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URBAN HEAT ISLAND MITIGATION AND MIYAWAKI FORESTS: AN ANALYSIS

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ABSTRACT

The effects of Urban Heat Islands (UHI) are on an upsurge all over the world due to rapid urbanization and demographic explosion. So, mitigating the UHI became an urgent need of city dwellers as well as everyone due to the widespread impact of global warming. Conservation of natural environment is considered as the most suitable mechanism for countering the adverse effects of UHI. But maintenance of natural environment in urban centres are challenging due to lack of space, maintenance cost etc. Here, the Miyawaki forests put forward a solution to the UHI as well as the greening of urban space. Thus this article looks into the causes of UHIs and the effectiveness of Miyawaki method of forestation in mitigating the adverse effects of UHI and its suitability in urban areas.

KEY WORDS : Urban Heat Islands (UHI), Miyawaki forests, Natural vegetation, Urban areas.

INTRODUCTION

The world nations have been witnessing rapid urbanization and by 2050, about 66 percent of the global populace is anticipated to reside in cities. India has also witnessed hasty urbanization during the last few decades and currently, the urban dwellers constitute well beyond 32 percent of total population that is likely to continue in the future. Urbanisation is a complex phenomenon and urban areas are hot spots of environmental changes with some extreme environmental issues such as alteration in biodiversity, water cycle variation, microclimate change etc. (Kumar *et al.*, 2017). The expansion of urban centres over the years has created an obvious high heating pattern of air temperatures in relation to their less urban areas or rural environment particularly in densely constructed urban centres with meagre vegetation where temperatures tend to be higher. This rise in urban air temperatures in comparison with rural temperatures is known as Urban Heat Islands (UHI) (Alves and Lopes, 2017; Pandey, 2017; Lee *et al.*, 2020). This phenomenon was first identified by meteorologist Luke Howard in 1818 and UHIs were first studied by medical doctors because of its linkage between urban air quality, air temperatures and health (Bristow *et al.*, 2010).

Today, the expanding urban population all over the world and the devastating environmental, energy and health implications; UHIs are receiving amassed attention from scientists, planners as well as policy makers. In fact, it is a usually experiencing phenomenon worldwide and exists in almost every city; big or small depending on the population, morphology and size of the urban area (Madhumathi *et al.*, 2018; Sachindra *et al.*, 2016). Increasing the amount of vegetation or green patches or urban forests is one of the most effective strategies to mitigate the effects of the urban microclimate. Among all the mitigation strategies, green vegetation seems to be the most effective measure to encounter UHI effect (Devadas and Rose, 2009). Also, its effectiveness is well proven and widely acknowledged by the experts as an efficient mitigation measure. The benefits of vegetation in

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urban areas include:

- Improving air quality through oxygen production, CO_2 capture, filtration of suspended particulate matter and minimizing ground temperature differences through air cooling thereby reduces the energy demanded for air conditioning;
- Improving water quality and availability through retention of rainwater in the ground and soil erosion control;
- Health benefits for the population, including protection from ultraviolet (UV) radiation, reducing heat stress and providing spaces for outdoor exercise;
- Seasonal shading of infrastructure (Giguère, 2009);
- Evapotranspiration contributes to air cooling and water availability;
- Biodiversity preservation thereby aesthetic features for recreation means.

However, ecosystem services provided by urban trees are highly related to the growing conditions of a tree, the individual tree size and age, tree vitality, species and specific species features such as wood anatomy and water stress behaviour (Moser-Reischl, *et al.,* 2018). But, Miyawaki forests overcome these difficulties.

Causes of Urban Heat Islands

There are voluminous factors that contribute to the formation of Urban Heat Island (Lall *et al.,* 2014). The major reasons which play significant role in the creation of UHI are described below:

i. **Low Albedo Materials:** Albedo is usually assessed by the ratio of the reflected solar energy to the incident solar energy and depends on the arrangement of surfaces, materials, pavements, coatings etc. The albedo in a city differs according to several factors like surface arrangement, i.e. orientation, heterogeneity, materials for roofs, pavements etc. Thus, albedo has a direct effect on the development of microclimate because if the albedo of the urban surface is low, it will store more solar energy and lead to subsequent increase in urban temperature (Mobaraki, 2012).

ii. **Increased Energy Usage:** Air conditioners are massively used with a rising trend to provide comfort to people. On the one hand, air conditioners keep the building cool inside and on the other release the heat absorbing from inside to the atmosphere. Consequently, the outside environment is getting warmed which leads to the increase of atmospheric temperature as a whole (Mohajerani *et al.,* 2017).

iii. **Lack of Vegetation**: The development of various urban facilities led to the destruction of natural vegetation of cities comparing to its surrounding rural areas. The decrease in the vegetation naturally reduces the cooling efficiency in the urban areas because greenery intercept the solar heat also absorb CO_2 for their own photosynthesis, makes the environment cool. Therefore, the wiping out of vegetation destructs the efficiency of cooling system; causes UHI effect (Hewitt *et al.,* 2014).

iv. **Human Gathering:** The density of population in urban centres emits CO_2 on a large scale and leads to the enhancement of atmospheric temperature. Ultimately, this also affects the temperature balance of cities and forms the heat island to an extent.

v. **Urban Canopy**: Sky scrapers are the eye catching feature of cities but such multilayer buildings reflects as well as traps heat. The trapping of reflected heat by taller buildings are known as the urban canopy and UHI is intensified with the creation of urban canopy.

vi. **Wind Blocking:** The presence of densely situated buildings hinders the wind velocity as a result, the cooling effect by convection decreases. Thus, the heat trapped will not blow out, causes exacerbation of the UHI effect.

vii. **Air Pollutants:** In the urban areas air pollution is high comparing to semi-urban and rural areas. Emissions from vehicles and industrial pollutants trap solar radiation in the surroundings. Therefore, the temperature intensifies and the severe microclimate impact becomes more and more (Nuruzzaman, 2015)

Effectiveness of Miyawaki Forests

The Miyawaki method of forestation or Miyawaki forests are developed by Japanese Botanist Akira Miyawaki more than 40 years ago, gains momentum even in the 21st century due to its peculiarities (Thornton, 2020). The Miyawaki method for planting trees begins with phytosociological survey to acquire wide environmental description of the destination site. It helps to identify the types of vegetation then, classify them into natural vegetation and substitute

vegetation. This leads to the survey of potential natural vegetation and the preparation of map of actual vegetation of the area. After that the planning for planting takes place where selection process of appropriate species for planting by using the map of actual vegetation follows. Preservation of the top soil has highest priority in the preparation of the selected area for planting and for that purpose; the soil survey, soil examination, soil improvement etc. initiates through which reconstruction of top soil occurs. Meanwhile, the production or procurement of young plants for planting happens. After the reconstruction of top soil, the planting area covers with straw for mulching and plantation, then planting main tree species of potential natural vegetation densely and mixed. The saplings will take care for the initial three years by providing manure and weeding, after that they will self-sustain and by 20-30 years it develops into a native forest (Miyawaki, 2004).

The major peculiarities of Miyawaki forests to use it as an efficacious mechanism to mitigate the Urban Heat Island effects are the following:

i. **Potential natural vegetation:** it is the natural vegetation or native forests sustained by existing conditions of the location in the absence of any human support. natural vegetation is the basis of 'Miyawaki Method' where restoration and reconstruction of forests indigenous to the habitat based on rigorous field investigations of the local vegetation and ecological theories takes place (Blue Planet Prize, 2006). The speciality of native forests is that they are multi-stratal in which each forest comprises an over story tree layer, an understory tree layer, a shrub layer, a herbaceous layer and usually a moss layer (Miyawaki, 2014). It is the most suitable way of conserving environment either in urban conglomerations or in rural areas (Miyawaki, 2006a). Urban areas can utilize potential natural vegetation maps for its city planning, regional planning, planning of industrial areas and land conservation, as it has been used in Germany decades ago (Miyawaki, 2006b).
ii. **Minimal space:** Miniature urban forests can be planted through Miyawaki method even in one meter wide stripes (Miyawaki, 2008). The Kerala Forest Department has tried out Miyawaki forests in various places and revealed that it is conceivable to nurture a variety of native species in as little a space as 600 square feet (Radhakrishnan, 2020). So it is feasible to create forests in residential areas and around commercial buildings.
iii. **Defends natural calamities:** The local forests regenerated or created through Miyawaki method by using trees indigenous to the area carries out diverse functions including disaster prevention (Miyawaki, 2006a). On the pretext that the primary trees of real forests have deep and axial roots making them more resistant to falling thereby minimises destructions due to natural calamities like tsunami (Miyawaki, 2006b).
iv. **Maintenance of biodiversity:** The natural vegetation of any area provides environmental protection by restoring green environment and water source. The natural forests created through Miyawaki method have an ecological connection to the conservation and preservation of biodiversity in modern terms (Miyawaki, 2006a) thus sustains not only local environment but also global environments (Miyawaki, 1999). Restoration and regeneration of ecologically diverse forests is inevitable for citizens in every region to survive in this century and millennium (Miyawaki, 2004).
v. **Miniature forests:** In the classical succession theory, natural vegetation develops into forests takes over 200 years of time span but in the Miyawaki method, quasi-native forests with rich soil fauna forms within 25-30 years. Here occurs sustainable development of human society through ecological restoration of living environments (Miyawaki, 2004). Native forests should also have 30 times the ability to preserve the local environment and to mitigate impact in terms of noise insulation, dust filtration, air purification and maintaining water quality (Miyawaki, 2006b).
vi. **Survival capacity:** The threating global environmental issues like climate change demands fast tracking solutions for the problem and one cannot wait too long for solving the issue. As environment conservation found as the most suitable method to counter almost all negative impacts of global warming, taking several hundred years for reforestation and restoration of new forests is too long. But the Miyawaki method proved that multi-stratal quasi-natural forests can be built in a short span of time with 100 percent success

rate, for instance it took only 15-20 years in Japan and 40-50 years in Southeast Asia. Field experiences in various zones prove that this method is successful in restoration of native forests from cold-temperate zone to tropical forest zone (Miyawaki, 1999). And native forests are successful in safeguarding life and protect the environment than any other forms of man-made greeneries (Miyawaki, 2006a).

vii. **Low maintenance cost:** The cost of post planting is meagre as the site becomes maintenance free after three years of planting where nature manages itself through natural selection (Miyawaki, 2004) and forest quality is noteworthy compared to traditional techniques of reforestation (Schirone *et al.*, 2011). In addition, the preservation and regeneration of native forests will contribute to the economic activities of the local people (Miyawaki, 2011) and coexists with the local economy as it permits selective cutting and selling after 80-120 years (Miyawaki, 2014). Consequently, native forests safeguard the lives of all the populaces born plus raised in the area, they sharpen the senses for the formation of culture and offer rise to intellect for new progresses (Miyawaki, 2006a).

viii. **Acts as Carbon sinks:** The Japanese experience shows that creating native forests is the most certain and effective measure to reduce carbon dioxide. The green surface of a multi-stratal forest of the potential natural vegetation is about thirty times as large as for absorbing and accumulating CO_2 compared to monoculture tree plantations and mono-stratal lawns. Globally, they reduce global warming by absorbing carbon dioxide in the atmosphere and fixing carbon in biomass for countless years (Miyawaki, 2006b). Therefore, the Miyawaki method of afforestation, reforestation and restoration of forests has huge carbon sequestration capacity (Miyawaki, 1998).

ix. **City in a forest:** Akira Miyawaki and his team have been successfully experimented urban forests in metropolitan areas as well as residential areas in Japan and many other parts of the world (Miyawaki, 2006b). It is crucial to restore forest patches wherever possible especially at the existing cities, residential areas, transportation facilities, industrial expanses etc. Also, it is significant that the layout of forest patches, their scale and construction methods submitted along with new construction proposals especially in urban areas for residential as well as industrial purposes (Miyawaki, 2008). The re-creation of green areas in cities and restoration of damaged and derelict land to a more salutary condition will lead to greening of urban spaces thereby the creation of 'a city in a forest' (Miyawaki *et al.*, 1987).

CONCLUSION

Urban Heat Islands are a complex and emerging phenomenon around the cities of the world and it reflects mankind's undesirable development modules. The discussions over climate change enhanced the urgency to mitigate Urban Heat Islands because of its double edged effect as UHI is itself a reason for climate change and climate change leads to UHI. In fact, many of the reasons of UHI can be reduced through maintaining of natural vegetation. Thus it is evident that the major reasons for the urban heat islands such as low albedo materials, human gathering, increased use of air conditioner, destruction of trees, urban canopy, wind blocking, air pollutants etc. can be reduced through Miyawaki forestation along with the mitigation of climate change. The Miyawaki forests are thriving across the globe due to its multidimensional benefits including its contributions on human life as well as on biodiversity.

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