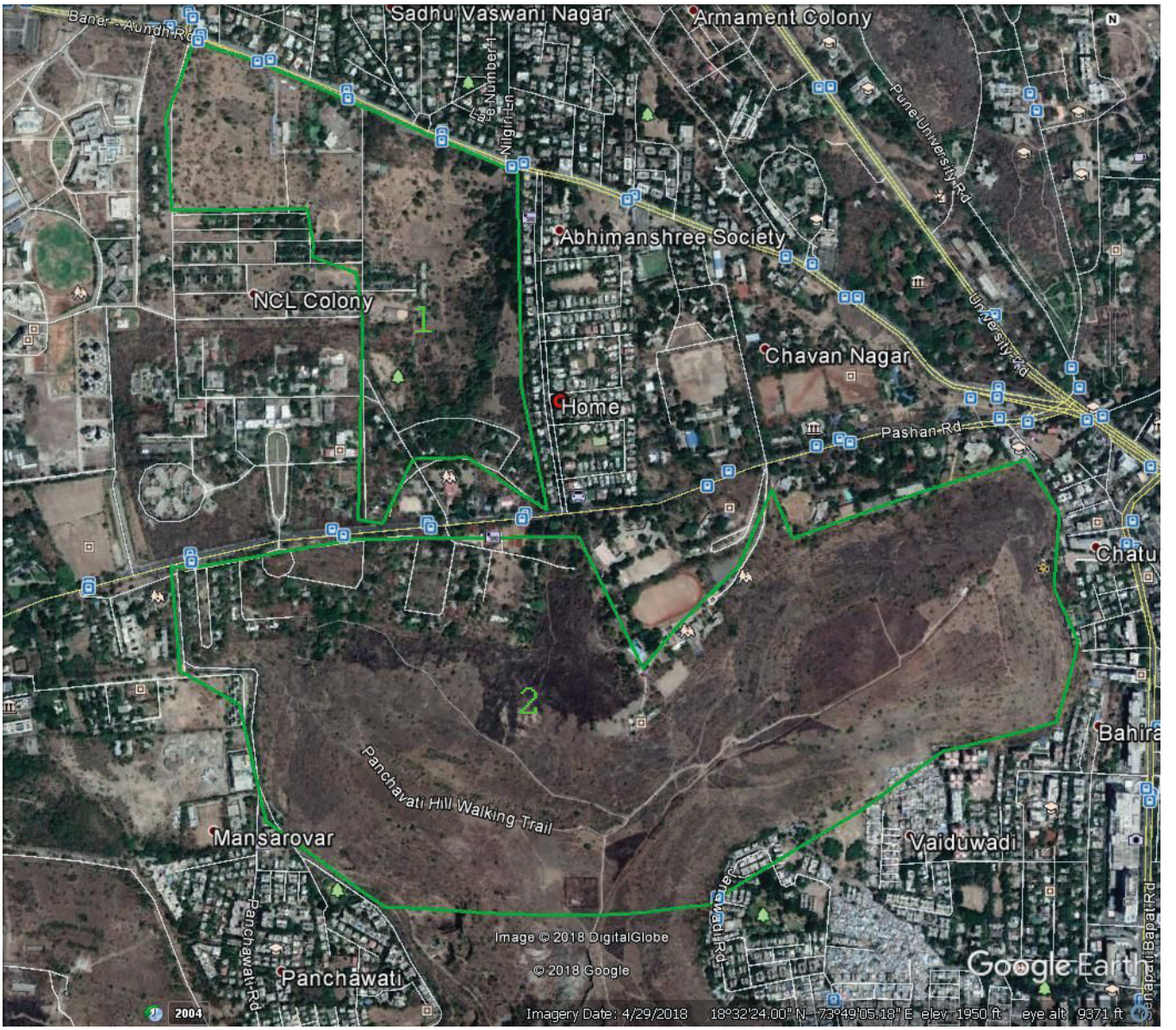
For this reason the diversity of common and widespread species also becomes important.

The importance of garden habitat in the urban area is also stressed by A.J. Bates and others (Ref. Jan 2014 Vol. 9 Issue 1/e86925, www.plosone.org). In their study, "Effects of Urbanization and Habitat Diversity with moth's conservation status," they state that "there is a consistent trend in species richness and total moth abundance; gardens with more diverse and extensive microhabitats were associated with higher species richness and moth abundance."

However, such studies are few and so there is a need to examine the situation in tropical urban areas, particularly in the matrix. Collection of data in such areas will add to the larger data bank.

Location

The house and the garden (See Map 1 : home) are located in the northern vicinity of 'Vetal Hill Complex' wilderness. (See Map 1 : 2) It is approximately one half kilometre distance away as crow flies. Top of the hill complex is the wilderness area, though large part of it is under plantation of non native trees. Another wilderness areas close by are NCL campus



Map 1 : Location Map

(See Map 1 : 1) and the Pashan lake and its surroundings. These wilderness areas are surrounded by growth of the city housing and the road network. On its northern direction the housing is of a bungalow type. Most of these bunglows have gardens and some open spaces.

The site of insect observations has its own peculiarities. Though the site is situated in urban area, it is not a part of dense construction. It has a semi-wilderness character. This semi-wilderness character is due to purposeful decision of not to have a manicured garden. The adjacent bungalows have manicured gardens with the use of chemical fertilizers and insecticides.

Materials and Methods

Notebook and camera are the main materials used. Since many insects are difficult to identify in the field, camera becomes most essential tool for record. The other observations such as activities like foraging, egg laying, nectar gathering, nesting, etc. were noted down. The association of a particular species of insect with a habitat was observed. Recurrence of same species was also noted. Identified insects not recorded

with photographs have also been included in the final list of observations.

A Sony Digital Camera was used for capturing photos of the insects. It was helpful in recording different life stages like larva, pupa and emerging adults of species like Brown Awl Skipper. Some activities like foraging on host plants, pollen and nectar gathering, and mating were also recorded using camera.

A few books were used for identification (Reference Books list is provided). Sometimes there were unexpected, unusual sightings. To identify such sightings, help of experts was taken. e. g. Tree Hopper or unidentified morph of a Moth. Butterflies were identified using few books, encyclopaedia and the website "I Found Butterfly" was used.

Identification of Habitats

Observing and taking photographs led to the realization that certain insects have an association with a particular place in the garden. Thus, by looking carefully and observing their activities, the variations or habitats in the garden were indentified.

The garden has got the following micro-habitats which suffice different needs of different insects.

1. Garden waste decomposition pit
2. Tall tree canopy with shady area
3. Wet mud spot
4. Sand flat
5. Terrace kitchen garden
6. Small patches of formal non-native lawn
7. Shrub clusters
8. Natural grass patch at the back of the plot where very little disturbance may occur

The grass patch is a very important habitat which has got lot of variety of natural grasses and herbs. The species of grasses succeed from early monsoon to late monsoon rains. And this habitat has a maximum diversity of small-sized insects.

Observations

1. Diversity of Insects and Plants

The total diversity encountered in the garden as well as inside the house is represented in the table 1. The insects were identified up to Order level and were further classified into morphospecies (distinct taxa identified easily on the basis of evident morphological traits). The species in the premises, thus recorded, were around 145 representing 11 insect Orders.

The table 1 shows that the maximum diversity is of Order Lepidoptera, including Moths, Skippers and Butterflies. The number of Butterfly species was almost equivalent to overall Moth species diversity. However, observations of activities of butterflies are much more. Moth behaviour was difficult to observe because of their nocturnal activity.

Table 1 : Classification according to order of the taxa

Order	Number
Coleoptera	10
Dermaptera	1
Diptera	7
Hemiptera	10
Homoptera	3
Hymenoptera	18
Lepidoptera	80+
Mantodea	1
Neuroptera	1
Odonata	5
Orthoptera	4

The second most abundant insects after Lepidoptera were Order Hymenoptera i. e. Bees and Wasps. Wasps, especially, use various niches like grills and window sills for nesting. Bugs and Beetles (Hemiptera and Coloeoptera) are the two other abundant Orders. Some small beetle species complete their lifecycle on small shrubs like *Plumbago auriculata* and an Elateridae beetle has infested the Mango (*Mangifera indica*) tree.

The study site garden has a combination of native and some few non native species. The number of tree species is much greater than shrubs, herbs and climbers. The ratio is 22:14:7:4. A detailed list of the species present in the garden is given in the table 2.

Some of the trees are slightly different than the usual horticultural varieties which are planted in gardens. To name the few, *Pterygota alata* (Roxb) R. Br. or Budha Coconut of Malvaceae family and *Bombax ceiba* L. of the same Malvaceae family which are usually seen in the wild. Another special tree is a palm species (which I was unable to identify). Among the non – native *Senna siamea* or Kashid and *Couroupita guianensis* or Kailaspati are prominent. However they are said to be Indianized and accepted by birds and insects.

Table 2 : List of plants

Sr. No.	Local Name	Scientific name	Family	Flowering season
		Trees		
1	Buddha Coconut	*Pterygota alata* (Roxb.) R.Br.	Malvaceae	Feb
2	All spice	*Pimenta dioica* (L.) Merr.	Myrtaceae	
3	Amba	*Mangifera indica* L.	Anacardiaceae	Jan-Feb
4	Bahava	*Cassia fistula* L.	Leguminosae	Apr-May
5	Bakul	*Mimusops elengi* L.	Sapotaceae	Feb
6	Chandan	*Santalum album* L.	Santalaceae	July-Aug
7	Chikoo	*Manilkara zapota* (L.) P.Royen	Sapotaceae	
8	Kadamb	*Neolamarckia cadamba* (Roxb.) Bosser	Rubiaceae	July
9	Kadhipatta	*Murraya koenigii* (L.) Spreng.	Rutaceae	Mar
10	Kailaspati	*Couroupita guianensis* Aubl.	Lecythidaceae	Oct
11	Kashid	*Senna siamea* (Lam.) H.S.Irwin & Barneby	Leguminosae	Aug-May
12	Katesawar	*Bombax ceiba* L.	Malvaceae	Feb-March
13	Naral	*Cocos nucifera* L.	Arecaceae	All
14	Palas	*Butea monosperma* (Lam.) Taub.	Leguminosae	Jan-Feb
15	Palm	Palm sp.	Arecaceae	
16	Pandhara Chafa	*Plumeria obtusa* L.	Apocynaceae	Apr-May
17	Seetaphal	*Annona squamosa* L.	Annonaceae	May
18	Sonchafa	*Magnolia champaca* (L.) Baill. ex Pierre	Magnoliaceae	Mar-Apr
19	Tabebuiea	*Tabebuiea* sp.	Bignoniaceae	Mar
20	Taman	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae	May-June
21	Thorel's Crape Myrtle	*Lagerstroemia thorelii* Gagnep.	Lythraceae	Oct-Nov
22	Tuti	*Morus alba* L.	Moraceae-	Feb
		Herbs		
1	Broom grass	*Thysanolaena latifolia* (Roxb. ex Hornem.) Honda	Poaceae	Mar-June
2	Ekdandi	*Tridax procumbens* (L.) L.	Compositae	All
3	Gavati chaha	*Cymbopogon citratus* (DC.) Stapf	Poaceae	Oct-Nov
4	Kardal	*Canna indica* L.	Cannaceae	Sept
5	Khulkhula	*Crotalaria retusa* L.	Leguminosae	Oct
6	Ova	*Plectranthus amboinicus* (Lour.) Spreng.	Lamiaceae	Oct-Nov
7	Terada	*Impatiens balsamina* L.	Balsaminaceae	Aug-Sept

Sr. No.	Local Name	Scientific name	Family	Flowering season
		Shrubs		
1	Adulasa	*Justicia adhatoda* L.	Acanthaceae	Dec
2	Anant	*Gardenia jasminoides* J.Ellis	Rubiaceae	July
3	Brahmkamal	*Epiphyllum oxypetalum* (DC.) Haw.	Cactaceae	August
4	Fire Bush	*Hamelia patens* Jacq.	Rubiaceae	Dec
5	Ixora	*Ixora sp.*	Rubiaceae	Aug-Oct
6	Jaswand	*Hibiscus rosa-sinensis* L.	Malvaceae	All
7	Karvand	*Carissa carandas* L.	Apocynaceae	Feb-March
8	Kavathi chafa	*Magnolia coco* (Lour.) DC.	Magnoliaceae	April
9	Hirva chafa	*Artabotrys hexapetalus* (L. f.) Bhandari	Magnoliaceae	April
10	Mogara	*Jasminum sambac* var. 'Maid of Orleans'	Oleaceae	May
11	Pivala Kanchan	*Bauhinia tomentosa* L.	Leguminosae	Dec
12	Powder puff	*Calliandra haematocephala* Hassk.	Leguminosae	Dec
13	Ratrani	*Cestrum nocturnum* L.	Solanaceae	Jan-June
14	Sandpaper Vine	*Petrea volubilis* L.	Verbenaceae	Jan-Feb
		Climbers		
1	Hoya	*Hoya sp.*	Apocynaceae	May
2	Jai	*Jasminum grandiflorum* L.	Oleaceae	Aug-Sept
3	Madhavilata	*Hiptage benghalensis* (L.) Kurz	Malpighiaceae	Oct
4	Vidhyache pan	*Piper betle* L.	Piperacaceae	

Some frequently observed insect activities included- Common Emigrant butterflies visit the garden in large numbers, but they rarely come down for foraging. Various forms of evening browns are common and numerous and they are seen almost throughout the year.

Four species of skippers viz Brown Awl, Indian Palm Bob, Canara Swift and Grass Demon add to the diversity of the garden. Out of these four, two, Grass Demon and Brown Awl complete their life cycle on *Hedychium coronarium* (Family Zingiberaceae) or Sontakka and *Hiptage benghalensis* (Madhavilata) respectively. I have been observing Canara Swift since 2011 and it is a regular visitor, but I could not observe its life cycle. On the other hand, Brown Awl is a relatively new addition ever since the introduction of *Hiptage benghalensis* four years back.

Moths can be categorized into two types : the small sized seen almost throughout the year, residents of natural grass patch, potted shrubs and shrub thickets, and same species are repeated throughout the year. The big size moths are of great variety. However very rarely these species are repeated. Exception is of Owl moth and *Micronia aculeata* (white lacy in appearance).

The most common and numerous species observed throughout the year are Blue butterflies and small sized moths.

Dendropathoe falcata (*Lorenthus*) has grown on *Lagarstroemia thorelli*. As described in the book "A Guide to the Butterflies of the Western Ghats, by Milind Bhakre & Hemant Ogale", it hosts Common Jezebel, Gaudy Baron and Peacock Royal butterflies. Out of these, partial life cycle of Gaudy Baron was observed (only larva stage and butterfly) in the garden.

Table 3 : List of Butterflies

Family Paplionidae (Swallowtails)	
Common Rose	*Patchliopta aristolochiae* Fabricius
Common Jay	*Graphium dosen* C & R Felder
Tailed Jay	*Graphium agamemnon* Linnaeus
Common Mormon	*Papilio polytes* Linnaeus
Great Jay	*Graphium eurypylus* Linnaeus
Family Pieridae (Whites and Yellows)	
One Spot Grass	
Three Spot Grass Yellow	*Eurema blanda* Boisduval
Common Jezebl	*Delias eucharis* Drury
Common Emigrant (Both Dry & Wet Form)	*Catopsilia pomona* Fabricius
Family Nymphalidae (Brush footed)	
Common Evening Brown Wet Season Dark, Dry Season	*Melanitis leda* Linnaeus
Common Five Ring	*Ypthima baladus* Fabricius
Common Sailer	*Neptis hylas* Moore
Common Baron and male	*Euthalia aconthea* Cramer
Great Egg fly (Female) Wet form	*Hypolimnus bolina* Linnaeus
Gaudy Baron	*Euthalia lubentina* Cramer
Family Lycaenidae (Blues)	
Red Pierrot	*Talicoda myseus* Guerin Meneville
Zebra Blue	*Leptotes plinius* Fabricius
Tiny Grass Blue	*Zizula hylaso* Fabricius
Pea Blue	*Lampides boetlcus* Linnaeus
Pale Grass Blue	*Pseudozizeeria moha Eurema anderssori*
Lesser Grass Blue	*Zizina otis* Fabricius
Forget me Not	*Catochrysops strabo* (Fabricius)
Common Cerulean	*Jamides celeno* Cramer
Pains Cupid	*Luthrodes pandava*
Slate Flash	*Rapala manea* Hewitson 1863 *Rapala manea* Schistacea Moore 1879
Family Hesperiidae (Skippers)	
Grass Demon	*Udasper folus* Cramer
Indian Palm Bob (common Grass Dart)	*Suastus gremius* (Fabricius)
Canara Swift	*Caltoris canaraica*
Brown Awl	*Badamia exclamattionis* (Fabricius)

The species richness in general and abundance of some species in particular is related to diverse micro-habitats. A small area like a garden shows almost eight microhabitats and species richness greater than 145 species. Some species like small sized moths and common emigrants are abundant.

This observation is corroborated by the following studies : "We found that associations with habitat and landscape composition were species-specific, but there were consistent trends in species richness and total moth abundance; Gardens with more diverse and extensive microhabitats were associated with higher species riches and moth abundance" (Ref. A.J. Bates and others : Garden and Landscape-scale correlates Jan 2014, Vol. 9 Issue 1, e86925, www.plosone.org.)

The other study of species richness in agro-ecosystems has similar findings and states : "The species richness generally increased with landscape heterogeneity on a farm scale. Habitat type had a major effect on the species richness for most groups, with most species found in pastures and lays" (Ref. Ann-Christin Weibull, Orjan Ostman and Asa Granqvist, "Species Richness in Agrosystems: the effect of landscape habitat and farm management, Biodiversity Conservation 12 1335-1355, 2003)

Ichneumon Wasps are also numerous; reason maybe they play an important role as biocontrol agent by parasitizing Lepidopteran larvae or eggs. Lepidoptera species were maximum in the garden.

2. Relations between Habitat Diversity and Insect Diversity

Habitats used by specific insects

Certain habitats are utilized by a particular set of insects. The natural grass patch with seasonal wild herbs was found used by Damselflies. Observation of three species of Damselflies indicate that they are always seen gliding through short natural grass. They were rarely seen using other micro-habitats. Similarly, small sized varieties of 'Blues', namely pale grass blue, tiny grass blue, Lesser Grass Blue use this natural grass habitat. These blues are also rarely seen using other micro-habitats. The Common Baron Female is always in the vicinity of the mango tree; many times observed basking in the sun on mango leaves. (Ref. Peter Smetacek 2017, A Naturalist's Guide to the Butterflies of India.)

Habitats used by several species

The grass patch, which is natural growth of grasses and seasonal herbs, shows maximum diversity of insects. Damselflies of 3 types and Dragonflies of 2 types were observed here. They visit for prey as this grassy patch hosts ants, various moth species and several butterflies like blues and yellows that visit herbs like *Tridax, Vernonia cineraria*. Damselflies glide in the stands of short grass.

The smaller sized moths are found in abundance and take refuge behind or perch on the underside of the grass blades. Honeybees also get attracted to the seasonal herbs mentioned above for nectar. Bordering the grassy patch are small shrubs which support a few beetle species. A few beetles and grasshoppers were also encountered in this patch.

Insects found across different habitats

Though 'Blues' and 'Grass Yellows' butterflies use grassy patch habitat, they also use other habitats. The flowers of 'Jasmine' climber are regularly visited by Blues. Butterflies also use the wet mud habitat near the tap and the kitchen garden on terrace and Blues and Female barons are commonly observed.

Shrubs and Climbers are used by specific species of butterflies to complete their lifecycle. But after the adults emerge, they use various habitats. For example, Brown Awl's lifecycle is completed on '*Hiptage*' climber but once it is on wing, it uses almost all habitats including the grass patch.

3. Relation between Vegetation and Insect type

There are trees and tree canopy in a part of the garden. Tree trunks are commonly used by Cicadas for perching. Tree canopy is always a favourite place for bigger Butterflies like Tailed Jay, Common Jezebel, Common Rose, etc.

There is a Loranthaceae Family member growing on *Lagerstroemia thorelli*. The larvae and adult of 'Gaudy Baron' butterfly were observed and photographed in the vicinity of this plant, which is a known host plant for this butterfly.

The shrub clusters and climbers also make another habitat for insects. Shrub cluster of *Hedychium caronarium* (Sontakka) supports complete lifecycle of a skipper 'Grass Demon'. I have seen successful life cycles of Grass Demon at least for four years. Another close association observed is of skipper ' Brown Awl' for the last two years. I have been observing larva, pupa and the butterfly stages of Brown Awl on *Hiptage*.

A significant diversity of pollinators like Lepidoptera and Hymenoptera shows that these pollinators get enough nectar and pollens from the

vegetation. Thus different types and stages of the vegetation provides for different needs of these insects including feeding, mating and resting.

4. Relations with other Taxa

Birds

There are about 26 different species of birds, some visiting and some resident, in the garden (Table 4). Out of these 26 species, 25 of the bird species are insectivorous. This indicates a strong prey-predator relationship. Insect population must be enough to support all these varieties of birds.

Another association observed is that of the habitat of decomposition pit shared by varieties of flies and Tickell's Blue Flycatcher. There are two types of Flycatchers, Tickell's Blue and Fantail Flycatcher, indicating a good population of flies and insects.

There is also a resident Spotted Owlet pair in the garden, residing on the palm tree. They commonly

Table 4 : List of Birds

1	Blue Rock Pigeon	*Columba livia*
2	Spotted Dove	*Streptopelia chinesis*
3	Little Brown Dove	*Streptopelia senegalensis*
4	Roseringed Parakeet	*Psittacula crameri*
5	Crow Pheasant or Coucal	*Centropus sinensis*
6	Koel	*Eudynamys scolopaceus*
7	Spotted Owlet	*Athene brama*
8	Common Grey Hornbill	*Ocyceros birostris*
9	Crimson breasted Barbet	*Megalaima haemacephala*
10	Golden Oriole	*Oriolus oriolus*
11	Indian Myna	*Acridotheres tristis*
12	Red vented Bulbul	*Pycnonotus cafer*
13	White cheecked Bulbul	*Pycnonotus leucogenys*
14	Tickell's Blue Flycatcher	*Cyornis tickelliae*
15	White spotted Fantail Flycatcher	*Rhipidura albicollis*
16	Ashy wren Warbler	*Prinia socialis*
17	Tailor Bird	*Orthotomus sutorius*
18	Magpie Robin	*Copsychus saularis*
19	Indian Robin	*Saxicoloides fulicatus*
20	Grey Tit	*Parus major*
21	Thick billed Flower Pecker	*Dicaeum agile*
22	Tickell's Flower Pecker	*Dicaeum erythrorhynchos*
23	Purple rumped Sunbird	*Nectarinia zeylanica*
24	Purple Sunbird	*Nectarinia asiatica*
25	White Eye	*Zosterops palpebrosus*
26	Spotted Munia	*Lonchura malacca*

feed on Geckos. Geckos, in turn, are found in abundance due to availability of insect prey in the garden.

Bats and Bees

Both Wasps and Honeybees have nests in the garden. Though honeybees go long distances for foraging, their requirement for building nest along with some amount of flowering is provided by available vegetation.

Profuse flowering of Kadamba tree not only gives nectar to bees but it is also shared by bats. There are a few long-nosed bats taking refuge on the Kadamba tree and chewing off the flowers and flower balls are thrown on the ground.

Discussion

Broader Context of Landscape Ecology

The study site garden supports unusual species richness of insects. This makes a case to look at this small part of wilderness matrix in a broader context of landscape ecology to understand its importance and ecological value.

"Highly developed landscapes encompass a patchwork of small, highly fragmented patches of semi-natural or favourably managed habitats set within a matrix of intensively managed agricultural and urbanized areas. Within this landscape gardens can provide substantial habitat resources, especially for highly mobile species able to utilize resources from spatially fragmented habitats" (Westrich, 1996)

"Matrix is a habitat between patches of semi natural habitats. The matrix was considered as uniform and ecologically irrelevant. But now because of recent research it is evident that various Matrix types such as agriculture, urbanization etc. can act to provide resource availability and services like movement of pollinators, seed dispersal etc." (Jules and Shahani, 2003)

These two references of research papers talk about the importance of Matrix in ecological functioning, especially their role in the semi-natural patch dynamics. The study garden is a part of the Matrix with large variety of micro-habitats. It provides resources to many insects and a connect between Vetal Hill Complex and National Chemical Laboratory Campus wilderness.

Partial Habitat

The entire home range of an insect species is not covered at one site when the landscape is fragmented into patches and Matrix. The Matrix may consist of several partial habitats. Partial habitats may not provide all resources needed by insect to complete the life cycle but each one is crucial to support some phase or need of the insect for its survival. For example, partial habitat may provide foraging area but not other requirement like nesting.

Partial habitats are usually divided by development activities such as road, railway tract construction etc. This may result in scattering of habitats in a wide space. If the scattered habitats are not close by, then they become practically unavailable to insects. This may lead to extinction of local populations.

Paul Westrich in his paper regarding honey bee habitat conservation says that, "But not all threatened bees can be conserved within nature reserves and not all of a given country side can be establish reserves. Therefore, we should implement programmes which encompass reserves as well as non-reserved habitats." The partial habitat quality is also important, especially to influence the availability of pollinators. The problems of partial habitats are : 1) insect pollinators require different habitats at different stages of their life cycle. 2) If matrix alteration takes place and it consists of more flowering plants, insects may not visit adjacent agricultural area and need of the agricultural crop will not be fulfilled. In case of other ecosystems role of insects in the matrix with the ecological dynamics of semi-natural patches will be restricted, resulting in less genetic diversity. (ref; Paul Westrich, 1996) This explains the importance of partial habitats in the Matrix.

Thus, the presence and distribution of partial habitats determine survival of insect population dependent on them. Partial habitats play an important role in landscape matrix. They may not serve all needs but are important to complete some phase of their life cycle and survival. Partial habitats become important for the following reasons.

1) Optimum distance between partial habitats is important. If the partial habitats are scattered and not close-by then they become practically unavailable to insects affecting local population of insect.
2) Quality of partial habitat available for use is important, as it decides existence, survival and population threshold of insects.
   a) Quality of partial habitat will be beneficial to insects if habitats are natural and not manicured.
   b) Use of chemical fertilizers and insecticide will have deleterious effect on insects.
   c) Habitat quality also depends on the number and type of micro-habitats.
3) Inclusion of Partial habitats into the landscape is

necessary.

Matrix is an important aspect of urban ecology but its dynamics remain a challenge. Matrix is essential to maintain connectivity between fragmented wilderness patches. But in urban area matrix is altered for the development purposes and very small area remains as matrix. Hence efforts need to be undertaken to preserve and enhance matrix areas in urban landscapes.

Significance of semi-natural grass habitat

Unlike planted trees and shrubs, grass patch in the garden is completely natural. The wild grasses start growing with the monsoon. As monsoon advances, there is a change in the grass species and wild herbs. This part of the garden is unfrequented, and without any intervention. All these conditions favour insect diversity. There is maximum diversity of insects which resides in this habitat.

Approximately four varieties of small sized moths, two big size moths, one species is owl moth, one species of wasp, four species of small size 'blue' butterflies, two species of grass yellow butterflies, three species of damsel flies, two species of bugs form species diversity of natural, non-manicured, grass habitat in the garden. This richness of species compared with the patch of lawn is much greater. The lawn with horticultural variety of *Paspalum* grass is visited only by four to five butterflies. Other insects, moths were rarely seen visiting lawn, indicating importance of natural habitats. It suggests that to support biodiversity in urban areas, there is a need to keep one corner of garden habitat in a natural state.

Conclusion

This study indicates role of surrounding habitats to support larger wilderness areas and acting as stepping stones for conserving local biodiversity.

Targeted efforts to protect and enhance habitat diversity and quality are needed in urban areas. And multi-taxa studies like these will help us to understand the local conditions that sustain urban wilderness and help in designing landscape restoration projects and biodiversity parks.

Advantage of this exercise is that solutions to enhance local diversity requires less effort and less investment as it is only benign neglect to allow the ecosystem to revive itself.

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Bug (Homoptera)

Moth (Lepidoptera)

Pale Grass Blue

Canara Swift

Common Hedge Blue

Honey Bee

Damsel Fly

One Spot Grass Yellow

Moth (Lepidoptera)

Damsel Fly

Damsel Fly

Moth (Lepidoptera)

Representative biodiversity in the natural grass patch

Lifecycle of Brown Awl on Hiptage benghalensis

Lifecycle of Grass Demon on Hedychium coronarium

Lifecycle of Gaudy Baron on Dendropathoe falcata (Lorenthus)

The following link shows the total insect diversity photos in the study site :
https://bit.ly/2UHaUMB

Reprint

What Should be basis of Human Life? – Engineering, Economics or Ecology?

Prof. Prakash Gole, Founder, Ecological Society

Present article is based on Dubhashi Memorial Lecture titled "Significance of 3 Es", delivered by Prof. Gole in 2007 at Pune University. It is being published here due to its relevance to present modern life which is relying more and more on engineering, technology and economics (crony capitalism) while completely neglecting Ecology.

The 3 Es, Engineering, Economics and Ecology should be the basis of human life. But are they really? Indeed the first 2 Es definitely form the basis of modern life. Without engineering and technology modern life cannot be conceived. Also human beings are taken to be rational, objective. Self interest governs their actions and attitudes. Objectivity, not sentiments, is essential for the advancement of science. Economics therefore, which assumes rational human behaviour based on self-interest, rules human behaviour and social relations.

The third E, Ecology, however, lacks recognition. It seems invisible, is neither immediately felt nor readily identified. The general consensus is, Ecology is something extraneous, can either be totally dispensed with or replaced by technology. Human beings are or can become capable of producing every arrangement that nature has taken millions of years to produce through evolution. In India we already have a role model in sage Vishwamitra who threatened to produce exactly a parallel world.

The first 2 Es are therefore, considered enough for the survival and welfare of people, rational human beings technologically adequately equipped. Let as now analyse what the first 2 Es imply. Human beings started using engineering and technology ever since they used a stick to grab a fruit from a tree or to dig roots and tubers. But the real use of technology began when people started harnessing energy first fire, then fossil fuels like coal and peat, then hydro-electricity, oil and atomic energy. Technology essentially involves transformation of matter by using energy. As everyone knows matter and energy are governed by laws of thermodynamics. The first law states that matter and energy can neither be created nor destroyed. Energy is used not consumed. Energy is high grade when it is in a form with high availability to do applied work. All natural and technological physical processes proceed in such a way that the availability of energy involved, decreases. What is consumed when we use energy, then, is not energy itself but its availability to do useful work.

The second law of thermodynamics tells us that it is impossible to recycle energy and that eventually all energy will be converted into waste heat. Also it is impossible to recycle materials with 100% completeness. Some material is irrevocably lost in each cycle. If matter and energy cannot be created or destroyed, what does the economic process do? Matter and energy enter the economic process in a state of low entropy and comes out of it in a state of high entropy.

Any living organism fights the entropic degradation of its own material structure. Man's economic activity may transform a high entropy copper ore into a low entropy copper sheet but this lowering of entropy is more than compensated by increase in the entropy of the surroundings. In entropy terms the cost of any biological or economic enterprise is always greater than the product. In entropy terms any such activity necessarily results in a deficit.

The transformation of matter by energy, which is the essence of technology therefore, involves costs - costs in terms of lost quantities of matter as 100% transformation is impossible and costs in terms of energy passing into a state of unavailability; also these two things involve creation of waste leading to entropy of surroundings - a local cost in terms of pollution and garbage. Now if all these costs are taken into account, the cost of production of any commodity, where energy other than solar energy, is used, is higher than its value. Increase in production means increased costs. This is how the first E is intertwined with the second E.

The economic effort is actually a dual effort. It aims

at producing a surplus by keeping down costs. In nature however, surplus is produced without apparent costs by plants using solar energy. The use of solar energy through solar energy apparently considerably slows down the operation of the laws of thermodynamics. In photosynthesis food is synthesised for plants for their survival needs and additional food is produced for the survival needs of other organisms. Very little solar energy is passed out as waste heat and almost no waste is produced to increase the entropy of surroundings.

What evolution has produced is a closed system. Matter is recycled and energy is radiated without producing waste. Entropy in the surroundings is mainly through accidental happenings, sudden, natural events such as exceptional floods, fire, lightning, earthquakes, meteoric hits, droughts or failure of rain. Evolution continues its work of remediation and rehabilitation resulting in reduced entropy.

In such a system as costs are low so is the surplus. In a mature forest the net productivity is zero. Whatever is produced is consumed and/or recycled. Surplus is small and cannot be stored for a long time. All animals living in the forest are tuned to utilise this small surplus whenever it is available. The small amount of this surplus controls their populations and keeps them in balance with food supply. Ecology thus puts limits on the creation and maintenance of this surplus and controls population growth. Human beings can only increase the food supply and consequently human population by negating controls prescribed by ecology.

The relationship between the three Es can be explained as follows: Engineering and technology aim at increasing the amount of the surplus and make it as long lasting as possible; Economics prescribed and regulated the distribution of the surplus in such a way as to facilitate advances in technology and Ecology defines the limits to the creation of this surplus and awakens in human beings a desire to desist from the possible disastrous consequences of man's actions in increasing the surplus.

Surplus is only produced by negating the influence of ecology. Agriculture is the earliest human effort to produce a surplus. Essentially agriculture means a mono-culture contrary to poly-cultural arrangements existing in nature. The ecological control on agriculture is expressed in terms of pests that try to destroy crops. In promoting agricultural surplus people are still trying to overcome these controls either by using chemical weapons or by following rather than opposing ecological principles, as in organic farming. The gross amount of surplus increased enormously when people started using machines run on various forms of energy such as coal, oil and electricity. Ecological controls were not immediately apparent as they appeared as social costs. As emissions and effluents were freely discharged in the atmosphere or rivers, the pollution so caused was borne by the society as a whole. Private costs were kept low through monopoly on raw material sources, low wages, child labour and captive markets. Natural wealth of colonies in Asia and Africa was freely exploited and manufactured goods sold in those countries. The scale of production came to be increased enormously through the application of technology realizing the economies of scale. The post Second World War boom resulted in overexploitation, indeed ruthless exploitation of resources, especially non-renewable resources. The result was rapid depletion of accessible stocks and rise in social costs such as pollution and waste. The industrial society of USA was described by Prof. Galbraith as producing private affluence and public squalor. With the growth in the scale of production, ecological controls came to be felt as waste and pollution increased by leaps and bounds. This was the time (in the seventies of the last century) when environtalism had its birth. It was an attempt by a few to make the majority aware of ecological controls and pay heed to them.

Industrialism which was the result of great advances in technology during the second world war, though global in character, may spawn its own anticlimax. One may even ask will it dig its own grave? At present industrialism, whose social incarnation is capitalism, is basking in its own triumph which resulted from the almost total annihilation of communism. But to make the surplus larger and more permanent, it must constantly search for cheaper and more accessible sources of raw material and energy and improve technology so as to reduce social costs, the so-called externalities, which costs have to be internalised due to pressures from the environmental lobby and legislation. This constant need to reduce costs (as scale is increased) results from the operation of laws of thermodynamics. Large-scale transformation of matter through the use of energy produces large-scale entropy, i.e. waste and pollution.

The need for reduction of costs calls for greater investments in raw materials, energy and improvements in technology. This calls for capital accumulation through savings which are made by concentrating wealth in ever fewer hands and if governments make the investments, by depriving the

majority of many necessities of life like good education, health, sanitation, fuel, fodder and shelter. In less developed nations it also involves destruction of natural capital on which the livelihood of many depends. Indeed the number of people in slums is a measure of the destruction of natural capital and the number of people in upper and middle classes is a measure of the population that can be supported by man-made capital! The need to reduce costs deprives people from having adequate purchasing power to make a living possible as creation of man-made capital has increased costs all round. Shrinkage of purchasing power leads to failure of demand which periodically plagues capitalism. One must realize the direct connection between poverty amelioration and existence of natural capital. The greater the amount of natural capital the less will be the poverty and the greater the amount of man-made capital the greater will be the poverty!

Deprivation of adequate purchasing power for the majority and greater inequity in distribution of income make a mockery of all the ideals that a free, capitalistic society is supposed to have!

In reality ecological controls are becoming manifest through these two forces. The so-called developed countries are trying to thwart them through improvements in technology and greater access to available energy and resources. Technology requires great investment which becomes readily available during a war effort. One wonders whether it is in the interests of advanced technological nations to fan the fire of wars so that they can justify to their people greater investments in technology which always come at the expense of peoples' welfare.

The tragedy is that the less developed countries are trying to follow the same model, i.e. larger scales of production, greater and ruthless exploitation of natural resources, higher entropy of surroundings, greater inequality of incomes and lack of purchasing power for the majority. Higher investments in technology and production are possible by denying a majority of people education, health, sanitation, fuel, fodder, shelter and clothing. The apparent prosperity and wealth that is seen in certain pockets, in rural and urban areas is due to mining and liquidation of stocks of natural resources : air, water, soil, forest and marine wealth. The figures speak for themselves. Almost 50% of the land area lies in various degrees of degradation; most of the rivers lack fresh water flows and are actually sewers; natural forests cover smaller area each year though plantation monoculture has increased; there are 86 threatened mammals in India as against 76 in China though in land area China is far larger than our country; there are 1236 threatened plant species in India as against only 312 in China. It seems that ecological controls are being negated by deliberately destroying ecology, the very foundation of our life. All people are not unaware of the impending crisis. There are efforts and movements to counter centralisation of power, to make the production of surplus more people-oriented, use soft technologies and restore degraded eco-systems. Watershed development, eco-system approaches and restoration are being used to promote environmental awareness and ecological rehabilitation.

All these may prove mere palliatives and not cures. A much more holistic approach is required. Only then will the promotion of greed inherent in the present system because of periodic failure of demand, be replaced by saner and judicious management of resources and markets. There should be a conscious effort to recognise ecological needs and to allocate adequate resources for them . In effect we must recognise the importance of and the necessity to bring back the operation of ecological controls. This is essential to control the greed of a few and satisfy the needs of many. The imperatives to achieve this are :

1. Decentralisation of planning: local resources used to satisfy local needs. Watershed development, the present local developmental effort, should not only aim at increasing the surplus but satisfying the basic needs of all. Basic needs include besides food, clean air, potable water, health and sanitation, adequate education, fuel, fodder, timber and other biomass etc. To provide these it is necessary to keep these resources in good shape ; i.e. restoration and qualitative improvement of atmosphere, water(stream), soil, vegetation etc. in other words to allocate resources for eco-system functioning. Agricultural production should be planned and market at village level. Though land remains individually owned, its utilization, i.e. crop pattern, water use should be planned by the village as a whole.

2. Landscape approach in planning: planning of the use of resources based on geographic and geomorphic features, soil and lie of the land, climate and vegetation. The aim should be welfare individuals in a particular landscape. Thus agriculture need not be taken into account.

3. Avoid settlement and other "brown uses" on agriculturally good soil.

4. Restoration of degraded eco-systems, especially compensatory restoration to be made compulsory to all major and medium projects; the focus has to be on

restoration of natural capital.

5. Rejuvenation and revival of local and indigenous varieties of crops, fruit, fibres, domestic animals breeds and their marketing on a village or a group of village basis. The idea is to develop specialties at local level and to that extent frees villages from the middlemen. Also to encourage service and processing of produce at the village level.

6. The basic idea is to restrict the scale of production in such a way as to provide minimum resources for the production of intermediate goods. Such abstinence and restriction of ostentatious and orgiastic consumption can be possible with universal, correctly designed, holistic education. It should emphasize inter-relationships between various disciplines and should not erect unbreakable walls between them. Ecological research will have to be the foundation of this system. Technology has to change its direction and content. Soft technology seems to be essential for providing welfare to all sundry. Technology should facilitate rather than obstruct and replace the essential ecological services and processes. Replacement is costly and will have side effects.

The welfare of the individual should be the prime concern and not of the economic system. In all fields and areas, today's policies seem to favour the market and the economic system and not the individual. Dreams of a strong and powerful India can be realised not by augmenting the GNP or by increasing the growth rate from 3 to 13% but by making individual citizens educated, enlightened, responsible, work conscious, healthy and happy.

Book Review

Alternative Futures : India Unshackled
Edited by Ashish Kothari and K. J. Joy

Bhargavi S. Rao

Bhargavi Rao works with Environment Support Group (ESG), where she leads variety of Research and Educational projects and Campaign initiatives. She coordinates educational and training programmes at ESG with a focus on enhancing awareness and critical engagement in social and environmental justice issues. She is currently working with Azim Premji Philanthropic Initiatives (APPI).

The book could not have been written at a more appropriate time. It is a timely contribution to enrich our understanding of what it takes to not be depressed about the state of the planet, and our world, but to find ways to work for a future of harmony with each other and nature. Students, regulators, journalists, judiciary, civil society, corporate sector, philanthropists and just about anyone who wishes to influence positive change for the present and future will find this book an invaluable read.

At a time when the world is undergoing unprecedented political turmoil, when marginalization, discrimination and violence is being normalised, when fundamental freedoms of human rights and environmental activists are being substantially compromised, and political leadership in country after country and region after region is proposing policies of intolerance, this book emerges as a silver lining in a dark political cloud hanging over our lives. This is a book that seeds hope and shows us how there is a way out to make this world a better place!

Working around broad themes, the book collects views of people who have worked tirelessly on alternatives over decades. The writing is easy, as it comes from the heart and the lived experiences of the writers. Eye catching and beautiful illustrations, aptly chosen for each of the themes, make reading of this to me pleasant. I did get lost, like a little child, looking at these illustrations. Bindia's illustrations, are particularly illuminating, and one wishes more of her distinctive art style would cheer us up, especially now.

This book is crafted with essays that use no complex language. Each essay has a summary that helps one decide what to expect, and so invest one's time with prudence, and to great satisfaction. The essays aren't too long, making reading tiring, nor too brief, suffocating the writer from expressing with clarity. Each essay also has some concluding points which guide the reader on pathways of solutions; not in any didactic manner, but inspiring one to employ one's imagination and agency to deal with the challenge at hand. There is clarity, and no uncertainty in what is said.

When one looks up from reading this book, one is empowered with a useful lens to look at what's going on in his/her neighbourhood/village/city, and assists in how s/he might want to respond. I say this because often we are consumed by a problem, or problems, that capture our attentions that we fail to focus on possible solutions.The book helps us leave a disorienting and disempowering space and enter one where one does not feel defenceless in dealing with the complex challenges of our times. We are pushed out of a cynical space. Urban Setu in Dahanu Taluka, Mendha Lekha, Deccan Development Society, Dharani initiative of Timbaktu, the question of Bengaluru Lakes, SRI method of cultivation and several other initiatives propel the reader to get engaged in positive reform, and with sound alternatives to boot.

Systemic governance challenges are addressed as well: that of land degradation, erosion of seed sovereignty, encroachment of commons, pollution of rivers, lakes and out air, challenges of local governance. They need deeper enquiry, and that is missing in the book. In the urgency to present, even illustrate, utopic futures, and that from prevailing dystopias, this is not sufficiently explored. Distressing environmental catastrophic events that India has suffered aplenty, such as the criminal leak of poisonous gas in Bhopal, the contamination of Plachimada's ground waters, mercury poisoning in Kodaikanal, the damming of the

Narmada, the systematic despoliation of the mighty Ganges, the recklessness of urbanization, all need to be critically examined, and exhaustively deconstructed so the construction of a future is guided with care not to repeat the mistakes of the present.

Imagining utopias is essential. And some essays do that. This helps the next generation to figure out how to push beyond the imaginations of the future from the understandings of the present. Some of these exercises in imagination are imaginative and extremely well articulated, even leaving one with the feeling of living that now. But some don't – they stop short, fearing imagination and argument against the present.

The book seems simple at first glance. But do give it a detailed reading. And slowly the book will ooze out a range of positive and thought provoking ideas, and put one in an intriguing place.

A few major takeaways :

Kartik Shankar and colleagues argue "The power to produce certain forms of knowledge gives selected actors the power to govern in specific ways. We hope to see in future a democratic production of knowledge in which more forms of knowledge are included enabling what Vishwanathan (2005) has called 'cognitive justice'. This will ensure more equitable conservation governance than is currently the case" This reminds one of the rich ethnobotanical knowledge that constitutes traditional farming in India and of the extraordinary knowledge of tribal communities' of their ecological landscapes, and raises crucial questions how to protect and conserve these knowledge systems and of natural resources that they help shelter from prevailing extractive forms of development.

Discussing Pastoral futures, Ilse Kohler and Hanwant Singh Rathore in their vision for 2047 discuss Livestock Keepers Revolution, in which the livestock keepers have become empowered through education and organisational strengthening and are adept at managing the country's livestock wealth healing the pastures. They draw attention to many international and national efforts empowering pastoralists, and examine how we can turn away from prevailing conditions when commons are under attack eroding pastoralism itself. It leaves the reader with questions how to organize pastoralists now, mobilize them and ensure their livelihoods are secured, how selling meat, milk and wool craft gets better and fair price. How does one ensure they can lobby powers that be and demand their right to exist and prosper is secured.

Uzrammaclosely examines the state of cotton growers and the handloom sector,and draws our attention to the fact that India still retains one of the largest scales of craft production. The essay has beautifully woven accounts of the nature of the handicraft form, which uses hardly any resource but demonstrative of great ingenuity: "the artisan is naturally frugal; it is part of artisanal respect for and relation to nature". She also throws light on the syncretic folk philosophy, of how Kabir's verses often referred to earthen pots and woven threads resonating with a diverse continent. As one travels across India and pays close attention to the different kinds of textiles, the yarns, the embroidery and other craft works that are typical of each region, one realizes the delicate fabrics and products are interwoven with the lives, livelihoods and futures of the craftspeople. . It reminded me of the range of embroidery of the Kutch region: Suf, Khaarek, and Paako, Rabari, Garasia Jat and Mutava, each with its own distinct style, using the needle, thread, pattern, mirror, beads, etc. and each style emerging from a different community.

It is all so fascinating how the womenfolk of the Rabari community, who are essentially cattle breeders and embroiderers, craft with joy that also build the economy. There are various villages across the Kutch region famous for their exquisite Kutchi embroidery with appliqué work, as well as Kutch embroidery on leather. Uzramma argues for a law that will protect artisan's rights to collect raw materials from forests, and at once also allows them to prosper with their craft. She bemoans how prevailing policies destroy the landscapes that support such rich tradition - bamboos given away to paper mills almost free, local craft based communities are not allowed to touch the bamboo or it is rationed to them. There are many other interesting vignettes Uzramma narrates, such as the one on Indigo - how it is fermented; the story of Guruppa Chetty; the Kalamkari artist's childhood and how they got a little pocket money from indigo dyers!

Discussing *Industry, Workers and Nation*, Dunu Roy describes the Assembly line that gave birth to the Human Relations discipline, and the emergence of automation. This, he argues, has resulted in prevailing outsourcing and contractual arrangements. He details how many formal, informal and 'illegal' workers' protests across the country, to secure rights and access justice, are slighted by such industrial models that extract to reward a few and punish most others. It takes the reader back in history to the days when many of our cities and towns were witness to rallies and protests organized by the public sector trade unions, watching workers take out a protest march

every now and then shouting slogans; and makes us wonder whatever happened to such a spirit of asserting rights and claims for fair distribution of wealth. Where are such protests today? It sure is an essay that disturbs settled notions of our understanding of labour, and on the basis of empirical evidence challenges the reader to examine prevailing growth models with great criticality. To put it in Dunu's words, it is about being "part of the politics of a politics of challenging and changing the structures of exploitation, inequality and injustice that are deeply rooted in contemporary capitalist society"

Dare to Dream, the essay by Parameswaran, is thoroughly enjoyable. An interesting line from this essay: "Our Panchayat is freed from alcoholism. It is not total abandoning but tempered consumption". This essay is not about utopia, but of securing the possibility of simple living with high thinking. It helps reorganize our thoughts on the socio economic, ecological and cultural dimensions of a city/village/neighbourhood, and make them work without worrying about limits. The ideas from this essay are exactly what our planners need now to aid in redesigning our cluttered cities, towns and neighourhoods. It provides all the right ingredients to make a perfect dream come true.

Rajni Bakshi's essay entitled *Future Bazar in India* begins and ends with reference to the kulfiwala in Shivaji park, Mumbai. The kulfiwala's business model: a limited quantity of resources, no branding, affordable pricing, and devoted customers, and without any ambition of scaling up, is the story of thousands of self-employed across India. The essay touches on various aspects of the bazaar: those socially anchored all the way to the impersonal capitalist Markets. It discusses the implications of organizing a bazar justly to local agriculture, food chains and trading. The essay concludes with the need to materially reward and socially honour those who celebrate sufficiency, and make their living intricately linked to the common good. This is a very rewarding read, particularly to those who love shopping and eating off the street, making friends with street vendors and small enterprises, and thus enjoy living in a community sense – a world that is being quickly obliterated in many urban areas.

Sujit Patwardhan in the essay on *Alternative Transportation in Future India* discusses many examples from across the world, and also in India, of how to make travel and transport work without costing us the earth. The cycle rickshaw eco cab of Fazilka is a great example that can be easily adopted in every one of our cities and townsm if we are really keen on cutting carbon emissions and making our cities friendly to non motorized transport.

The essay on *The Future of Languages in India*, by G. N. Devy, captures how the many languages of the subcontinent have disappeared and how this is linked to the threats there are to traditional and indigenous communities and their knowledge systems. He discusses the implications of how human societies can get reduced to digital identities. At a time when women self-help groups and farmers in tribal areas are using smart phones and tabs to capture their meetings, upload information, videos, voice recordings and more, in responding to the demands of development interventions guided by funding agencies, a model that government portals want to upscale, the dangers latent to such methods is alerted to us in Devy's writing. It is worrying how easily we seem to shovel so many to fall between the cracks of accessing 'development' and securing the right to live justly and with sovereignty of language and culture. Is technology causing distance and dividing us more, erasing memories and culture, is a crucial question that emerges from this essay.

Pallav Das explains in *Power and Violence* how India's Future is determined by its energy policies. Quoting Dahl's idea of Power "A has power over B to the extent that he can get B to do something that B would not otherwise do" he paraphrases Dahl to assess the Future of Power as "A would exercise no Power over B in pursuit of any task and vice versa, yet the two would form a relationship of equality, reciprocity and sharing where all the necessary tasks of their lives get done under rubric of mutual care". Such unpacking of assumptions is fundamental to our learning as a society if we are to address Power and its latent Violence, and ensure energy is empowering and not violent and disempowering.

Aruna Roy and colleagues from MKSS take the reader through the journey that resulted in the Right to Information Act, onward to MNREGA and then to securing the Forest Rights Act. The essay opens with: "Given the fact that democracy reflects complexity, dreams of the future are bound to be hazy, untidy and unfinished; the wonder lies in its ability to serve as a platform of our collective conscience". It leaves one wondering if we have secured gains from the freedom movement, and of ensuring "collective interest" and "collective thought" being fundamental to our democratic futures.

Khindri and Biswas articulate the problems of the current education system in the essay Future of Learning in Indian Schools. A line that resonated with me

was " During the first forty years after independence, large public sector undertakings and comparatively inclusive townships provided a space where in children (and Families) from diverse socio-economic and cultural backgrounds lived side by side and this provided an environment rich in diversity in settlements as well as learning spaces. That has also shrunk drastically and almost evaporated today" Growing up in cosmopolitan towns and cities which were essentially a hub of the Public sector undertakings that caused cosmopolitan living, children grew up learning multiple languages -Tamil, Telugu, Malayalam, and also developed a taste for the varied cuisines. All this helped build syncretic traditions. But today living in Metros has become increasingly and experience of being gated. This essay draws us to take a critical look at how our schools are adjusting to this new reality, instead of aiding students with skills to challenge the status quo.

In offering their concluding perspectives, Shrishtee Bajpai and Sarita Bhagat discuss how the authors came together for a dialogue. The motive behind the book, we are told, is to enable a cross fertilization of ideas, as in nature. The narrative of these discussions has been captured so well, that one gets the feeling one was there!

The last of the essays, *Looking back into the future : India, South Asia, and the world in 2100* : leaves the reader spellbound, may be even teary eyed. Yes it's possible that this is the positive world one will leave behind for the future generations! This essay is like one has the agency to construct facts into the Utopian world we are all egging to imagine, so we head in the right direction from here on!

Project Report

Ecological Guidelines and Recommendations For Mula-Mutha Riverfront Development

Dr. Swati Gole, Revati Gindi, Dhruvang Hingmire, Sneha Ghate, Aditi Deodhar, Dr. Gurudas Nulkar

The Mula and Mutha rivers that emerge in the Western Ghats and flow through Pune are integral to the evolution and life of the city of Pune. The ecosystem benefits from these rivers are linked to the physical form of the river and its watershed. For more than 300 years, citizens of Pune have a close spiritual, cultural, recreational, educational relationship with the rivers. In the last few decades natural ecosystem functions of the rivers have diminished considerably because of increasing anthropogenic pressures.

Public deliberation is critical in the decision and choice of improvements, and the best strategies for achieving the desired outcomes. The upcoming riverfront development program of the twin rivers of Mula and Mutha is intended to beautify the rivers and is expected to offer citizens a place to relax and rejuvenate. Such deliberation must be informed by sound public information and multi-disciplinary knowledge. It is this concern for knowledge-based environmental governance that led Centre for Environment Education to partner with the Ecological Society to bring out this study.

The Ecological Society conducted this research between June 2017 December2017. The aim was to review ecological state of river Mutha and while developing river front what could be the ecological "Does" and "Don't's". It especially focused on the diversity of habitats, and sites of geological and historic interest.

Past studies and reports were reviewed. The experts on river ecosystems were invited for the brainstorming workshop by the Ecological Society. Dr. Himanshu Kulkarni expressed his views regarding ground water situation along the Mutha river, Dr. Priyadarshani Karve about social repercussions of riverfront development proposed by Pune Municipality , Dr. Hemant Ghate about fauna of the river, Dr. Vinaya Ghate about flora of the river and Dr. S. N. Rajguru, eminent geologist and archaeologist regarding conservation of paleo-deposits along the river. Geological records reveal that the Mula and Mutha rivers are nearly 200,000 years old. Their continuous ecological functions and processes have crafted the neighbouring landscape.

Ecological survey was conducted over a stretch of approx. 22 kms along Mula-Mutha rivers flowing through the Municipal boundaries of the city. The stretch was divided into 5 zones, based on the nature of the river and cross section of the channel.

For each zone a quantitative and qualitative assessment of habitat was carried out in which ecological and cultural hotspots were recorded, interventions and threats were identified and opportunities were examined. Twelve types of culturally and ecologically important spots were identified and marked them on the zone maps. Special ecological features like Rocky banks, Mouths of Feeder streams, Alluvial surfaces, Grassy patches, Riparian habitats, Faunal hotspots, and cultural feature like Ghats, Places of worship, Memorials and Heritage structures were recorded. Based on this analysis, we classified the zones into three grades and broad strategies for each grade were recommended.

Grade 1 : Zone 5 (Babasaheb Ambedkar Bridge to Aga Khan Bridge) and Zone 4 (Mula-Mutha Sangam to Ambedkar Bridge (Bund Garden)) are classified as the relatively best zones. Here the flow and character of the river are good, there are hotspots and these zones have minimum interventions. The overall strategy for this zone should be one of no intervention and benign neglect.

Grade 2 : Zone 1.1 (1Warje Bridge on Pune-Mumbai Highway to Rajaram Bridge) and Zone 1.2Rajaram Bridge to Mhatre Bridge) have a relatively moderate ecological and cultural value. The broad strategy for this grade is one of partial intervention.

Grade 3 : Zone 3 (Baba Bhide Bridge to Mula-Mutha Sangam) and Zone 2 (Mhatre bridge to Baba Bhide Bridge) have the least ecological value and severe interventions. For this grade we recommend

substantial interventions and monitoring.

Inundating the river fully will submerge several of the important features in the river bed. Physical modifications of the river bed, such as excavations for laying pipes, building of bunds, retaining walls, conversion of natural banks into manicured gardens, expansion of ghats etc. would destroy not only these features but may completely stop the functioning of the river as a living ecosystem resulting in permanent loss of a healthy natural system to society. Proposals to create manicured gardens while seeming benign are also destructive of natural biodiversity.

These findings must be considered in the Environmental Impact Assessments of any of the river related projects being planned. These findings also contribute to developing a deeper understanding of the ecosystem values and benefits of the Mutha to the city and how they can be restored.

Any complex decisions about how the river ecosystem can be improved must be done with the participation of the public. Both ecosystem values as well as democratic values must be integrated into decisions about these precious assets of our city.

The vision plan for a holistic improvement in the river rejuvenation must address :

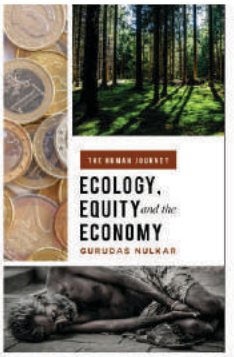
A. Conservation of the river as a natural entity.
B. Restoration of natural zones along the river
C. Maintaining environmental flow and carrying capacity
D. Decentralized approach to river rejuvenation
E. Restoration for utility and aesthetic value

Some key recommendations include those about :

- Selection of plant (native) species for plantation in riparian and upland area and management of alien and invasive plant species
- Restoration of in-stream habitats and riparian zone and protection of existing riparian zone vegetation.
- Retention of The natural topography and drainage patterns of the river banks and river bed during construction.
- Minimum use of cement.
- Water quality of the river to be maintained as per international / tropical standards
- Removing channelization of the river ecosystem to facilitate restoration
- Conservation of natural springs in the catchment of the river and removal of obstruction in their flow.
- Creation of retention / detention basins along the river wherever sufficient space is available.
- Preservation of geologically important areas such as alluvial filled surfaces
- Management of biotic pressures such as grazing, fishing, Dhobi ghats, places for ritual, eateries and recreational areas
- Restoration of Heritage structures along the river and creating places for environmental education.

The full report is available at the Ecological Society, Pune office.

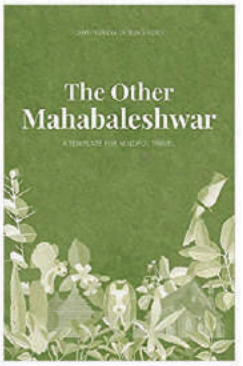
New Release



Available on Amazon

Ecology,Equity and the Economy | Gurudas Nulkar

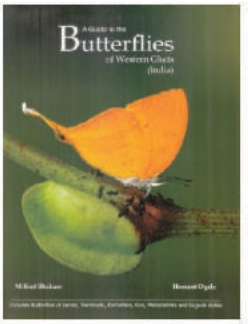
Even as some of the greatest minds have contributed to its development, modern economics clearly seems to have missed society's expectations. Human economic activities have continuously grown our ecological footprint and widened the gap between haves and have nots. This book takes the reader on a fascinating journey of the history of trade and commerce and analyses what went wrong at each stage. The author discusses reasons and impacts of natural resource depletion and effects of consumption driven growth on society and nature. An alternative economic system to facilitate the transition towards a sustainable future, is proposed.



Available on Amazon

The Other Mahabaleshwar | Sonam Ambe, Anand Pendharkar, Seema Hardikar; Editor - Dhruti Vaidya

Located at a height of 1353 m, Mahabaleshwar boasts of multiple attractions, rich in history, biodiversity, and architecture. This book introduces readers to the natural and historical treasures of Mahabaleshwar. It serves as a field-guide for nature lovers and conservationists, and also a travel-guide. It is a valuable record of history that may be lost, if not documented so wonderfully by the authors. The book gives a deep insight into what really matters - preservation of this beloved hill-station. The book is a one-of-its-kind field guide to that place of continual wonder and delight, an invitation to share in an ongoing love story.



Available here http://bit.ly/2RxeV4k

A guide to the Butterflies of Western Ghats | Milind Bhakare,Hemant Ogale

The butterfly fauna of the Western Ghats, a biodiversity hotspot in peninsular India, is unique because it is diverse and yet exhibits low levels of endemism. The butterfly assemblage here has Oriental and African elements which have dispersed to give rise to the unique community. The authors have explored this region at length and present here the first butterfly guide to this region. The book is aimed at students and butterfly enthusiasts and the information about natural history will be helpful to seasoned butterfly observers too. The book describes life history and behavior and the morphology of butterflies. The book is flush with images and the identity features and comparison plates are useful for identification.