Watershed Organisation Trust

Connecting the Dots

Evolving Practical Strategies for Adaptation to Climate Change

Biodiversity

A Key for Adaptation to Climate Change

WOTR

Biodiversity: A Key for Adaptation to Climate Change

Authorship and Citation
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Reviewed by: Prof Madhav Gadgil (Retired) Renowned ecologist; founder and former Director of Centre for Ecological Sciences (CES) at Indian Institute of Science (IISc); former member of National Advisory Council (NAC); was Chairman of the Western Ghats Ecological Experts Panel (WGEEP) set up by Ministry of Environment and Forests, Government of India. He was awarded the Padma Bhushan by the President of India. He is a Fellow of Indian National Science Academy, Third World Academy of Sciences, and Foreign Associate of the US National Academy of Science.

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Foreword

Climate change is already underway and its effects, especially on rural communities in India, are particularly adverse. The need is to highlight the key issues and understand the practical challenges that must be addressed if India is to build the capacities of rural communities to robustly adapt to climate change and realise the National and State Action Plans on Climate Change (NAPCC and SAPCC).

Since the last four years, WOTR has been implementing a large-scale integrated project on climate change adaptation in rural Maharashtra, Andhra Pradesh, and Madhya Pradesh in collaboration with NABARD, the Embassy of Switzerland in India, the Swiss Development Cooperation (SDC), the Indian Meteorological Department (IMD), the Central Research Institute for Dry-land Agriculture (CRIDA), the World Agro-Forestry Council (ICRAF), and the State Agricultural University (MPKV).

This experience has crystallised insights, lessons, and observations from multiple stakeholders, which we have formulated as Position Papers across 12 thematic areas, namely Watershed Development, Water, Food and Nutrition Security, Agriculture, Livestock, Biodiversity and Ecosystem Services, Disaster Risk Reduction and Risk Prevention, Alternative Energy, Economics and Livelihoods, Health, Gender, and Governance.

These papers assess and analyse the key policy and operational challenges faced in building adaptive capacities across sectors, from the perspective of key stakeholders; aim to contribute towards formulation of an enabling policy and operational framework that would facilitate effective implementation of the NAPCC and SAPCCs in rural India; and hope to trigger creative dialogues between key stakeholders with a view to providing effective support to efforts that seek to build the adaptive capacities and resilience of rural communities.

The paper 'Biodiversity – A Key for Adaptation to Climate Change' explores the role that biodiversity plays in shaping the adaptive response to climate change. It also documents how degradation of biodiversity can amplify the impacts of climate change, and how biodiversity itself would be under increasing threat from both the climate change and its anthropogenic response, aka adaptation, under business-as-usual economic models. It argues for community-driven, ecosystem-based adaptation, with a call to scrutinise the adaptation programmes and projects for their impact on ecosystem services, which are the true building blocks of adaptation, as also proxy indicators of the health of biodiversity.

Key Messages

- *Biodiversity is a key to how well people can adapt to climate change;*
- *The poor, the marginalised, and women need to be involved in planning and decision-making so that they also derive sustainable livelihoods from these resources;*
- *We need to set different guidelines for policy, alter incentive structures, reduce or phase out subsidies (that promote wanton degradation of ecosystem services), and engage businesses and the common person in a vision for a new economy – an economy that recognises the value of nature's services and the costs of their loss;*
- *We must establish environmental limits to ensure that society remains within them, in order to achieve sustainability; and*
- *We need to use Ecosystem-based Adaptation (EbA), an emerging approach that works with nature to help vulnerable communities build resilience into their ecosystems and livelihoods which are being threatened by climate change impacts while generating significant multiple benefits – social, economic, and cultural.*

Background

Biodiversity is a variety of all forms of life. It is the variability among living organisms and their habitats, including the diversity within species, between species, and within ecosystems.

Biodiversity underpins the essential goods and services that ecosystems provide, and has value for current uses, possible future uses, and intrinsic worth. There are 530 million distinct species on Earth, the most being micro-organisms. Only about 1.75 million have been formally documented.[1] All the interactions between the components that make up the total global biodiversity set the foundations on which human society has evolved.

The links between biodiversity and climate change run two ways: biodiversity is threatened by climate change; but proper management of biodiversity can reduce the impacts of climate change.

Biodiversity: to Reduce the Impacts of Climate Change

Biodiversity-based adaptive and mitigating strategies can enhance the resilience of ecosystems and reduce the risk of damage to human and natural ecosystems. Mitigation is described as a human intervention to reduce greenhouse gas sources or enhance carbon sequestration. Adaptation to climate change refers to adjustments in natural or human systems in response to climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.[2]

Examples of activities that promote mitigation of or adaptation to climate change include[3] maintaining and restoring native ecosystems;

[1] http://intranet.iucn.org/webfiles/doc/SSC/SSCwebsite/Policy_statements/IUCN_Guidelines_for_the_Prevention_of_Biodiversity_Loss_caused_by_Alien_Invasive_Species.pdf

[2] Ad hoc Technical Expert Group on Biological Diversity and Climate Change. 2003. CBD Technical Series No.10, Secretariat of the Convention on Biological Diversity. Guidelines for promoting synergy among activities addressing biological diversity, desertification, land degradation, and climate change. CBD Technical Series No. 25, Secretariat of the Convention on Biological Diversity.

[3] Ad hoc Technical Expert Group on Biological Diversity and Climate Change. 2003. CBD Technical Series No.10, Secretariat of the Convention on Biological Diversity. Guidelines for promoting synergy among activities addressing biological diversity, desertification, land degradation, and climate change. CBD Technical Series No. 25, Secretariat of the Convention on Biological Diversity.

protecting and enhancing ecosystem services; managing habitats for endangered species; creating refuges and buffer zones; and establishing networks of terrestrial, freshwater, and marine protected areas that take into account projected changes in climate.[4]

Traditional crops, on the verge of extinction, bouncing back to the rescue!

Several farmers in the Akole *taluka* of Ahmednagar district in Maharashtra, India, plant crop varieties resistant to floods, drought, and other difficult weather conditions. Sattechiwadi is one such village. Located in the rain-shadow area, it receives an average of about 500 mm of rain each year. Normally, these conditions should preclude the growth of rice altogether. However, some farmers here were observed to have successfully planted a variety of rice locally known as *Dhobal*. This variety is obviously drought resistant and is grown widely in village Fofsandi of Akole *taluka*, which normally receives moderate to high rainfall. The farmers in Fofsandi grow nine varieties of traditional/indigenous cultivars of rice to cope with variability in weather. A diverse genetic base, together with extensive traditional knowledge, is necessary to produce varieties with such characteristics. Therefore the indigenous cultivars, coupled with the traditional knowledge, form the adaptive knowledge systems. One in absence of the other would be suboptimal and likely to fail.

Similarly, in Sattechiwadi village, a couple of farmers cultivate the *Dhobal* variety of paddy in the Kharif (monsoon) season. The farms are very small in size (not exceeding, in any case, four acres) and lie in the main drainage line of the village. As this area gets flooded for a few days every monsoon, there is nothing other than paddy that can be grown there. It has two cultivars: one white and the other red.

Specialties of *Dhobal*

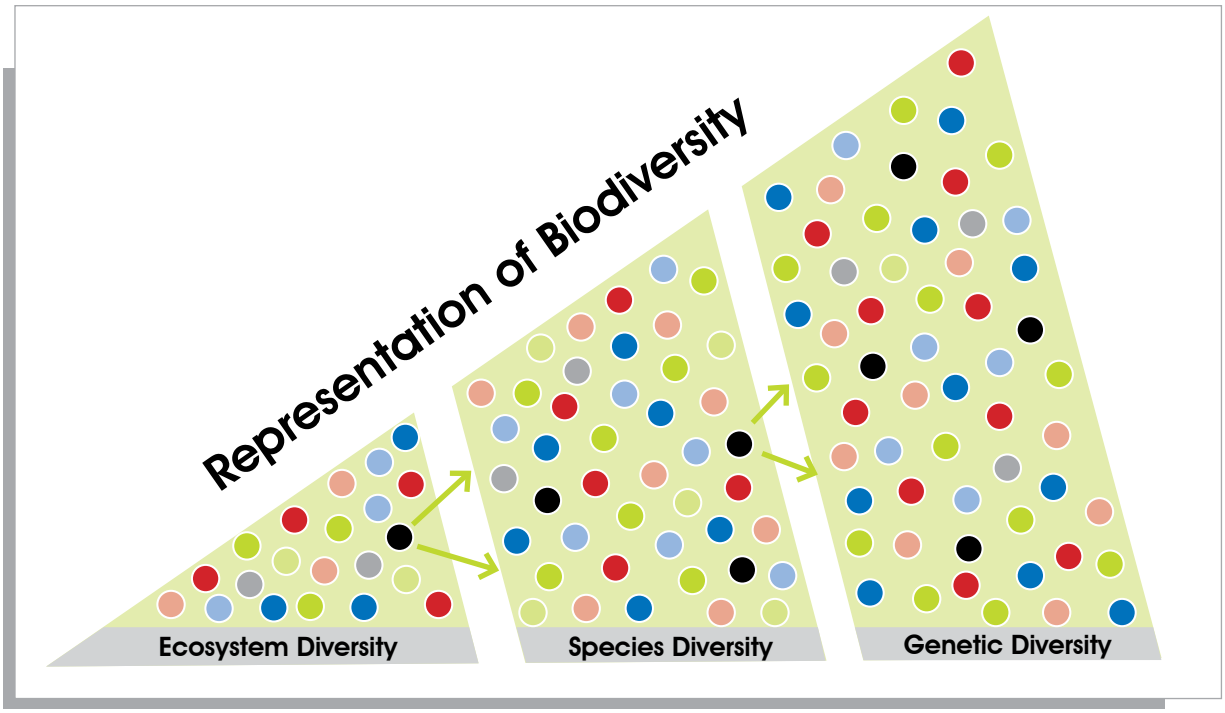
This rice variety has unique characteristics of surviving in high as well as scanty rainfall. Production, using the traditional method and organic manure as fertiliser, is about 600 to 1000 kilograms per acre, maturing in 130 to 140 days. It is mainly used in the village's daily consumption and some of its varied uses are in *kheer* (porridge), *sar bhaat* (curry rice) and *masala bhaat* (spicy rice). Women farmers say that when the paddy is ground on traditional grinders the grains split into two.

Paddy seeds of Dhobal

Red rice of Dhobal

Dhobal fields in Sattechiwadi

[4] People's Biodiversity Register, Shiswad, Akole 2012



Biodiversity and Ecosystem Services[5]

Political leaders, policy makers, economists, development professionals, and common people do not adequately appreciate the import of biodiversity. The classic example is the Biodiversity Act of 2002, which is still not being implemented effectively.

The benefits that we gain from biodiversity go far beyond the mere provision of raw materials.[6]

Ecosystem services provide us with resources for living and livelihoods. They also clean up and detoxify the wastes that we generate, and convert them afresh into usable resources. Human beings benefit from a multitude of resources and processes that are supplied by natural ecosystems. Together, these benefits are known as ecosystem services and include products like clean drinking water and processes such as the decomposition of wastes.

Our **food and energy security** strongly depends on biodiversity. So does our ability to mitigate **vulnerability to natural hazards** such as fires, flooding, and drought. Biodiversity loss has negative effects on our **health** and **material adequacy,** and it largely limits our **freedom of choice.** As all cultures gain inspiration from ecosystems or their components, e.g. landscapes, trees, hills, rivers, or particular species, or attach **spiritual and religious values** to them, biodiversity loss also strongly influences our **social relations.**[7]

Every decision we take that affects biodiversity, also affects our lives and the lives of other people. Biodiversity is crucial to **human wellbeing**, **sustainable development,** and **poverty reduction**.

[5] http://www.unep.org/policyseries/Sustainable_intergrated_Solutions.pdf
[6] http://www.iucn.org/what/tpas/biodiversity/about/biodiversity/
[7] Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington. 155pp.

Various ecosystem services of great significance for living and livelihoods have been observed at the project villages of Shiswad and Khadki Budruk, and others in the Akole *taluka* of Maharashtra. Akole *taluka* is hilly and lies predominantly in a non-recharge zone, due to which the capacity of groundwater recharge is extremely poor. Forests in the region regulate the flow of surface water, thus improving its availability beyond the rainy season. Reduced tree cover, however, has shortened the availability of water in several streams.

In one case, a farmer in Shiswad village has quite innovatively constructed *Vak Nalika* – an arrangement of pipes which feeds water to parts of the upper catchment with the help of gravity and the natural force of flowing water.

The villages of Shiswad, Khadki Budruk, Kohane, and Purushwadi have healthy soil of adequate depth due to which there is less reliance on chemical fertilisers. They also use fewer pesticides than villages where the forest systems are badly degraded. The snakes and birds found in these ecosystems also contribute to the control of pests.

These villages are surrounded by forests, with hills relatively free of exposed rocks. The current agricultural practices support natural systems that contain pests and protect the health of the soils. The protection of soil health and control of soil erosion is a primary ecosystem service available to these communities.

Studies carried out in the villages of Shiswad, Khadki Budruk, and Purushwadi show that people have, during times of drought stress, used the wild edibles from the surrounding forests. In Khadki Budruk alone, more than 32 such plant species have been documented in the People's Biodiversity Register (PBR) now maintained by the village.

Several medicinal plants have also been documented. Local healers, who have knowledge of their use and the practice of these medicinal plants, have been administering them. The village vouches for their efficacy and healing abilities.

The villagers also depend on non-timber forest products like **Hirda** *(Terminalia chebula)* and **Mahalung** *(Citrus medica)*, known for their medicinal value, **Shikakai** *(Acacia concinna)* and **Ritha** *(Sapindus emarginatus)* for cosmetic use, **Rametha** *(Gnidia glauca),* a natural pesticide, **Saapkand** *(Rauvolfia serpentina)*, used to treat snake bites, **Bharangi** *(Clerodendrum cerratum)* to control high fever, **Laxmivange** *(Solanum anguivi)* used to treat hyperacidity, **Kartule** *(Momordica dioica)* to treat diabetes and hyperacidity, **Kallavi** *(Gloriosa superba)* roots to control hypertension, etc. They also use bamboo to make several household items as well as apparatus to catch fish.

The natural environment is scenic and has a moderate climate. Taking advantage of this, at least three villages have initiated rural and eco-tourism.

The residents also have a deep cultural connection with their ecosystems.

Wherever these ecosystems have degraded, ecosystem services appear to suffer, resulting in reduced water availability, poor soil health, and disappearance of wild edibles and medicinal plants.

Degradation of ecosystems has also resulted in increased instances of human–animal conflicts. We have documented several cases of wild

boars razing standing crops, and of damage to groundnut in early sowing by peafowl. Common langurs are also a menace faced by the villages of Purushwadi and Shiswad. In addition, due to anthropogenic interference, a growing number of leopards in Akole could be a cause of serious conflict[8] in the foreseeable future.

Lack of understanding of ecosystem services damages them

In the long term, the value of services lost may greatly exceed the short-term economic benefits that are gained from transforming ecosystems. When we modify an ecosystem to improve a specific service it provides, this generally also impacts other ecosystem services – often negatively. For instance, actions to increase food production can lead to reduced water availability in terms of quantity and quality for other users. This can result in the degradation of many services, such as fisheries, water supply, and protection against natural hazards, seriously affecting people's wellbeing.

Another example of a well-meaning but exceedingly damaging intervention is seen in the afforestation programmes often undertaken as part of watershed development projects in India. The grassland ecosystems are generally classified as wastelands in India. This erroneous classification encourages well-meaning proponents of the project to initiate afforestation programmes. Grasslands are rather delicate ecosystems that are a habitat to myriad species of insects, reptiles, mammals, and birds. They also provide other vital ecosystem services like rejuvenating soil and sequestering carbon, while laying the foundations for the succession of new ecosystems. There is a long-standing relationship of mutualism between grasslands and pastoralists. Afforestation carried out in these grasslands adversely impacts not only the species that depend upon it, but also has serious consequences for pastoralists. Their livestock, now deprived of the mutually beneficial interactions with grasslands, become a source of damage to the forest ecosystem.

'Traditionally, grasslands and scrubs have been construed as wasteland; and the Forest Department's policy, until recently, has been to convert them to forests with the plantation of fuel or fodder shrub and tree species, even exotics like Leucaena leucocephala, Gliricidium, *and* Eucalyptus *spp., under social forestry and compensatory afforestation schemes (Forest (Conservation) Act 1980; Indian Forest Act 1927) resulting in further loss of habitat. Overgrazing on unprotected lands has also led to degradation of some areas.'*[9]

The Millennium Ecosystem Assessment (MEA) has broadly identified 24 Ecosystem Services grouped into four types:

1. Provisioning Services
2. Regulating Services
3. Supporting Services
4. Cultural Services

The following table shows the ecosystem services availed by the communities in the project area

[8] Athreya V (2006) Is Relocation a Viable Management Option for Unwanted Animals? – The Case of the Leopard in India. *Conservation and Society,* Volume 4, No. 3,Pages 419–423.
[9] http://www.birdlife.org/datazone/speciesfactsheet.php?id=2767

Ecosystem Services defined and their relevance to CCA project villages

Provisioning Services	**Resources used**
Food, Fibre, and Fuel	Edibles and fuel wood are available in the wild – Akole.
Genetic Resources	Varieties of indigenous grains, e.g. rice – Akole and Sangamner.
Bio-chemicals	Alkaloids from plants are used as pesticide and for fishing – Borban (Sangamner) and Akole.
Fresh Water	Drinking water in project villages in Sangamner and Akole
Regulating Services	
Invasion Resistance	Arrest invasion of lantana in well-forested areas – Shiswad, Purushwadi.
Herbivory	Fodder for cattle in all CCA villages, wild vegetables and fruits for human consumption.
Pollination	Honeybees, butterflies and other insects, birds such as sunbirds and white-eyes.
Seed Dispersal	Birds and small mammals.
Pest Regulation	Birds, snakes, and mammals as predators of pests.
Disease Regulation	Control of pests and disease Dragonfly *(Pantela flavescens)* and small bats help control and reduce vectors like mosquitoes. Rats and insects (disease vectors) are consumed by birds of prey and owls.
Natural Hazard Protection	Forested ecosystems give protection from landslides and floods.
Erosion Regulation	Soil depth is relatively great in the forested villages of Shiswad and Kohane, where the forested ecosystems arrest soil erosion.
Water Purification	Spring water is used for drinking in villages such as Khandobachiwadi, Pimpaldari, and Gurukul.
Climate Regulation	The Western Ghats play a major role in regulating local as well as regional climate.
Supporting Services	
Primary Production	Crops in most of the villages.
Provision of Habitat	A variety of wildlife is supported in these habitats. In Akole and some villages of Sangamner, such as Khandagedara and Malegaon Pathar, it is the leopard. In others too, there is a varied range of wildlife, from insects to mammals.
Nutrient Cycling	Healthy ecosystems in the Akole region support recycling of nutrients like carbon and nitrogen.
Soil Formation and Retention	Akole block's forested villages such as Shiswad, Purushwadi, and Kohane.
Production of Atmospheric Oxygen	Clean and healthy air in the villages of Akole is an indication of a high quantity of atmospheric oxygen which comes from the plentiful vegetation of the region.
Water Cycling	Healthy forests causing percolation of water and recharging of aquifers.
Cultural Services	
Spiritual and Religious Values	The Fort of Harishchandragad is a famous historical site of medieval India, which was built during Shivaji's reign. This region is also a hub of *Varkaris* of the *Bhagvat Sampraday,* one of the largest and oldest spiritual sects in India.
Knowledge Systems	Traditional and indigenous knowledge is being put into practice in all the villages of Akole and Sangamner.
Recreation and Aesthetic Values	Harishchandragad Sanctuary, Kohane, Shiswad in the Akole cluster
Education and Inspiration	Akole's healthy environs have inspired a tradition rich in preserving knowledge orally and can be seen in their folklore, dances, food habits, and living.

Biodiversity is a Solution that itself Faces Major Threat

In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change (IPCC) states with 'very high confidence' that human activities since 1750 are the major cause of worldwide trends of global warming. For the next two decades, about 0.2 °C of warming per decade is projected while the sea level could rise more than 50 cm by 2100. It is also likely that between 20 and 30 percent of plant and animal species assessed will be at greater risk of extinction if the rise in global average temperatures exceeds 2–3 °C.[10]

The IPCC report suggests that even if greenhouse gas emissions were to stabilise soon (an unlikely scenario) global warming will persist for centuries, due to the time scales (lags) associated with climate dynamics and feedback processes.

The need to adapt to the impacts of climate change is therefore inevitable. It is already happening across the globe. Many people are using natural resources and biodiversity, including genetic diversity, as part of the adaptation process. For instance, wild relatives of food crops are used to breed new varieties that can cope with changing conditions. In many regions of India and the developing world, the rural poor already rely on wild food sources and medicinal plants to supplement diets and maintain health. Some species are used on a daily basis; others gain in importance during periods of drought or stress.

Climate change: a threat to biodiversity

Climate change is already affecting biodiversity and will continue to do so. The Millennium Ecosystem Assessment (MEA) ranks climate change among the main direct drivers affecting ecosystems. Consequences of climate change on the species component of biodiversity include: (1) changes in distribution, (2) increased extinction rates, (3) changes in reproduction timings, and (4) changes in length of growing seasons for plants.

Some already-threatened species are particularly vulnerable to the impacts of climate change and climate variability.[11]

Changes in rainfall distribution, temperature, flooding, and sea level rise will be the most obvious effects on ecosystem boundaries and the functions within them. As a result of these changes in functions and shifts in boundaries, some ecosystems will expand into new areas, while others will become smaller. Habitats will change as rainfall and temperatures change, and some species will not be able to adapt, leading to a sharp increase in extinction rates. Global warming is also causing **shifts in the reproductive cycles and growing seasons of certain species,** which can in their turn affect how ecosystems function. The equilibrium of ecosystems can also be upset when, for example, insect pests and microbial pathogens, previously unknown in a region, survive the warmer winters. **Migrating species may be affected dramatically by any alteration to stop-over sites key to their survival, or when seasonal availability of food sources is no longer in sync with the duration of such migration.**

Changes in the rainfall pattern and temperature can be seen in the Akole and Sangamner villages. Frost in February 2012 in the Akole region was an indication. It will take a long time to see the visible impacts of climate change with reference to shift in ecosystem/habitats. Yet, changes in the habitat due to agricultural expansion are clearly visible.

[10] IPCC (2007) The Intergovernmental Panel on Climate Change Fourth Assessment Report. Summary for Policymakers.
[11] WWF. ClimateChange. Nature at risk. Threatened species, accessed online a http://www.panda.org/about_wwf/what_we_do/climate_change/problems/impacts/species/index.cfm

Also observed is the shift in habitat amongst species. Habitat generalist species like Pied Bushchat, Indian Black Robin, etc., are also spreading into forested ecosystems. Moisture indicators like moss and lichen have been observed to be disappearing from trees or rocks around the villages where these were once abundant. These, then, are clear indications of changing climate. Its impacts on biodiversity will vary across regions. Species are more likely to get trapped with no alternative habitat to which they can migrate. Species with small fragmented populations, or populations restricted to small areas, are especially vulnerable to any climatic shifts.

Possible adverse impacts of adaptation and mitigation strategies on biodiversity

There is very little literature surrounding the impacts of adaptation and mitigation strategies on biodiversity, as only a few adaptation measures have been actually implemented.[12] However, potential impacts can be identified through our knowledge of likely adaptation measures and the environmental impacts of past management practices.

There is a need to develop a policy framework for climate change adaptation and mitigation, wherein it should be made imperative to perform Environmental Impact Assessments (EIAs), Strategic Environmental Assessments (SEAs), and Systems Analyses as needed, as also address the need to consider ecosystems-based landscape planning where appropriate.[13] This is based on the recognition that considering these at the onset of the interventions can reduce environmental costs and increase the sustainability of the project.[14] When considering the impacts of adaptation strategies on biodiversity it is important to consider trade-offs, such as the implications for local incomes and adaptive capacity.

The unintended impacts of development

In villages like Gunjalwadi (Sangamner, Ahmednagar), Patalganga (Aurangabad), and Darewadi (Nanded), farmers have dug so many tube wells that it has led to a drop in the water table. In these villages, the groundwater table improved after watershed treatment. Due to the improved availability of water, farmers have dug tube wells and started cultivating sugarcane. Within a few years the water table plummeted to an all-time low. Deeply concerned, the villages imposed a complete ban on the use of bore-wells. The situation has partially improved in the past few years.

At Shiswad, trees were cut down on the slopes of hills to make way for agricultural land, thus increasing the chances of landslides. The area was already prone to earthquakes due to geological formations and has several faults, lineaments, and dykes. Any abnormal movement of the earth's crust can easily destabilise some slopes. Along with this, extensive tree cutting for various livelihood purposes has seen a drop in the quantity of medicinal and food plants obtained from the forest.

Invasive species, climate change, and biodiversity[15]

This brings us to another hazard threatening to undo the gains from adaptation and mitigation to climate change. Invasive species present one of the greatest threats to biodiversity and the provision of valuable ecosystem services. The estimated damage from invasive species worldwide totals more than US $1.4 trillion annually – 5 percent of the global economy

[12] Adgeret al. 2007; Paterson et al. 2008
[13] Wilson and Piper 2008
[14] Quintero 2007
[15] Burgiel, S.W. and A.A. Muir. 2010. 'Invasive Species, Climate Change and Ecosystem-Based Adaptation: Addressing Multiple Drivers of Global Change'. Global Invasive Species Programme (GISP), Washington, DC, US, and Nairobi, Kenya.

– with impacts across a wide range of sectors including agriculture, forestry, aquaculture, transportation, trade, power generation, and recreation.[16] In environmental terms, islands, for example, with their unique and varied biodiversity, have suffered disproportionately from invasive species, which are responsible for half to two-thirds of all species extinctions.[17] In comparison, economic projections of losses induced by global climate change may range from 1–20 percent of gross domestic product (GDP), which is equal to about 5 percent of GDP annually.[18] These projections should raise alarms for development decision-makers and practitioners to take action.

In combination, the complex interaction of the two global drivers – climate change and invasive species – increases their effects dramatically. Climate change would compound the already devastating effects of invasive species. Climate change impacts, such as increasing temperatures and changes in CO_2 concentrations, are likely to increase opportunities for invasive species due to their adaptability to disturbance and to a broader range of bio-geographic conditions and environmental controls. The impacts of the invasive species may be amplified as they increase both in numbers and extent, and compete for diminishing resources such as water. Changes in air and water temperatures may also facilitate movement of species along previously inaccessible pathways of spread – both natural and human-made. Disturbing trends have been noticed in villages of Sangamner and Akole *talukas* of Maharashtra, and Mandla district of Madhya Pradesh during the collection of data for the People's Biodiversity Registers (PBR).

Spread of lantana is quite visible in the region of Akole and Sangamner in Maharashtra and Partala in MP. It has occupied large swathes of degraded lands and is competing with local vegetation for resources. It has affected the local biodiversity, which in turn has impacted the food supply (for humans) from the forest. Birds like bulbuls and sunbirds, and insects like butterflies, help to spread lantana through seed dispersal and pollination.

From a food security perspective, there is little point in addressing the impacts of climate change on the productivity of a staple food if an invasive pest has already decimated the crop. Similarly, from a conservation perspective, there is little point in addressing climate change if the biodiversity we are trying to protect has already been lost to invasive species.

Major agricultural pest outbreaks or health pandemics could result in significant human suffering and loss. This calls for immediate action. Ecosystem-based adaptation is gaining attention as a cost-effective means of protecting human and ecological communities against the impacts of climate change.[19] Ecosystem-based adaptation builds nature's resilience to the impacts of climate change, while also helping to meet people's basic needs. Invasive species can threaten those basic needs and compromise ecosystem functions by taking advantage of habitat disturbance, species under stress, and other weaknesses in otherwise healthy systems. This affects the multiple roles of ecosystems in providing provisioning, regulating, supporting, and cultural services.[20] Such **ecosystem-**

[16] Pimentel et al. 2001
[17] Donlan and Wilcox 2008, IUCN 2009b
[18] Stern 2006
[19] Heller and Zavaleta 2009, Mooney et al. 2009, World Bank 2009
[20] Millennium Ecosystem Assessment 2005, Vila et al. 2009

based approaches are not simply about saving ecosystems, but rather about using ecosystems to help 'save' people and the resources on which they depend. Such an approach can also provide an integrative framework to address impacts from both climate change and invasive species.

The three key messages arising from the report prepared by Global Invasive Species Programme (GISP) are:

- Climate change will have direct and second-order impacts that facilitate the introduction, establishment, and/or spread of invasive species;
- Invasive species can increase the vulnerability of ecosystems to other climate-related stressors; and
- Reduce their potential to sequester greenhouse gases.

For instance, it has been observed that lantana now occupies all of the deforested and degraded patches of land in the villages of Khandagedara, Malegaon Pathar, and Warudi Pathar, falling within the WOTR project area in Maharashtra, and Partala, Dungaria, and Bhaval in Madhya Pradesh. It is inhibiting the growth of hard-wood species, especially the trees, resulting in fragmenting the habitats for the forest species.

The most notable example is a valley full of lantana in Khandagedara village that has ousted the growth of native vegetation. Due to lantana, few people now enter the valley and leopards have occupied the place. This has increased the incidences of human-animal conflict in the village. The lantana is also invading the crop fields and affecting the yield of the crops on the fringes of the fields.

Using an ecosystem-based adaptation approach, these pressures on ecosystems and their ability to provide important services can be offset by preventing the introduction of new invasive species and by eradicating or controlling those damaging species already present.

Lantana invasion

In Shiswad and Khadki Budruk villages, people have started using bio-char made from lantana. People from these villages use it as an alternative for fuel wood. A youth group from Khadki Budruk has planned a business enterprise using the bio-char of lantana.

The Need to Place Biodiversity as a Fundamental Unit of the Economy

The economic invisibility of nature in our dominant economic model is both a symptom and a root cause of biodiversity loss. We value what we can put a price on, but nature's services – providing clean air, fresh water, soil fertility, flood prevention, drought control, climate stability, etc. – are not traded in any markets and therefore not priced. These 'ecosystem services' are all 'public goods' provided free.

However, monetising biodiversity for only its provisioning services could easily lead to deprivation of biodiversity for which the local poor will bear the biggest brunt.

Holistic economics, or economics that recognises the value of nature's services and the costs of their loss, is needed to set the stage for a new 'green economy'[21]. In order to proceed any further, we first need to fully understand the real value of ecosystem services before monetising it.

There are difficulties in determining how a market-driven economy can take account of ecosystem services, which may not have market values, and incorporate them into policy making. Similarly, there are difficulties in understanding how ecosystem services can be maintained or restored through policy or other measures, due to the complexity surrounding the study of ecosystems in general.

The crisis of biodiversity loss can only be addressed in earnest if the values of biodiversity and ecosystem services are fully recognised and represented in decision-making. This may reveal the true nature of the trade-offs being made: between different ecosystem services (food provision or carbon storage), between different beneficiaries (private gain by some, public loss to many), at different scales (local costs, global benefits), and across different time horizons. **When the value of ecosystem services is understood and included within economic accounting, what may have passed off as an 'acceptable' trade-off may appear quite untenable.**

Conversely, **when benefits which were previously unrecognised become visible (e.g. the role of ecosystems in climate regulation), they become worth preserving.**

Therefore, a cautious approach needs to be adopted when valuing ecosystem services. Under no circumstances should any ecosystem be traded/exploited to the extent that it becomes unable to recover.

Further to this, investment in ecosystem protection and management can, with appropriate full environmental economic accounting, yield high returns. For example, recent research findings[22] show that an annual global investment of $45 billion in protecting ecosystems could deliver an estimated $5 trillion a year in societal benefits, a cost-benefit ratio of over 100:1.

Many examples now exist of payment for ecosystem services (PES). Here people who manage or interact in some way with ecosystems receive payments for the benefits provided by the ecosystem to the wider community.[23]

[21] Greening the economy refers to the process of reconfiguring businesses and infrastructure to deliver better returns on natural human and economic capital investments, while at the same time reducing green house gas emissions, extracting and using less natural resources, creating less waste, and reducing social disparities.
[22] The Economics of Ecosystems and Biodiversity (TEEB) Interim Report 2009.
[23] The Economics of Ecosystems and Biodiversity (TEEB) Interim Report 2009.

Poverty, Gender, Climate Change, and Biodiversity[24]: The Nexus

Poverty, climate change, and biodiversity

People in poor countries are disproportionately vulnerable to the loss of biodiversity and reduced ecosystem services. Despite emitting the lowest levels of greenhouse gases, they would suffer the most from the impacts of climate change.

The UNFCCC asserts that there are 'common but differentiated responsibilities' for tackling climate change. The Convention on Biological Diversity (CBD) and the Millennium Development Goals (MDGs) offer possible solutions to the issues raised. However, these agreements do not specify the strategies and methods to be used by parties to each agreement to meet their stated aims.

The links between climate change, biodiversity, and poverty are clear. There is an obvious need to support projects and activities that meet the objectives of all three agreements. But, in practice this is often not the case. And in some instances, activities intended to meet the goals of one agreement may negatively affect the goals of another.[25]

The integration of objectives can be improved through stronger linkages between UNFCCC, MDG, and CBD, better research and inter-disciplinary thinking, and a wider engagement between the public, governments, agencies, and other stakeholders.

Geographic location is a key factor in the vulnerability of poor people and poor nations,[26] with most residing in regions prone to high risk from climate change impacts. Many amongst the poor live in marginal areas such as floodplains or at the foot of unstable hillsides. The poor also have the fewest choices available and the lowest capacity, because of a lack of resources and mobility, to cope with climate change related shocks.

The interventions under Climate Change Adaptation project in Ahmednagar (Maharashtra) and Mandla (Madhya Pradesh) are interdisciplinary. They connect livelihoods, biodiversity, alternative energy, agriculture, Disaster Risk Reduction (DRR), etc. in a single programme. Activities at various levels involve both the village and government agencies.

The DRR approach under the project has a defined component of interactions with the *taluka*-level government system to integrate bottom–up community-based risk reduction with the top–down District Disaster Management Plans. It helps sensitise both the communities as well as the government functionaries to the limitations and strengths that each have.

WOTR's work in developing the PBR in various villages is an example of inter-disciplinary thinking where the village, the government, and other agencies work together to plan the benefits of PBR and address biodiversity concerns in development work to reduce intrinsic vulnerability and enhance the resilience of the natural systems.

[24] 'Ecosystem Management: Tomorrow's Approach to Enhancing Food Security under a Changing Climate', Richard Tingem Munang, Ibrahim Thiaw and Mike Rivington

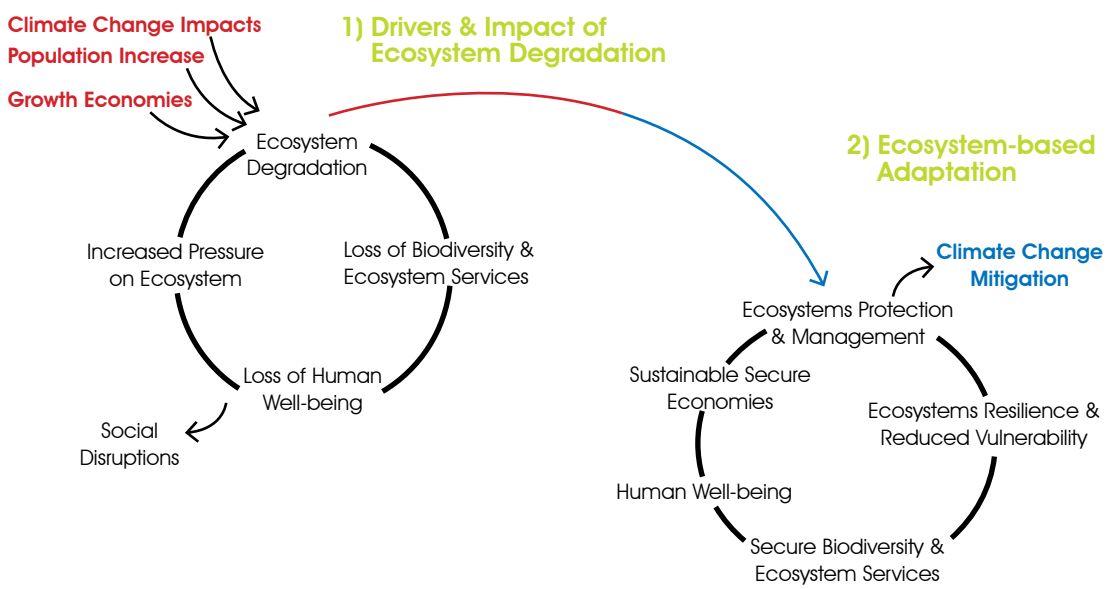
[25] http://www.unep.org/policyseries/Sustainable_intergrated_Solutions.pdf pp 4,5

[26] Haq S, Konate M. et al. (2004) Mainstreaming adaptation to climate change in Least Developed Countries (LDCs). Climate Policy 4(1): 25-43.

Healthy, fully functional ecosystems are better placed than degraded ones to achieve cost-effective multiple objectives (ecosystem services), including progress towards food security under a changing climate. They have underpinned all past and existing economic activity and will form the basis to achieve long-term economic sustainability while continuing to provide the essential services on which we depend. Local communities should be authorised to manage/collect local ecosystem benefits sustainably. However, inadequate ecosystem protection, coupled with a lack of economic mechanisms that do not include the costs of environmental damage, has led to the degradation of the ecosystem services, thus reducing their ability to feed substantial sections of society.

Ecosystem management can be defined as *'an integrated process to conserve and improve ecosystem health that sustains ecosystem services for human well-being'.*[27] Incentives and disincentives should be brought into the picture while dealing with biodiversity conservation. Climate change will alter the patterns of net primary production and alter growing conditions for many crops and livestock systems.[28] Healthy ecosystems and their services provide opportunities for sustainable economic prosperity while providing a defence against the negative effects of climate change[29] through human adaptation and behavioural change, as opposed to a continuation of degradation (Figure 1).

Figure 1: Recovering from the vicious cycle of poverty, ecosystem degradation, and climate change



[27] This is an aggregated definition based on *The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB.* The TEEB Synthesis Report, Nagoya, Japan, 20 October 2010.

[28] *Ecosystem Health: New Goals for Environmental Management,* Costanza, R., Norton, B.G., Hakell, B. (Eds.), Island Press.

[29] Mackey, B. *Connecting Biodiversity and Climate Change Mitigation and Adaptation.* Report of the Second Ad Hoc Technical Expert Group on Biodiversity and Climate Change.CBD Technical Series No. 41. Secretariat of the Convention on Biological Diversity: Montreal, Canada, 11 September 2009; ISBN: 92-9225-134-1.

Gender, biodiversity, and climate change[30]

Gender roles affect economic, political, social, and ecological opportunities and constraints faced by both the sexes. Recognising women's roles as primary land and resource managers is central to the success of biodiversity policy. For instance, women currently account for 60–80 percent of all food production in developing countries, but gender often remains overlooked in decision-making on access to and the use of biodiversity resources.

The significance of biodiversity for individuals varies according to gender. Based upon their social roles and the power equations between men and women, gender is shaped by culture, social relations, and natural environments. **We therefore need to incorporate gender dimensions into our understanding of biodiversity and its conservation, sustainable use, and the sharing of its benefits.**

Just as poorer communities disproportionately feel the impact of biodiversity loss, there are also inequalities along gender lines. Biodiversity loss affects access to education and gender equality by increasing the time spent by women and children in performing certain tasks, such as collecting valuable resources and services, like fuel, food, and water.

To conserve biodiversity, we need to understand and expose gender-differentiated biodiversity practices, gendered knowledge acquisition and usage. Various studies demonstrate that projects integrating gender dimensions generate superior results. Gender considerations are not solely a women's issue; this outlook could yield advantages for whole communities and benefit both sexes.[31]

Understand and expose the gender-differentiated biodiversity practices and knowledge of women and men enhances biodiversity conservation[32] and adaptation to climate change. Many case studies from around the world and WOTR's own experiences have demonstrated that biodiversity conservation efforts become more effective and efficient,

Elderly women of villages like Shiswad in Akole have knowledge of forest plants which are a source of food in the form of vegetables, fruit, tubers, etc. Recently, a 90-year-old lady was observed cutting pods of the *Bombax ceiba* tree to prepare a dish. This kind of knowledge of wild food plants, usually within the domain of women, becomes very important in times of crisis.

90-year-old Mangalabai Bhau Bhangare possesses significant knowledge about wild edibles

[30] http://www.cbd.int/climate/doc/biodiversity-gender-climate-change-en.pdf
[31] The Bhoyre Pathar Watershed Project – We Too Can Do It! Achieving Quality Results in Large Budget Short Term Developmental Projects, WOTR
[32] http://www.cbd.int/gender/why/

where women were empowered to participate as equals in information sharing and knowledge generation, education and training, technology transfer, organisational development, financial assistance, and policy development.

In an initiative by WOTR, wherein women belonging to Self Help Groups (SHGs) of 12 villages have been trained to manage indigenous plant nurseries. Communities choose the plant varieties carefully, keeping in mind their traditional uses. These are planted in community lands, farms, and back yards. As women play a key role in the functioning of these SHGs, they also pay attention to special needs of women – like provisioning for fuel wood for cooking, and fodder for domesticated livestock – provisions traditionally carried as head-loads over long distances.

Only with a gender perspective in place, can a complete picture of human relationships and ecosystems be built up.

The Millennium Development Goals emphasise clear linkages between gender equality, poverty alleviation, biodiversity conservation, and sustainable development. Such insights should be embodied into our outlook and approach towards reversing biodiversity losses, reducing poverty and improving human wellbeing. **Without the participation of women and the realisation of their full creative and productive potential, it will not be possible to attain the Millennium Development Goals (MDGs), including those related to environmental protection.**

Women often make their contributions to the family, community, and society with unequal access, control over, and benefits from resources and resource use. Women manage households and care for family members, which often limits their mobility and increases their vulnerability to sudden weather-related natural disasters. Drought and erratic rainfall force women to work harder to secure food, water, and energy for their homes. Girls drop out of school to help their mothers with these tasks. This cycle of deprivation, poverty, and inequality undermines the social capital needed to deal effectively with climate change.[33]

The CBD further recognises that women, and distinct groups of women, require special consideration because of institutionalised systems that do not explicitly value women's contributions to biodiversity.

Therefore, gender equality is a matter of fundamental human rights and social justice. Taking gender into account, when considering the environment, is a pre-condition for sustainable development.[34]

Although the present-day economy pulls money out of the villages, WOTR is developing models which attempts to reduce excessive dependence on the external economy. The cluster approach, and attempts to revive the intermediate markets like haats and country fairs, are examples of efforts in this direction. To this end, a Biodiversity Festival was held at Shiswad in December 2011, which registered an attendance of more 5,000 people. Transactions involving locally made goods and services exceeded Rs 2,00,000 during the three days of the event.

[33] UNFPA state of the world population 2009, Facing a changing world: women population and climate
[34] http://www.iucn.org/about/work/programmes/social_policy/sp_themes_ge/

The Way Ahead

Biodiversity and ecosystem services can be the foundation of many successful adaptation strategies, especially for the poor. They can also deliver climate change mitigation benefits. But meeting all of these objectives can be difficult. Adaptation activities in one sector may end up compromising those in another, besides mitigation, biodiversity, or poverty objectives. Decisions should therefore be based on a sound understanding of the full environmental–economic trade-offs.

At the very least, climate change solutions should aim to avoid damaging biodiversity and ecosystem services and thereby increasing inequity and exacerbating poverty.

This requires a fundamental shift in the structure of the current economic models, where resource consumption is the primary driver, which has led to environmental degradation, biodiversity loss, and hence unsustainable societies. Instead, **there is a need to develop economic models that reverse the market failures of the existing models by fully valuing the environment. They must be able to balance the capacity of the ecosystems to provide essential services with the basic needs of all sections of human society in an equitable way. Such models need to foster greater individual and global collective responsibility and facilitate a shared equity towards resource use.**

Governance is a key issue in biodiversity conservation and climate change adaptation. Governments, individuals, bilateral organisations, and the private sector should seek to achieve better integration of information, thinking, and decision making to ensure that initiatives which meet the objectives of the MDGs, the UNFCCC, and the CBD are supported. Currently, however, the bodies responsible for each convention, and the governments and ministers in charge of implementing them, tend to have a sectored approach, focussing on their own objectives. The synergies between objectives need to be better recognised by governments, who must facilitate change by supporting both top–down and bottom–up initiatives. To strengthen it, Gram Sabhas should be empowered while increasing their capacities and capabilities, to take decisions consistent with sustainability. Similarly, businesses and communities need to take advantage of the economic benefits that the ecosystems-based adaptation approach will bring. Only by collectively addressing the multiple issues of climate change, biodiversity loss, and poverty in an integrative way will the synergistic solutions be developed.

To improve the outreach of education and awareness, various information technology tools can be used at community level.

As a systemic approach, various tools have been tried and tested in Akole and Madhya Pradesh, like CoDriVE Livelihoods Assessment, PBR (People's Biodiversity Register), LM3 (Local Money Multiplier), and CoDriVE–Visual Integrator (Participatory 3D Modelling). WOTR's programmatic intervention in Maharashtra and MP does cover various components ranging from livelihood generation to developing a self-sustaining village. The approach being ecosystem based, it automatically conserves biodiversity. WOTR also has a plan for working on transition ecosystems which are not so degraded.

Conclusion

Ecosystems play an essential role in enhancing food security by supplying the fundamental units of life support that enable us to produce or utilise food and water. They also provide clean air and climate regulation, shelter and medicines, cultural and aesthetic wellbeing, and play a vital role in disaster risk reduction. These are, however, under increasing pressure and threat of further degradation. As climate change and other pressures bring to bear increasing stresses, we need to ensure that ecosystems do not continue to degrade. Instead we must ensure that they remain healthy and fully functional in order to provide the vital ecosystem services we rely on. We should therefore seek to protect, restore, and improve ecosystems, particularly those that have been most degraded.

Given this vital role that ecosystems play in sustaining a growing human society, their current rate of degradation, and the emerging threats of climate change, the existing approaches to integrating environmental concerns with economic policy development will NOT be sufficient by themselves to tackle the problems we face. Instead, whilst the ecosystem-based adaptation approach is not a panacea for all problems, it is one that, when integrated with other strategies working towards the same goals (climate regulation, poverty alleviation, and sustainability), forms the foundation for a successful integrated strategy for food, water, and ultimately, societal security.

Ecosystem management acknowledges the importance of human needs while at the same time confronts the reality that the capacity of our world to meet those needs in perpetuity has limits and depends on the sustained functioning of ecosystems.

The greatest challenge for governments and global leaders is to adjust national and international economies in line with climate change mitigation and adaptation efforts whilst maintaining ecosystem health and financial stability. Use of the life support services of ecosystems and societal behaviour will help economies, financial institutions make those adjustments in the progress towards a food-secure, green, low-carbon economy, but only if ecosystem health is maintained. Fundamentally, ecosystems form the foundation of life support and hence require appropriate protection and management at a level commensurate with their true value in supporting global wellbeing.

About WOTR

Aware of the fragility of ecosystems and our symbiotic link with it, WOTR has since 1993 applied a systems-based approach to watershed development, focusing on people-centric participatory interventions. With more-than-normal weather variations now being experienced, WOTR has moved into an Ecosystem-Based Adaptation (EBA) approach that helps vulnerable communities build resilience of their degraded ecosystems and livelihoods threatened by climate change impacts. This approach generates significant benefits, social, economic and cultural.

WOTR is now oriented and equipped to specifically address the challenges (and opportunities) posed by climate change to vulnerable communities. In the process, WOTR has introduced a bottom-up, holistic and integrated approach towards Adaptation and Resilience Building.

Constantly learning from experience, WOTR has been revisiting conventional development. Systems Thinking and Complexity Analysis have been incorporated in program design leading to formulation of new tools and frameworks while adapting the existing ones. This helps us shift to a Framework-Based Management, in contrast to activity focussed project.

At WOTR, Applied Research is a constant companion. Our team, guided by experts, help local communities become researchers - observing, measuring, and assessing for themselves problems as also improvements that a project brings about. Having tested methodologies, WOTR disseminates the learning through Capacity Building Events to implementers and donors, far and wide, so as to benefit rural communities across India and to countries in the South.

WOTR has carried out developmental work in over 2,500 villages in six states. Its program on Climate Change Adaptation project is currently being implemented in over 70 villages in Maharashtra, Madhya Pradesh and Andhra Pradesh.

For more information visit us at www.wotr.org

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