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Urban Reforestation: A comparative case study of Contextual Challenges and Strategies

Sub theme- Goal 11: Sustainable Cities and Communities.

Goal 13: Climate Action

Goal 15: Life on Land.

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Abstract

Nationally, the trend in migration from rural regions to urban regions has been ongoing for decades. This trend continues even today. Along with migration, upward mobility in urban areas lead to greater demand for more robust infrastructure. This combined impact of population growth and an ever-increasing need for infrastructure has led to shrinkage of urban green areas, which has further led to ecological and habitat destruction for the flora and fauna inhabiting the cleared forests.

Green cover, as individual trees, in the city support a very limited biodiversity. Forests, which cover large areas and also a variety of flora and fauna, allow for a more complete and robust green cover. Hence, urban reforestation becomes a vital strategy for sustainability as well as reducing certain impacts of climate change. It not only can help overcome microclimate challenges, but also help mitigate weather disruptions, making urban areas more resilient.

Under this premise the paper looks to explore multiple case studies through their parameters of context of location, climate, scale and land condition. It will also look at various strategies implemented to successfully achieve reforestation. Based on the comparison, the paper aims to identify the various steps and processes involved in implementing urban reforestation strategies.

Keywords

Urban Planning, Reforestation, Micro climate, Revitalization ,Carbon sequestration Nutrient retention Sediment retention Socioeconomic benefits Restoration Forest policy.

1. Introduction

Urbanization is a global phenomenon that is still evolving. Although today, globally we have 4.4 billion inhabitants (World Bank, 2022) in urban regions as per world bank, the idea of a modern city feels unevolved. Upgrading urban infrastructure and incorporating new ideas in development control regulations is a slow and tedious process. Hence, urbanization largely focuses on density and the physical infrastructure required to support that density of humans. As per the world bank, “Building cities that “work” – green, resilient and inclusive– requires intensive policy coordination and investment choices. As per the report this cannot be done with participation of the local governments and policy makers (World Bank, 2022)

Although various urban civic bodies have certain provisions for green spaces, recreational areas or public open spaces within the jurisdiction of boundaries, it rarely accounts for how green infrastructure is needed to support the very same density of humans. Green infrastructure and natural regions are of far more significance in an urban environment as it strikes a balance between the built and natural world. This makes the urban area more balanced, allows for growth of ecology, improves sustenance and resilience of the city. As per research, planting of trees in an urbanized area will become an inevitable infrastructure requirement in the 21st century to combat global warming and climate challenges (Zappa, n.d.)

The significance of natural environments within built environments is an idea that has existed for a long time, however, restriction in updating policies and seeing needs of stakeholders differently has led to a situation where implementation of these concepts has taken a real backseat. The paper aims to explore cases that have been successful in implementing reforestation and revive an ecosystem within them.

- 1.1. **Aim:** To conduct a comparative study of urban reforestation implementations through case study across the world.
- 1.2. **Objectives:** Compare the cases on parameters of -
 - 1.2.1. *Context:* Look at density, land use, climate and region in which reforestation was conducted.
 - 1.2.2. *Strategies:* Understand the strategies used including types of trees and species
 - 1.2.3. *Impact:* Understand the impact.
- 1.3. **Definitions:**
 - 1.3.1. *Urban areas:* The urban area in which the case study is located
 - 1.3.2. *Reforestation:*
 - 1.3.3. *Urban Forest:* “The term "urban forest" refers to all trees within a densely populated area, including trees in parks, on streetways, and on private property. They offer environmental, economic, and social benefits.in some capacity’ (Safford et al., n.d.)
 - 1.3.4. *Climate:* Macro climate of the region under consideration
 - 1.3.5. *Land Use:* Planning or ownership of land or current land use
 - 1.3.6. *Density:* Population Density of the urban area
 - 1.3.7. *Area:* Area of intervention
 - 1.3.8. *Methods:* Unique methods used in execution of the project
 - 1.3.9. *Species:* use of type of trees and vegetation
 - 1.3.10. *Planning:* The time and process for execution of the project
 - 1.3.11. *Site Selection:* reasons to select the site
 - 1.3.12. *Biodiversity:* Types of flora and fauna found
 - 1.3.13. *Green Infrastructure:* CO2 capture oxygen contribution

2. Main Body

The paper looks at three different cases to arrive at the comparison. The following cases 1. How the Miyawaki reforestation method impacts through case study of Navi Mumbai, 2. Reforestation of Costa Rica's urban riverbanks and 3. Warje Smriti Van, Pune will be compared on the parameters of context, strategies and results.

1.1. Case Study 1: Impact of Miyawaki reforestation method: a case of Navi Mumbai

1.1.1. *Context:* Urban Forest are an integral part of India from primaeval days. Sanskrit, Buddhist and various religions have highlighted the importance of forests and green spaces. During the pre-colonial times as well, emphasis was given on having natural cover within large urban sprawls. This also holds true for post-independence city planning in some cities like Chandigarh and Navi Mumbai.

"I wanted to improve the green cover and found this method to be more useful than parks and gardens," S Vaidyanathan, the revenue divisional officer of Lalgudi. (Nayak & Times Of India, 2022)

As per the article, using Miyawaki strategy helps in developing the biodiversity of the region as it also promotes use of native plants and trees instead of using monoculture methods of planting. (Nayak & Times Of India, 2022)

Indian Town/ City	In Square meter, Per Capita Urban Green Spaces (m²)
Gandhinagar, Gujarat	162.80
Chandigarh, Punjab	54.45
Delhi	21.52
Bangalore, Karnataka	17.32
Jaipur, Rajasthan	2.30
Navi Mumbai, Maharashtra	2
Mumbai, Maharashtra	1.8

Miyawaki project through *not-for-profit Green Yatra* at Koparkhairane: large scale Urban Forest with dense forest cover planted 40,000 trees. the Morbe dam which supplies drinking water to the city, NMMC targeted 1 Lakh trees plantation in future near dam area.

Through "Green-Yatra "Urban forests": The Miyawaki method attempts to create densely packed green pockets in the city in 1 year. City has many recreational areas including Gardens, playgrounds, jogging and cycling tracks which will be covered with green belt in future with this project, Bhakti Park which is 57,000 sq.m located in Chembur/Wadala, has about 1,100 native plants, planted a year ago. (Green Yatra, n.d.)

With vision to make Navi Mumbai as an environmentally friendly city, NMMC has launched a Largest Miyawaki Forest restoration which is one of India's largest projects with over a lakh of trees incorporating over 60 varieties of indigenous trees.

The upcoming urban forest in NMMC (Navi Mumbai Municipal Corporation) has already planted 68000 trees in Nerul Public Park.

1.1.2. Strategies:

The Navi Mumbai Municipal Corporation has used Miyawaki Reforestation strategy for planting and reforesting urban areas under its jurisdiction. To achieve this the municipal department has been planting trees at a rapid pace. It has

planted around 2.2 lakh trees in the past two years. Another 60,000 trees will be planted in the next year, by 2022. (Srivastava, 2022). Through a CSR Project, NGO Green Yatra has also planted 40,000 trees in sector 14 of Koparkhairne by the NGO Green Yatra. Maintaining the momentum, in the year 2022, more than 1.4 lakh saplings were planted in 7 places across the city by Miyawaki method, in which 20,000 saplings are of native species. (Srivastava, 2022)

In the Miyawaki Technique all native trees including neem, adalsa, ashok, badam, bor and others have been used. (Nayak & India, 2022). Miyawaki technique has shown great success in the Navi Mumbai project. The rate of growth of young saplings has been rapid. 'Seedlings have grown from 1.5 to 2 feet at the time of planting **up to 15 feet in 12 months**. fruit-bearing plants have been shown to support the increase in the biodiversity of the region'. (Srivastava, 2022)

Image 1: Site Area, Credit: Geen Yatra

Image 2: View of Road in Navi Mumbai, Credit: Amit Srivastava, Free Press Journal



(Green Yatra, n.d.)

According to Green Yatra, special care was taken to improve the survival rate of the saplings being planted. Around 60 species of plants, canopy trees, shrubs and sub-trees were planted in order to have a balanced support system and biomass distribution.

Pathways are being created to allow citizens to access the forest. The aim is to create a recreational hub for all age groups and also provide area for meditation and walking. (Nayak & India, 2022)

1.1.3. Impact:

Forest near Koparkhairane Node Forest through Miyawaki method in Navi Mumbai where plants of 1 foot to 2 feet have grown to 15 feet trees with rapid growth in height it will help to the biodiversity, the fruit-bearing trees have started attracting birds, contributing to the biodiversity. Recycled water from the most modern sewage treatment plant (STP) is being used for the plants. The green drive is being managed through different CSR funds of various companies and the maintenance for 3 years is also being taken care of by the plantation forest under Miyawaki forest.

1.1.3.1. Ecological Benefits:

Urban forestry helps resolve soil erosion, help reduce noise and air pollution, wastewater management, watershed protection. They can greatly reduce glare, reflection and provide shade in an urban area. A fully-grown tree can annually absorb up to 150kg of CO₂. Urban vegetation greatly helps during monsoons as they help maintain flow of water and help control stormwater runoffs. Trees greatly contribute to improving the air quality and the microclimate of the region. They also improve the thermal comfort and reduce the energy consumption of the surrounding areas.

1.1.3.2. Social Benefits:

Urban trees impact the aesthetics of place as well. They help in breaking the visual monotony of built environment and urban sprawls. Urban forest can also become important focal points for recreational activities that lead to a healthy and a more social life style allowing people to meet and celebrate in natural scenic forests.

1.1.3.3. Economic Benefits:

Urban forest greatly impacts the microclimate of the nearby region. This in turn can allow in reduction of heat island effect which can reduce ambient temperatures allowing frugal use of mechanical HVAC systems. Not only do forests provide space for recreational activities and can aid tourism, they can also bring economic benefits by providing firewood, timber fruits etc.

Image 3 : Jewel of Navi Mumbai Miyawaki Forest , Credit: Green Yatra



Image 4 : Lake of Navi Mumbai Miyawaki Forest , Credit: Green Yatra

Planning is an important part of achieving successful planting drive. Systematic management of the trees including, planning, pruning, felling, etc should be planned and timed according to the type of tree and seasons. To achieve this it is important to have integration between the planning team, the policy makers, the execution team and the maintenance teams. Tree plantation should be integrated with planning of region instead of being an afterthought.

1.2. Case Study 2: Reforestation of Costa Rica's urban riverbanks

1.2.1. Context: In the Torres River in Costa Rica route, an area of 2.9 hectares was considered for rehabilitation of the biological corridor along the banks of the river. This was done by planting 680 trees. These trees belonged to 49 different native and endangered species. It also involved the removal of invasive elephant grass which inhabited the growth of native species. The project ran for nine months with nearly 200 citizens participating and volunteering. "It is important that countries across the world consider riparian restoration through policy-relevant models to design restoration plans that incorporate multiple ecosystem services." (by Fundacion Rutas Naturbanas & Global Giving, n.d.)

Image 5 - Before View,
Credit: Global Giving Fundacion Rutas Naturbanas

Image 6 - After View,
Credit: Global Giving Fundacion Rutas Naturbanas



1.2.2. Strategies: A two prong strategy was used to create a more sustainable solution. The first involved planting of endangered and endemic species. To do this 680 individual trees were strategically planted. However, it was equally important to remove invasive species of plants that had encroached the area being rehabilitated. This was the second part of the strategy. For this two major invasive species were identified, bamboo and elephant grass. The management and removal of invasive species is an important aspect of restoration and cannot be undermined.

<i>Investment plan</i>	<i>US\$</i>
<i>Planting of 680 individuals</i>	<i>\$44,200</i>
<i>Management of invasive species</i>	<i>\$25,800</i>
<i>TOTAL</i>	<i>\$70,000</i>

1.2.3. Impact: The impact of the strategy has been significant. Creation of biological corridor has led to increase in the biodiversity of the region. (Fundacion Rutas Naturbanas & Global Giving, n.d.). The corridor has provided connections and refuge for wild populations in the middle of the urban matrix like amphibians, reptiles, birds and mammals. It is believed that use of native trees will also help against soil erosion and also help in forest regeneration and avoid contamination of the river. It is also providing a public space for 600000 citizens of the city allowing them space for recreation and physical activities. (Fundacion Rutas Naturbanas & Global Giving, n.d.)

Image 7 – Rivers of Costa Rica. . ,Credit: Christoph Lischetzki / Alamy

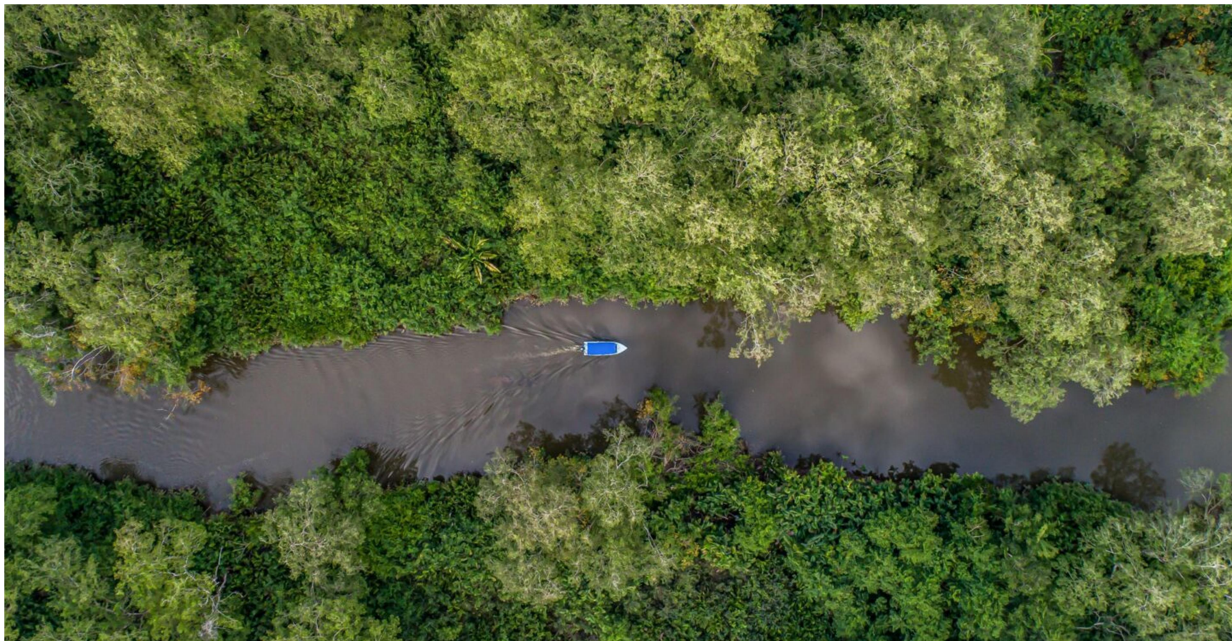
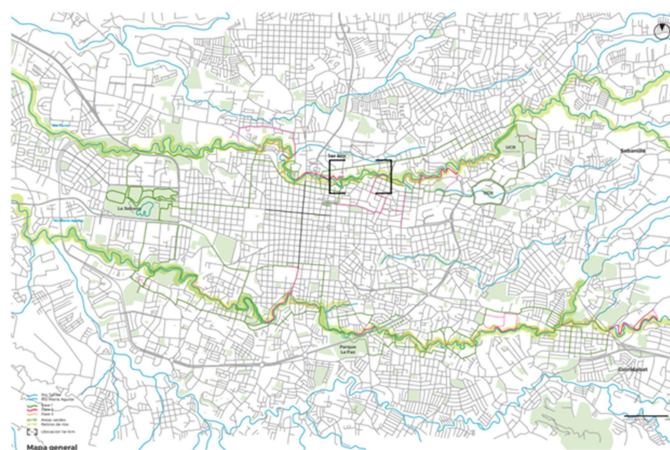


Image 8 - City Map ,
Credit:RutasNaturbanas

Image 9–Phase 1 Master Plan ,
Credit:RutasNaturbanas



1.3. Case Study 3: Warje Smriti Van, Pune

- 1.3.1. *Context:* Wajre Urban Forest is located in Pune, India. It is one of the fastest growing urban areas of India. The population density of Pune is 5,600 people per square kilometer. The climate of Pune falls in tropical wet and dry conditions as per Nematological Society of India and Indian Council of Agricultural Research. The WajreUrban forest is located in a land that was un utilized and encroached. 'A barren land with the forest department, Warje was of 16 hectares of land hill. The land had been encroached illegally by slums and certain developers.' (TERRE Policy Centre, 2018). It is a joint effort between the Maharashtra Forest Department, NGO TERRE Policy, Tata Motors and Persistent Foundation. 'A small region located in Pune, it was taken up for Urban reforestation by Terre and the forest department with participation of CSR.' (TERRE Policy Centre, 2018)
- 1.3.2. *Strategies:* The project started with planting of plants with height of 6-8 feet nearly 9400in number. Over the years the trees have grown to about 10 feet. 23 types of indigenous trees like Banyan, PeepalBadam, Amla have been planted. Volunteers help in upkeep of the forest. To help generate participation of the locals the forest has been developed as 'Smriti' van or as 'in Memory Forest' with people adopting plants in dedicating them in the memory of their loved ones.
- 1.3.3. *Impact:* Since the Warje forest was a barren land, nurturing of a forest in it has had a huge impact on the biodiversity, micro climate and the overall air quality of the region. The findings show a huge impact on the

oxygen production levels, CO₂ absorption levels and also on the flora and fauna. The tree density of the region has also been improved.

Table 1: Tree Density: Density is the number of trees per unit area {the number of trees per hectare (1 hectare = 2.47 acres)}.

No of Trees	9500
Total Area under plantation	16.8 Hectares
	9500 / 16.80
	= 565 Trees/Hectare

Source: (TERRE Policy Centre, 2018)

“The impact on the tree density can be seen in the table above. Similar impacts have been seen in the air quality and the level of oxygen and CO₂ that is being generated on account of planting of nearly 10000 trees. Charts below show the level of oxygen production and carbon dioxide absorption.”

Image 10 : Impact on oxygen production, Credit Terre Policy Centre

Oxygen production

A young tree absorbs approximately 130 pounds oxygen per year

So, $9500 \times 130 = 12,38,900$ lbs. (pounds) oxygen production

Before the vegetation growth, the hill is totally barren. Only few patches of grasses were seen seasonally i.e. during monsoon. Even the small contribution in oxygen production was 10000 lbs. per year.

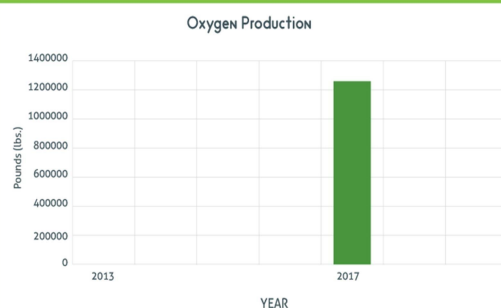


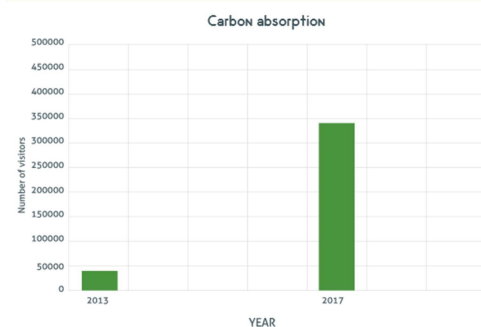
Image 11 : Impact on CO₂, Credit Terre Policy Centre

Carbon absorption

A young tree absorbs approximate 36 pounds carbon per year

So, $9500 \times 30 = 2,85,000$ lbs. (pounds) carbon absorption

Four years before, the barren area could absorb about $2300 \times 16.8 = 38640$ lbs. Where carbon absorption by few grassland patches



The biodiversity of the region is also positively impacted as indigenous tree species like banyan, neem, Peepal tree, Chafa tree, etc have been planted. Since indigenous flora has been used, local fauna has also been helped with this. Various types of birds (29), mammals (3), reptiles (10) and butterflies (15) have been spotted within the Warje Urban Forest. (TERRE Policy Center, 2018)

3. Findings

As per the research findings, “Solutions that are harnessing natural and modified ecosystems to address social and environmental issues are very important to achieve sustainable solutions..” (Teo et al., 2021, #). To reverse the impact of climate change it is important to have solutions that are inexpensive, easy to implement and simple at a global level. “Carbon sequestration and reduction of emission are two strategies that can economically reduce emissions by a 1/3rd of the <2 °C target in the Paris Climate Agreement, while improving overall ecology and environment.” (Teo et al., 2021, #)

To achieve urban reforestation participation and contribution from all the stakeholders is of the essence. The paper finds that a collaborative effort with political will, peoples' participation, planning and preservation of existing natural areas can greatly help in achieving various sustainability goals. As per the research, 'Growing an equitable and resilient urban forest', "Greener areas tend to have better air quality, more recreation opportunities to encourage physical activities, and more social space for neighbors and friends to relax and connect." (Cheng et al., 2019)

A good example of political will can be seen in Singapore garden city, which has greatly spent financial resources to achieve a more greener and sustainable city development model. Medellin Urban Revitalization highlights how public participation and planning can bring about change. "The program involves a wide variety of stakeholders, including government agencies, publicly-owned companies, private companies, and local community members. In order to improve transparency and efficiency, Mayor Farjado established an independent agency called the Urban Development Corporation (EDU) for designing and managing various urban revitalization projects (including the greenbelt project)." (Cheng et al., 2019)

Preservation of existing forests and green cover should also be supported. Today, cities across the world are trying to measure the green cover of city and how it can greatly improve microclimate conditions. "Urban areas like mega cities (population more than 10 million) and smaller cities (population of 50-200,000) have a huge potential for climate mitigation through urban reforestation. (Teo et al., 2021, #)

Urban Reforestation Case Study Parameters					
Parameters		Definitions	Case 1	Case 2	Case 3
Context	Region	The urban area in which the case study is located	Navi Mumbai ,Maharashtra,India.	Costa Rica	Pune, India
	Climate	Macro climate of the region under consideration	Navi Mumbai has a tropical and wet climate. Mumbai's climate can be best described as moderately hot with high level of humidity.	Climate is tropical and subtropical. Dry season (December to April); rainy season (May to November); cooler in highlands.	The climate of Pune falls in tropical wet and dry conditions
	Land Use	Planning or ownership of land or current land use	NMMC	Costa Rica's urban riverbanks	Encroached, Owned by Forest Dept
	Density	Population Density of the urban area	108.7 per Km sq.	100 per Km sq.	The population density of Pune is 5,600 people per square kilometer.
	Area	Area of intervention	Sector 14 Koparkhairane	2.9 hectares	16 Hectares
Strategies	Methods	Unique methods used in execution of the project	Miyawaki	Miyawaki, Rehabilitation of the biological corridor increases the diversity of ecosystem services.	Joint venture between NGOs, Government and Corporations through CSR, people participation as creation of ownership in form of dedication memory of loved ones.
	Species	use of type of trees and vegetation	Native species: Karwand, Curry, Tagar, Adulsa, Neem, Khair, Bell, Limb, Kanchan, Apta, Umber, Khair, Ashok, Badam, Bor, Anjan, Bahawa, Kokam, Jambul, Moh. There are more than 60 native tree species such as Bakul, Karanj, Rithe, Cashew, Chinch, Amla, Wad, Pimpal, Sonchafa, Mango, Kadamba, Saag, Saras.	49 different native , endangered and endemic species. Invasive species like elephant grass , mahogany, kapok, golden trumpet, lignum vitae, rosewood and oak trees	Indigenous Indian trees including, banyan, peepal, jamun, chafa, badam, aloe vera , etc
	Planning	The time and process for execution of the project	3 Years	9 Month for process & Planting	it took four years to maintain the planted trees till they matured to full height trees allowing greater benefits
	Site Selection	reasons to select the site	City per capita green cover	River banks	Revitalization of Forest Department Land
Impacts	Biodiversity	Types of flora and fauna found	Ecological Benefits: Urban forestry plays an important role in addressing environmental engineering problems, including those related to erosion control, noise and air pollution abatement, wastewater management, watershed protection, and glare, reflection, and traffic control .	Biological corridor increases the diversity of amphibians, reptiles, birds and mammals such as bats, three and two-toed sloths, common opossums, coatis, porcupines, coyotes, raccoons and more.	Plant : 23 Bird : 29 Butterfly : 15 Reptiles : 10 Mammals : 03
	micro climate	impact on micro climate	Thermal comfort, energy use, and air quality by providing shade, transpiring moisture, and reducing wind speeds.	increases the diversity of ecosystem services, habitat and biological connectivity. forest regeneration, protect the soil against erosion and retain slopes.	Significant improvement
	green infrastructure	CO ₂ , Oxygen generation, prevention of soil erosion, prevent pollution etc, green spaces for people	Urban forest offers significant benefits in reducing building air-conditioning demand and reducing energy consumption	protect the soil against erosion and retain slopes, thus avoiding greater contamination of the river and natural disasters involving communities.	2,85,000 lbs. (pounds) carbon absorption
			A fully grown-tree can annually absorb up to 150kg of carbon dioxide.	Opportunities for nearby 600,000 inhabitants that will be able to access public spaces for active mobility, recreation and physical activity, free from noise and pollution, which reinforces feelings of appropriation of the communities to collaborate in benefit of the local environment.	12,38,900 lbs. (pounds) oxygen production
	imp link		https://www.freepressjournal.in/mumbai/navi-mumbai-nmmc-to-create-largest-miyawaki-method-urban-forest	https://www.globalgiving.org/project/urbanriverbanksreforestationcosta-rica/	https://terrepolicycentre.com/pdf/Vvarie-Urban-Forestry.pdf

4. Conclusion

Urban reforestation is both a challenge and an opportunity. Governments across the world are working to come up with policies that can help utilize the huge potential of urban areas as carbon capture areas allowing for more sustainable development. Reforestation positively impacts the social and economic well being of the citizens. They also act as natural recreational spaces, as compared to gardens and local parks which tend to have a cosmetic impact on the environment. “Seoul, Singapore and Bangkok can become good examples that have built green corridors that provide space for nature and wildlife while improving the lives of city dwellers. These interventions will become imperative as 68% of human population is expected to be residing in Urban areas.” (Lal, 2020).

It is important to look at urban forestation strategies of various governments to come up with strategies that can improve the livability of the citizens.

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