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A Framework for the Conservation and Enhancement of Ecosystem Services

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Abstract—*Ecosystem Services include all ecosystem functions and processes people and society benefit from in economic terms or related to their quality of life. These benefits from water and climate regulation, over biodiversity and pollination, to aesthetic and recreational services. The role of cities in maintaining biodiversity for functional ecosystems is becoming an important topic on the global agenda. In particular urban green spaces–that is forests, trees, parks, allotments or cemeteries–provide a whole range of ecosystem services for the residents of a city. Recreation and climate moderation are highly valued Ecosystem Services. An increase of built-up land by urban sprawl and densification in the inner parts of a city reduces the much needed Ecosystem Services. This paper includes the concept and definitions of Ecosystem Services, Importance of Ecosystem Services and its role in sustainable urban development, best practices and few examples giving understanding of how can a focus on ecosystem services help city authorities? Some facts and Fig. about land degradation, over exploitation, climate change, Impact of landuse change on ecosystem services, cities impact on environment etc. have been globally understood related to Ecosystem Services. Case studies explains the importance of Ecosystem Services and suggests various parameters for evaluating Ecosystem Services. Therefore this paper giving detail framework for conservation and enhancement of Ecosystem Services in Nagpur city. The scope of this study is to integrate Ecosystem Services into urban policy making process. The study involves Evaluating Role of Vegetation for Ecosystem Services i.e. Provisioning Services (Food, Raw Material, Medicinal Resource), Regulating Services (Air Quality), Cultural services. (Aesthetic Recreational and Educational).The study doesn't deal with Habitat Services and Supporting Services. Selection of study area within the Nagpur city based on Six parameters i.e. Tree category, Plant Species Diversity, Land use, Air Quality, structure of parks/ open spaces, lakes water Quality Index For comparing current trends and drivers of change for Ecosystem Services. Valuation Assessment Methods of Ecosystem Services Adopted for household survey i.e. Participatory Environmental Valuation which gives Qualitative and Participatory Approach in order to understand what people think the most important ESs for the well-being and how they value them for marketed and no marketed services.*

1. INTRODUCTION

Humankind benefits in a multitude of ways from ecosystems. Collectively, these benefits are known as **Ecosystem Services**. Ecosystem services are regularly involved in the provisioning of clean drinking water and the decomposition of wastes. While scientists and environmentalists have discussed ecosystem services implicitly for decades, these the ecosystem services concept itself was popularized by the Millennium Ecosystem Assessment (MA) in the early 2000s. This grouped ecosystem services into four broad categories: provisioning, such as the production o f food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and crop pollination; and cultural, such as spiritual and recreational benefits. To help inform decision-makers, many ecosystem services are being assigned economic values.

Fig. 1: Pollination by a bumblebee, a type of ecosystem

2. BRIEF HISTORY: ECOSYSTEM SERVICES

The simple notion of human dependence on Earth's ecosystems reaches to the start of our species' existence, when we benefited from the products of nature to nourish our bodies and for shelter from harsh climates. Recognition of how ecosystems could provide more complex services to mankind date back to at least Plato (c. 400 BC) who understood that deforestation could lead to soil erosion and the drying of springs. However, modern ideas of ecosystem services probably began with Marsh in 1864 when he challenged the idea that Earth's natural resources are unbounded by pointing out changes in soil fertility in the Mediterranean. However, his observations and cautions passed largely unnoticed at the time and it was not until the late 1940s that society's attention was again brought to the matter. During this era, three key authors , Osborn, Vogt, and Leopolda wakened and promoted recognition of human dependence on the environment with the idea of 'natural capital'. In 1956, Sears drew attention to the

critical role of the ecosystem in processing wastes and recycling nutrients. An environmental science textbook called attention to “the most subtle and dangerous threat to man’s existence... the potential destruction, by man’s own activities, of those ecological systems upon which the very existence of the human species depends”.

The term ‘environmental services’ was finally introduced in a report of the Study of Critical Environmental Problems, which listed services including insect pollination, fisheries, climate regulation and flood control. In following years, variations of the term were used, but eventually ‘ecosystem services’ became the standard in scientific literature. Modern expansions of the ecosystem services concept include socio-economic and conservation objectives.

Examples: Four categories of Ecosystem Services

The Millennium Ecosystem Assessment (MA) report 2005 defines Ecosystem services as **Benefits People Obtain From Ecosystems** and distinguishes four categories of ecosystem services, where the so-called supporting services are regarded as the basis for the services of the other three categories.

The following lists represent the definition and samples of each according to the MA:

Supporting services: ecosystem services "that are necessary for the production of all other ecosystem services"

- Nutrient Dispersal And Cycling
- Seed Dispersal
- Primary Production

Provisioning services: "products obtained from ecosystems"

- Food (Including Seafood And Game), Crops, Wild Foods, And Spices
- Water
- Minerals (Including Diatomite)
- Pharmaceuticals, Biochemical’s, And Industrial Products
- Energy (Hydropower, Biomass Fuels)

Regulating services: "benefits obtained from the regulation of ecosystem processes"

- Carbon Sequestration and Climate Regulation
- Waste Decomposition and Detoxification
- Purification Of Water and Air
- Crop Pollination
- Pest and Disease Control

Cultural services: "nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences"

- Cultural, Intellectual and Spiritual Inspiration
- Recreational Experiences (Including Ecotourism)
- Scientific Discovery

The most recent revision by TEEB the “Economics of Ecosystem and Biodiversity” to synthesize work in this field and prevent double counting in ecosystem services audits, has revised the MA definition to remove "Supporting Services" and replace it on the one hand with "Habitat Services" and on the other hand with "ecosystem functions" that "are defined as a subset of the interactions between ecosystem structure and processes that underpin the capacity of an ecosystem to provide goods and services".

3. LITERATURE CASE STUDIES

3.1 Foshan China

Urban landuse zoining based on ecological evaluation for large contribution for less developed cities, suggests different methods for evaluating ecology and Ecosystem Services in given region i.e Ecological Capacity, Ecological Suitability, Ecosystem Services, Ecological Footprint while understanding to land use zoning for mentioned area i.e Ecological Conservation Area, Ecological Sensitive Area, Ecological Construction Area, Ecological Regulation Area. It also suggests that landuse planning based oecological evaluation is of great significance to sustainable urban development.

3.2 Leipzing Germany

Urban Landscape and Ecosystem Services, the study show the comparison of urban green spaces and residential landuse for recreational and climate change regulation services This study compared old villas and city centre with the parameters like usage, built up density, built up type, Structure of open space, ratio of vegetation and degree of soil sealing and analysis go into demand and supply relation of Recreational Ecosystem Services.

3.3 Mapping and assessment of outdor recreational: EU cities,

Study (recreation) presents evidence that millions of people visited forests several times per year and they expressed their willingness to pay to continue doing so. The visitor statistics that are used in this study confirm the usefulness of the ROS approach (Recreation Opportunity Spectrum) to identify areas in terms of their accessibility and potential to provide recreation services. In addition, PRESS-2 for Europe presents a spatial analysis of city population density and green urban areas.

4. BEST PRACTICES

4.1 The Eco-Roof Incentive Program: Toronto (Canada), Established Since 2009)

The Eco-Roof Incentive Program initiated by the City of Toronto aims to encourage residents, public institutions and economic agents to install eco-roofs on their buildings. Eco-roofs comprise green roofs and cool roofs which effectively reflect solar radiation and cool the local climate.

Fig. 2: Toronto Environment

Fig. 3: Toronto Environment

The problem. The need to implement the Climate Change Action Plan, a municipal environmental framework designed to reduce Toronto's greenhouse gas emissions to 80% of 2009 levels by 2050.

The solution. Toronto's authorities have long been interested in promoting eco-roofs. One of the first initiatives in which the City took part was the creation of two showcase green roofs on the municipal building and the East view Community Centre. In 2004, the City commissioned Ryerson University to carry out a study on the potential ecological benefits that a large-scale green roof and cool roof program might bring, taking into consideration the local climatic and environmental conditions. The City also organized a series of consultation workshops for local stakeholders to gauge their opinion on the proposed program. Subsequently, a report on "Making Green Roofs Happen" was published describing how best to encourage their creation. On the 1st of February 2006, the City Council approved a 3-year plus strategy to promote this idea. The strategy included 4 main categories of action: the installation of green roofs on buildings owned by the City, a pilot grant program, implementation of a green roof incentive program, and a program of information and education.

Budget. Eligible green roof projects receive grants of USD 50/m2 up to a maximum of USD 100,000.

Responsible institution. Green Roofs.

The categories of ecosystem services used.

Supporting–photosynthesis and primary production, the hydrological cycle, Regulating–climate regulation, air and water purification, attenuation of weather extremes (reduced urban heat island effect), Cultural–aesthetic and educational functions.

4.2 "Garden For A Living London": London (United Kingdom), Established Since 2009

The "Garden for a Living London" campaign launched by the London Wildlife Trust aims to transform the city's 3 million gardens into a network of mini nature reserves which will make London more resilient to climate change and a sustainable habitat for wildlife. The program assumes Londoners' voluntary participation.

The problem, Due to climate change, summers in London (as in many other cities) are becoming increasingly hot and dry, while winters are becoming wetter and warmer. As a consequence, residents face high temperatures, droughts, and flash floods. According to forecasts, the impacts of climate change will be felt more strongly in cities where many impervious surfaces hinder water infiltration into the ground. Areas affected by rising temperatures are at risk of an influx of new animal species that can disrupt the ecological balance by altering the numbers and types of predators or pests in a given area or contributing to the appearance of new diseases. Some animal in situ species might need help in adapting to these new circumstances

Fig. 4: Photo: Jamie Grier, courtesy of London Wildlife Trust

The solution. The London campaign aims to highlight the critical importance of London's gardens to both people and animals. The London Wildlife Trust wants private garden owners to commit to one of seven initiatives that will make their garden better for wildlife and allow the city to be better able to cope with the impacts of climate change.

Fig. 5: Photo: Jamie Grier, courtesy of London Wildlife Trust

These initiatives include: planting drought resistant plants, planting mixed hedgerows, planting broad leaved trees, making ponds, using mulch, creating green roofs and introducing more plants on terraces.

The campaign received the endorsement of the Mayor of London and continues to be supported by Thames Water–a private company responsible for the public water supply and waste water treatment in London. Participants are expected to join the initiative and take their own actions. To help garden owners interested in the program, the Trust created a web page with practical information on how to implement the initiative and published a guide called the Wildlife Gardening Pack with advice on wildlife and climate-friendly gardening.

Responsible institution. The London Wildlife Trust

The categories of ecosystem services used.

Supporting–the hydrological cycle, the biochemical cycle (CO_2 sequestration), habitat for birds and other animals, areas suitable for wildlife migration, Regulating–attenuation of

weather extremes (decreased urban temperature), climate regulation, Cultural–aesthetic and educational functions.

5. ECONOMICS AND ECOSYSTEM

5.1 Valuation Methods

The economic valuation of ecosystem services also involves social communication and information, areas that remain particularly challenging and are the focus of many researchers. In general, the idea is that although individuals make decisions for any variety of reasons, trends reveal the aggregative preferences of a society, from which the economic value of services can be inferred and assigned.

This section presents and discusses the pros and cons of each method. Valuation methods can broadly be split into 6 categories, as in table 1

Table 1: Valuation Methods

Table 3.1 Comparison of valuation methods

Group	Methods	Summary	Statistical analysis?	Which services valued?
1. Direct market prices	Market prices	Observe market prices	Simple	Provisioning services
2. Market alternative	i. Replacement costs	Finding a man-made solution as an alternative to the ecosystem service	Simple	Pollination, water purification
	ii. Damage cost avoided	How much spending was avoided because of the ecosystem service provided?	Simple	Damage mitigation, carbon sequestration
	iii. Production function	How much is the value-added by the ecosystem service based on its input to production processes?	Complex	Water purification, freshwater availability, provisioning services
3. Surrogate markets	i. Hedonic Price Method	Consider housing market and the extra amount paid for higher environmental quality	Very complex	Use values only, recreation and leisure, air quality
	ii. Travel Cost Method	Cost of visiting a site: travel costs (fares, car use etc.) and also value of leisure time expended	Complex	Use values only, recreation and leisure
4. Stated preference	i. Contingent valuation method	How much is the survey respondent willing-to-pay to have more of a particular ecosystem service?	Complex	All services
	ii. Choice experiments	Given a 'menu' of options with differing levels of ecosystem services and differing costs, which is preferred?	Very complex	All services
5. Participatory	Participatory environmental valuation	Asking members of a community to determine the importance of a non-marketed ecosystem service relative to goods or services that are marketed	Simple	All services
6. Benefits transfer	Benefits transfer (mean value, adjusted mean value, benefit function)	'Borrowing' or transferring a value from an existing study to provide a ballpark estimate for current decision	Can be simple, can be complex	Whatever services were valued in the original study

Market prices: Certain ecosystem goods and services have a market. Timber and fish, for example, have economic values that can be calculated with little statistical analysis. Markets for less tangible ecosystem services are also emerging, such as mitigation of greenhouse gas emissions. Most ecosystem goods and services, however, do not have readily observable market prices. When they are available, they may be either undervalued or distorted. Distortions in the market (subsidies, price regulations, taxes) may produce incorrect values which must be accounted for in an effective valuation analysis.

Market Alternatives: When direct market prices are not available, indirect market prices may be. Valuation based on market alternatives can take three forms:

1. **Replacement cost:** What does the alternative cost? (The value of fish habitat can be determined by measuring the cost of artificial fish breeding and stocking programs);

2. Damage costs avoided: What protection is being provided by ecosystems, and what is this protection worth? (A healthy mangrove forest protects against storm damage. What would be the costs of damages if the mangrove didn't exist?);

3. **Production function:** If nature is providing inputs to production, what are the monetary implications of changing the quantity or quality of these inputs? (Changes in land-use practices may alter the flow of ecosystem services).

4. Surrogate Markets: In the absence of clearly defined markets for ecosystems services, surrogate markets can be used to ascertain value. People's preferences and actions in related (surrogate) markets are measured to determine the value of the ecosystem service in question. Two common valuation methods are:

1. Travel cost: Service demand may require travel, whose costs can reflect the implied value of the service (e.g. value of ecotourism experience is at least what a visitor is willing to pay to get there)

2. Hedonic pricing: Service demand may be reflected in the prices people will pay for associated goods (e.g. coastal housing prices exceed that of inland homes)

Stated Preference:

1. Contingent Valuation: Service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives (e.g. visitors willing to pay for increased access to national parks)

2. Choice modeling: respondents choose preferences. Instead of determining willingness-to-pay, People chose between different situations. Given a 'menu' of options with differing levels of ecosystem services and differing costs, which is preferred?

Participatory Valuation

Participatory valuation is often carried out after a focus group exercise where stakeholders voice concerns and table issues to infer values indirectly. For instance, participants may be asked to use counters pebbles, rice to represent the significance of certain factors that are important to them. Some of these factors may be difficult to value using market prices alone (security of water supply). Others may have a direct market value (fuel prices, for example). While determining causation

is difficult, this process can elicit the significance of certain factors relative to others. If a respondent uses six grains of rice to describe impediments caused by irregularity of water supply and four to describe obstacles created by fuel prices, something can be inferred about the significance of water security in relation to fuel prices. One important advantage of this methodology is that it can be used with respondents who are illiterate or not used to expressing preferences in monetary terms.

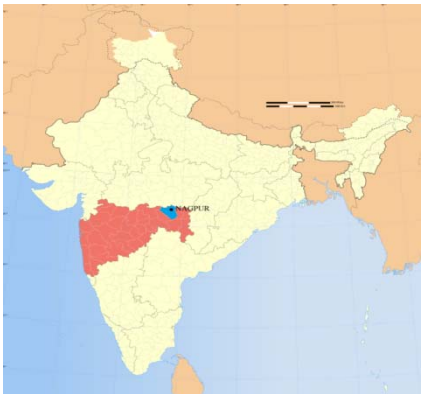
Benefits transfer: Benefits transfer (BT) is not a methodology per se and it includes several variations. Bt uses primary valuation studies from other sites to inform decision making. This method is inexpensive and expedient. It is, however, not as precise as a primary valuation.

6. FOCUS ON ECOSYSTEM SERVICES: HELPING CITIES TO ACHIEVE THEIR GOALS

This section examines how cities can benefit in various ways from a focus on ecosystem services, especially with regard to urban planning, budget allocations and municipal service delivery.A focus on ecosystem services can support the work of city authorities in at least three ways:

Firstly, the benefits we derive from a functioning environment become visible at the local level. If we adopt a focus on ecosystem services, their relation to municipal service delivery becomes evident. For example, cities are often responsible for the provision of clean water to their citizens. A focus on the ecosystem services relevant to water provision can help identify the water purification capacity of, for example, nearby forests. The preservation of the forests can therefore become an integral part of the strategy to provide clean water to local residents.

Secondly, focusing on ecosystem services allows decision makers to better anticipate the consequences of decisions or policies. Ecosystems generate multiple services and by looking at ecosystem services the costs and benefits of the choices can be compared. For example, when a forested area that is valued by both residents and local decision makers for the full range of services it provides, is threatened by a new development, this will have to be considered in terms of the benefits which would be lost.



An ecosystem services approach is complementary to other motivations to conserve nature, encouraging policy makers to consider the connections between natural systems and human well-being through various policy and management processes, including planning, budget allocations or infrastructure. Focusing on ecosystem services will help achieve a balance between developmental and environmental objectives.

7. NAGPUR CITY PROFILE

Nagpur is one of the fastest growing cities of Maharashtra in India. Nagpur is also called as the 'Orange City.' Nagpur is also said to be the second greenest city in India and the 10th largest in India in terms of population. The city is the winter capital of the state of Maharashtra. The climate of Nagpur follows a typical seasonal monsoon weather pattern. The average annual rainfall is 45 inches, with more rain in the east than in the west. The city administration is vested with the NMC. NMC also provides other services like running city bus services, primary and secondary education, and health services in the city. Construction, operation and maintenance of urban infrastructure are the prime responsibilities of NMC.

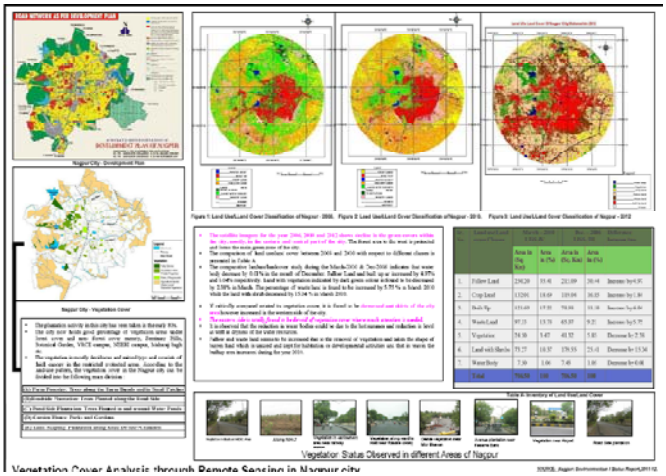


Fig. 6: Nagpur Location

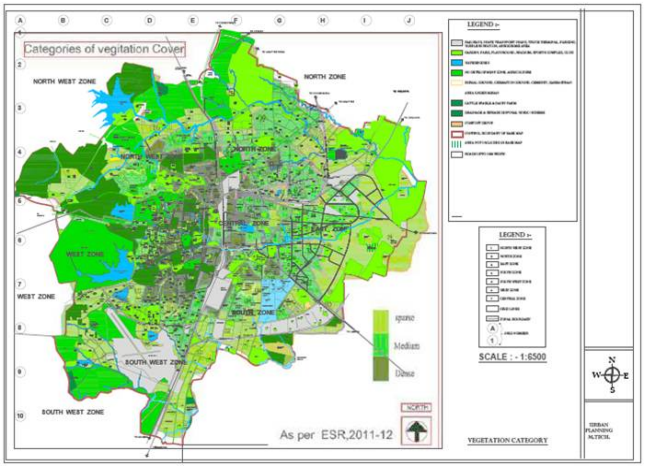
7.1 Green Cover Analysis

Nagpur is known as the second greenest city in India. The city is flourished with greeneries in all part of the city with varied plantation. The green areas within the city not only served as aesthetic and recreational purposes but also help in regulating the temperature and Vegetation Pattern maintaining the humidity especially during the hot and dry summer months. Although the planning of Nagpur city is being made with a great importance to protect and increase the green spaces and the natural systems, all efforts to increase the green cover of the city should be made by the local authority and also the citizens of Nagpur. The city has natural forest areas which are declared protected areas while the fertile plains fed by the rivers was used as developed lands. The institutional belts exist within the city limits with large green tracts which have

remained protected even till today. This ensured ample green zones within the city. However the newer developments should also focus for the development of the green zones. This needs to be taken care at the city planning level. Since the soils within the city zone areas and also outskirts of the city are clayey and productive, plantations can be done easily.

Nagpur city is the best place to study the interactions of atmospheric pollutants such as SO2, NO2 and suspended particulate matter (SPM) on vegetation, as it is high traffic zone industrial area on the outskirts as well as have good vegetation cover in the city.

This study is to understand, urban pollution in relation to Vegetation cover in the Nagpur City using ambient air quality monitoring, remote sensing for land use cover, biochemical responses of the trees to air pollution. So that we could understand the role of vegetation as an important element of ecosystem for ecosystem service functions within the city.



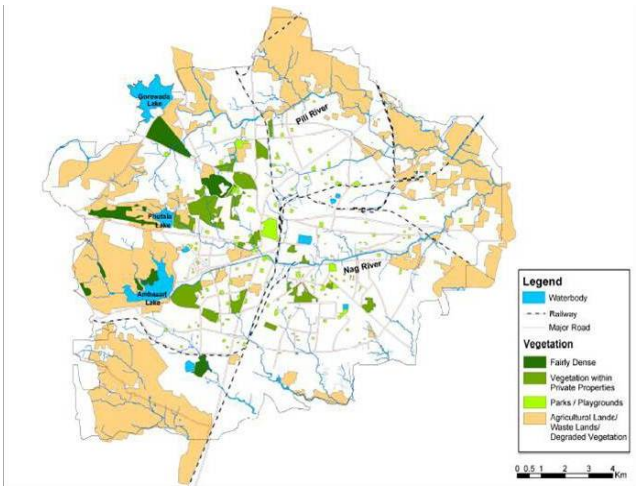


Fig. 7: Vegetation pattern

Selection of study area within the Nagpur city based on Six parameters i.e. Tree category, Plant Species Diversity, Land use, Air Quality, structure of parks/ open spaces, lakes water Quality Index For comparing current trends and drivers of change for Ecosystem Services. Valuation Assessment Methods of Ecosystem Services Adopted for household survey i.e. Participatory Environmental Valuation which gives Qualitative and Participatory Approach in order to understand what people think the most important ESs for the well-being and how they value them for marketed and non marketed service.

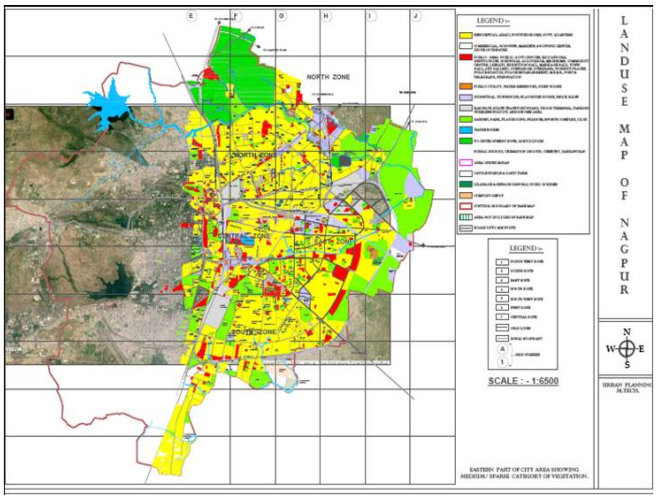


Fig. 8: Vegetation Category

7.2 Selection of Study Area for Analyzing Current Trends of Ecosystem Services

The selection of study area based on the different categories of vegetation within city limits Table 2 is giving the vegetation category and the area of selected wards within the Nagpur city.

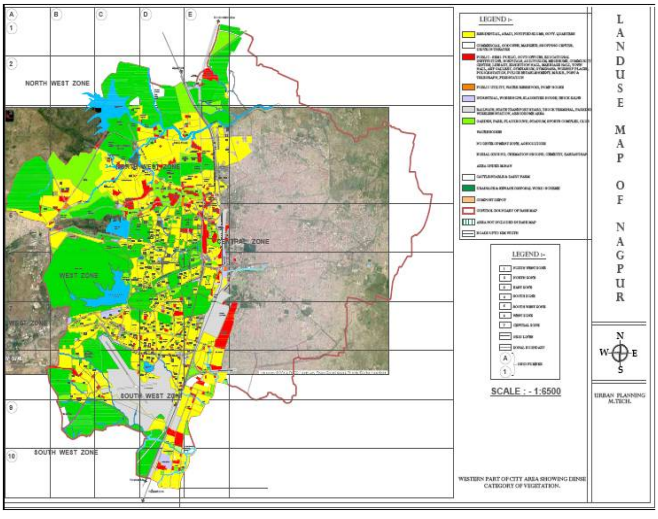


Fig. 9: Comparison of landuse with vegetation category of western side of Nagpur City

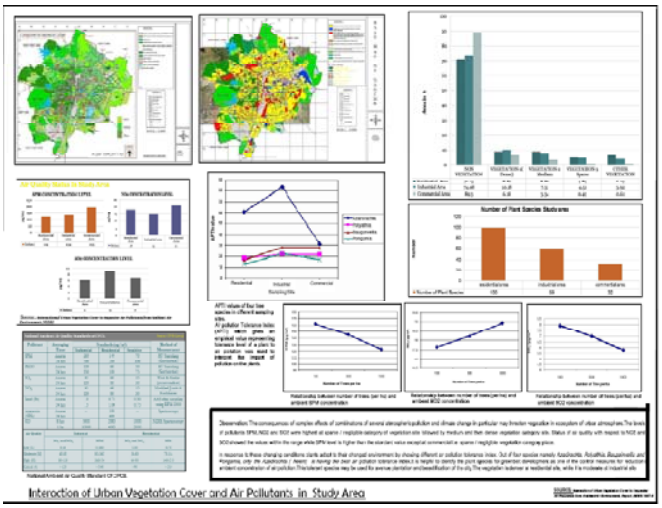


Fig. 10: Comparison of landuse with vegetation category of Eastern side of Nagpur City

Table 2: Vegetation category and the area of selected wards within the Nagpur city.

Area (3000 M Radius)	Total Buffer Area In (Ha.)	Total Wards Area In Buffer (Ha)
1. Dense Category	2800	2723 (31) Nos.
2. Negligible	2800	2830 (57) Nos.
3. Medium	2800	1557 (5) Nos.

Table 3: Selection of wards from core area of Nagpur city

Area	Selected Wards For Analysis	Area In Ha	Population (2011)
1. Dense Category	Dharampeth,	78.1	12343
	Hiltop	40.9	15802
	VNIT,	181.4	12282
	Neeri	111.9	12888
	Dikshabhoomi	180.1	11894
	Kaushlyanagar	0.44	14498

Table 4: Selection of wards from in-between area of Nagpur city.

Area	Selected Wards For Analysis	Area In Ha	Popultion (2011)
Negligible	Gandhibagh	0.37	12527
	Mahal	0.44	14498
	Lendi Talav	0.21	13868
	Maskasath	0.28	13434
	Boriyapura	0.40	15371
	Padolenagar	0.21	18576

Table 5: Selection of wards from outside area of Nagpur city.

Area	Selected Wards For Analysis	Area In Ha	Population (2011)
Medium	Trimurti Nagar	1.08	19836

7.3 Participatory Environmental Valuation

Qualitative and Participatory Approach in order to understand what people think the most important ESs for the well-being and how they value them.

Table 6: The Questions Focused originally on following entry points:

1. To get Approximate cost of goods and services. Based on Market Prices and and Damaged Cost Avoided. (Market Price of fuel wood/wood, Agri. Product within city which generates economy for city, health issue from Air pollution.
2. Recreational Areas.
3. Public participation and their views
4. Willingness to pay
5. Asking People To Determine The Importance of A Non-marketed Ecosystem Service Relative To Goods or Services That Are Marketed

7.4 Ratings from Participatory Environmental Valuation:

Questionnaire has been design for the Participatory Environmental Valuation where TEEB has given one of the assessment method for evaluating the Ecosystem Service Conditions And Trends, Drivers in Study Area.

Ratings evaluated for different category of vegetation. Table 7 shows ratings for Ecosystem Service Conditions And Trends, Drivers in Study Area

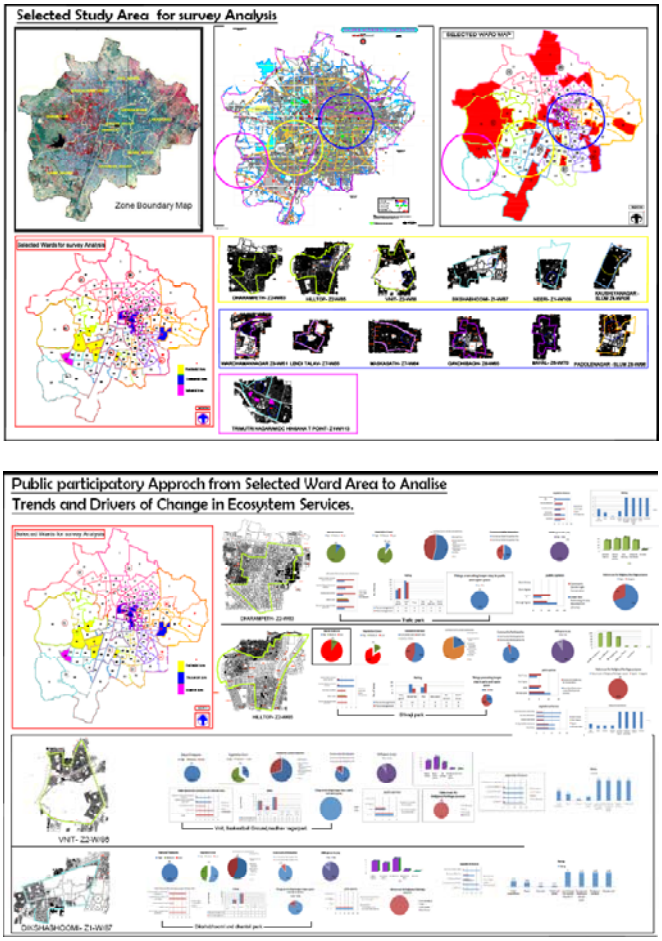


Fig. 11: Showing Area selection for Analysis within Nagpur city limit

Table 7: Ecosystem Service Conditions And Trends, Drivers In Study Area :

Ecosystem Services in Dense vegetation category	Selected parameter that generate the service (site / habitat , (Vegetation)	Current condition of ecosystem service (++ very good, + good, – bad, –– very bad	Likely current trends (increasing, stable, Decreasing)	Drivers of change
Provisioning Services	Food (crops/fruits) (p-)	-	Decreasing	Land Use Quality Of Life
	Wood /timber (c-/p-)	-	Decreasing	
	Fuel wood(c-)	-	Decreasing	
	Medicinal plants	--	Decreasing	
Regulating Services	Local climate & Air Quality regulation	++	Increasing	
Cultural Services	Recreational mental and physical health	++	Increasing	
	Religious / spiritual	+	Stable	
	Aesthetics	++	Increasing	
	Educational	+	Stable	

Ecosystem Services in medium vegetation category	Selected parameter that generate the service (site / habitat (Vegetation)	Current condition of ecosystem service (++ very good, + good, – bad, –– very bad	Likely current trends (increasing, stable, Decreasing)	Drivers of change
Provisioning Services	Food (crops/fruits) (c-/p-)	-	Decreasing	Land Use Lack of Awareness
	Wood timber (c-/p-)	-	Decreasing	
	Fuel wood (c+)	-	Increasing	
	Medicinal plants	--	Decreasing	
Regulating Services	Local climate & Air Quality regulation	+	Stable	
Cultural Services	Recreational mental and physical health	--	Decreasing	Less community participation Pollution
	Religious / spiritual	++	Increasing	
	Aesthetics	+	Stable	
	Educational	-	Decreasing	

Ecosystem Services in Negligible vegetation category area	Selected parameter that generate the service (site / habitat (Vegetation)	Current condition of ecosystem service (++ very good, + good, – bad, –– very bad	Likely current trends (increasing, stable, Decreasing)	Drivers of change
Provisioning Services	Food (crops/fruits) (cons./production)	-	Decreasing	Land Use Quality Of Life Pollution Lack of Awareness
	Wood(timber) (production -)	-	Decreasing	
	Fuel wood (c +/p-)	-	Increasing	
	Medicinal plants	--	Decreasing	
Regulating Services	Local climate & Air Quality regulation	--	Decreasing	
Cultural Services	Recreational mental and physical health	--	Decreasing	Less community participation
	Religious / spiritual	++	Increasing	
	Aesthetics	--	Decreasing	
	Educational	-	Decreasing	

Table 8: Observation and Inferences

Indicators/ Land Use	Core (Negligible vegetation category)	Planned (dense vegetation category)	Outskirts (Medium,vegetation category)
Trees Per Ha	Negligible	800	200
Category Of Trees	Very Less	Dense	Medium
Provisioning services: Crops, wood. fuelwood, medicinal plants	only Consumption of fuel wood, no crops, no land availability	Land available but no crop production.	only Consumption of fuel wood, no crop production.
regulating services: Air Pollution (SPM)	High	Within The Range Of Standard	Within The Range Of Standard

Culturalservices: recreational, parks	Less parks , Poor condition	Stable condition	no area reserved for recreational
Aesthetics	poor	good	medium
Community participation	No	No	yes
Potential Areas for conservation, preservation and enhancement of Ecosystem Services. (Based on water Quality & Extent , tree density)	(Lakes and parks) Gandhisagar, Lendi talav , Naik talav and parks gandhibagh, nit mahal, shivaji park, maskasath.	Dence vegetated ares Neeri and vnit, pkv land, parks and open spaces Ambazari lake	Buffer areas

The consequences of complex effects of combinations of several atmospheric pollution and climate change in particular may threaten vegetation in ecosystem of urban atmosphere. The levels of pollutants SPM, NO2 and SO2 were highest at sparse / negligible category of vegetation site followed by medium and then dense vegetation category site. Status of air quality with respect to NO2 and SO2 showed the values within the range while SPM level is higher than the standard value except at commercial i.e sparse / negligible vegetation category place.

In response to these changing conditions plants adopt to their changed environment by showing different air pollution tolerance index. Out of four species namely *Azadirachta, Polyalthia, Baugainvellia and Pongamia, only the Azadirachta(Neem) is having the best air* pollution tolerance index. It is helpful to identify the plant species for greenbelt development as one of the control measures for reduction of ambient concentration of air pollution. This tolerant species may be used for avenue plantation and beautification of the city. The vegetation is denser at residential site, while it is moderate at industrial site.

8. FRAMEWORK FOR CONSERVATION AND ENHANCEMENT OF ECOSYSTEM SERVICES

Table 9: Policy And Recommendations

Policy Points	Implementation And Consideration
Use zoning to keep land available for priority provisioning ecosystem services.	Needing legal framework and fair political process to apply zoning.
Use physical structures or technology to substitute for ecosystem services.	Provides a substitute for degraded ecosystem services that may mimic natural design.
Require ecosystem management best practices.	Defining and enforcing best practice standards.
Use regulating ecosystem services which Usually provides co-benefits such as carbon storage and recreation.	Trees having more capacity to store air pollutants in polluted areas.
public involvement for planting schemes	Initiative programmes by local authority or NGOs.
Design guidelines for potential areas for conservation and enhancement of ecosystem services.	ex. In commercial area : Lendi Talav or Naik talav, one of the focus areas where enhancement of these areas as recreational purpose can give provision of ecosystem services.
	ex. In industrial area : no recreational opportunity for people in nearby area. (zoning is necessary)

Site specific conservation

Changes of landuse from non-residential to a residential use or even a low-density use to a high-density use impacts the ecology of the area. Biodiversity conservation is site specific and the needs for conservation on each site would be different. Biodiversity conservation for eco housing has to be done before the site is built upon and not as a remedial action after the natural system has been destroyed. Thus site-specific conservation should be considered in a two-prong method, a) conservation of the existing natural habitats b) Remedial measures to restore and promote the natural biodiversity of the area.

a) Conservation of the existing natural habitats

1. The first step is to inventories the naturally occurring flora and fauna on the site with the involvement of taxonomy experts and other experts. Conduct a detailed ecological survey of the site to identify floral species of trees, shrubs and even weeds. Identify the faunal species present and survey their habits in the area.
2. The natural drainage pattern on the site, its topography and slopes are also a important component of its biodiversity. These should be studied and taken into consideration during design stage..
3. Based on the site inventory report identify pockets of microhabitats that need to be left undisturbed. The building layout should be designed with the aim of conserving these areas.
4. It is important to do a study of the movements of fauna in the area. A corridor study of the site and immediate surrounding area to understand the movements of fauna and the impact of construction activity on the path should be conducted, especially for those sites closer to hills forest patches.
5. The destruction of natural habitat could be because of absence of co-ordination between the various activities in the construction process. Developing a logical framework that provides a sequence of activities that ensures protection of the biodiversity of the area should be

prepared. Measures should be identified to conserve the biodiversity at every stage of the design and construction activity.

6. Transplantation of trees–Not all trees require to be transplanted. Sometimes the cost of transplantation may be exorbitant, compared to the cost of planting a sapling of that species.
7. Based on the site inventory trees that need to be conserved at its present location, and trees that can be transplanted should be prioritized.
8. It should be noted that although the emphasis is on conserving and developing native vegetation trees. If existing non-native trees/exotic species exist on the site, these should not be cut to be replaced by native vegetation.

b) Remedial measures to restore and promote the natural biodiversity of the area.

1. Once the site has altered it is impossible to regain the original natural biodiversity of the area. Remedial actions are therefore focused towards creating a conducive urban niche for the flora and fauna that have been displaced from the site.
2. Plant only native species in the landscaped area. Plant trees of species that existed naturally on the site before development.
3. Alternate paths should be identified and developed for the fauna movement wherever old paths have been altered.
4. Landscape for the building should be designed to integrate the conserved pockets of microhabitats.
5. Create urban niches to form environments conducive for fauna. *Refer to Need for Creating Urban niches in Report on Native Fauna of Pune.*
6. Landscape of the building should be designed to recreate the natural connections of the site with the surrounding area and not in isolation.
7. Provide for areas of natural growth in the landscape design that would allow weeds and seasonal plants to grow, as these would attract insects and consequently other fauna.
8. Buildings should not only have landscaped areas but also provide for children playgrounds where games such as cricket can be played.

1. **Better Land-use Planning** Decisions To Support Both Biodiversity Conservation And Enhancement of Ecosystem Service Delivery
2. **Enhancing Green Spaces to** support Economic Stability from Natural Capita within the city limit.
3. Provide Information To **Raise Awareness and community participation** to Build Public And Government Support .

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