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Green zones in urban area as potential sites for bird diversity conservation

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Abstract

In the world of urbanization, various problems are emerging as serious threats to the environment; and air pollution is one among those. Air pollution exerts various adverse impacts not only on human health but also on the avifaunal community. With rapid urbanization, the green cover in the cities is shrinking speedily. The loss of urban vegetation is causing a reduction in the diversity of the urban bird community. The purpose of this study is to highlight the potential of green areas and parks in urban areas for the conservation of the diversity of bird species and to ascertain the detrimental effects on the diversity of birds due to air contaminants. Five distinct sites were selected for the execution of the study in the summer of 2022. The point count approach was used for monitoring bird species. The air pollution contaminants (HCHO, PM 10, TVOC and PM 2.5) were measured through a portable 'Air Quality Monitor Pollution Metre'. The Shannon-Wiener diversity index and total species richness were used to calculate the diversity of bird species. A finding was made that the sites possessing dense vegetation cover have minimum pollution levels and rich diversity of bird population, while the sites with no or less vegetation cover have high pollution levels and the least diversity of birds. It is due to the reason that vegetation cover reduces the pollution intensity, thus supporting the system favorable for avifaunal diversity.

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Introduction

The world is experiencing the phenomenon of urbanization at a very fast rate. In developed nations, urbanization accounts for about 80% of the total human population. (World Resources Institute, 2006), and both the size and the number of urban areas are on the rise (Melles *et al.*, 2003). One of the most significant factors influencing global diversity is the worldwide urbanization of the population (Jokimäki *et al.,* 2003). With rapid urbanization, air pollution is also increasing at an alarming rate. In addition to being damaging to humans, air pollution has detrimental effects on bird species also (Tiwari *et al.,* 2022). Pollutants in the atmosphere caused by human activities have a significant impact on every living thing. The primary contributors to pollution in the city include a variety of anthropogenic activities, including combustion, industrialization, construction and vehicle emissions.

The processes and dynamics of the ecosystem where humans live are impacted by anthropogenic activities, which in turn affects the composition and structure of the avian community. (Bowman and Marzluff, 2001). The fragmentation carried on by human actions has been determined as one of the most significant factors contributing to the loss of biodiversity (Wilcox and Murphy, 1985). Urban parks play a significant function since they have greater bird diversity and richness than other urban environments (Tilghman, 1987).

Additionally, being harmful to humans, air pollution causes a serious hazard to bird species also. In comparison to mammals, bird species are a useful indication of air quality as they are more sensitive to high pollutant concentrations in the air (Brown *et al.*, 1997). Birds are a significant community in the global ecosystem as they play a remarkable role in controlling the population of harmful insects and help in spreading seeds and enacting as bio-indicators and tools to assess environmental problems (Burch Jr and Grove, 1993; Şekercioğlu, 2006). Due to the rapid rate of industrialization and urbanization, green cover is vanishing gradually and the air quality in cities is deteriorating constantly. Studies on the impacts of urbanization on birds have been conducted in extremely small numbers (Senguptaet *al.*, 2014). Birds in urban centers have to contend with difficulties like the availability of food sources, vegetation cover, etc. The avian community is highly susceptible to alterations in the elevated level of air pollution. Also, birds exhibit a notable sensitivity to environmental changes (Furness *et al.,* 1993). Additionally, birds could act as indicator species for observing air quality due to their widespread presence in both urban and rural locations around the world and the wide range of their habitat types (Brown *et al.*, 1997, Baesse *et al.*, 2015). Bird behavior is possibly an indicator of resilience techniques that helps in fashioning a more sustainable future. On the other hand, with the rapid expansion of urban settlements, mitigating future biodiversity loss requires an understanding of how urbanization influences biological communities and the creation of wildlife management plans that include urban environments (Miller and Hobbs, 2002). As parks and birds are important to ecosystems (Şekercioğlu 2006), this study was carried out with an aim to illuminate the usefulness of green areas and parks in urban areas for the conservation of bird diversity along with the assessment of the impact of air pollution on birds and to determine the avian community's response to it.

Methodology

Study site

This study was executed in the city of Bilaspur, which is located in the Indian state of Chhattisgarh. It ranks among the significant city of the state. River Arpa serves as the lifeline of the city of Bilaspur. The city has a 205 km² area and a 270 m. mean sea level. It is situated at 22.0797°N Latitude and 82.1409°E Longitude. With a maximum peak of up to 49˚C and a mean temperature of 33°C in summer and 15 ˚C in winter, the summers are comparatively hot and dry. The city of Bilaspur experiences subtropical, semiarid, and continental climates. The annual rainfall ranges from 580 to 680 mm. The research was undertaken at 5 distinct sites in Bilaspur City.

Fig. 1. Site I: Rajendra Nagar Chowk.

Fig. 2. Site II: Main Post Office.

Site I [*Rajendra Nagar Chowk*]: This location has a community garden, parkland, low traffic disturbance along with much vegetation and plenty of tree cover. (Fig.1).

Site II [*Main Post Office*]: This area has a small garden, rich vegetation and tree cover and moderate vehicular traffic. (Fig.2).

Fig. 3. Site III: Collectorate Office.

Site III [*Collectorate Office*]: The site has local governmental workplaces but has a scarcity of green foliage with a lot of bustle and masses visiting here frequently. (Fig.3).

Site IV [*Nehru Chowk*]: This site is the central location of the city with a constant rush of traffic, yet the location has a good number of trees and plant cover present there. (Fig.4).

Fig. 4. Site IV: Nehru Chowk.

Site V [*Near Indira Setu Bridge*]: There is barely any vegetation in this area, along with the constant, high automobile traffic. (Fig.5).

Bird count

The point count method, in which fixed sample spots were set up at a minimum distance of 200 m apart (Bibby *et al*., 2000; Vielliard *et al*., 2010) so as to reduce the possibility of recording the same individuals at different points and to enable the identification of species, was implemented for the counting and sampling of birds. Data were gathered in the summertime in Bilaspur City at 5 distinct sites between April 2022 to June 2022. Birds were counted twice: once in the morning from 06:00 hrs to 09:00 hrs and later in the evening from 16:00 hrs to 18:00 hrs (Vishwakarma *et al*., 2021). To ensure equal sampling coverage, varying numbers of points were used. 25 sampling points were set up in total, with a 15-minute sampling period at each location and various bird species heard or sighted were recorded.

Fig. 5. Site V: Near Indira Setu Bridge.

Observations were made using a Nikon Aculon 10 × 50 binocular, a Canon 700D camera with a 100-400mm Tamron lens, and a Nikon P900 83mm zoom lens.; and Grimmett *et al*., 2016 were referred for bird identification.

Air pollutants

Through the use of a "Portable Air Quality Monitor Pollution Metre,"the air quality and pollutants were monitored. The equipment measures airborne concentrations and the amount of HCHO, PM 10, TVOC and PM 2.5.

The equipment was calibrated initially for the purpose of data collection and then left undisturbed for 20 minutes at the fixed 5 sites in the city. The same procedure was followed at each selected location to measure the level of contaminants in the

air. A total of 25 readings were collected and the observations were made on the same day when the birds were counted.

Data analysis

The recorded and gathered data from the 25 total observations made at the 5 specified sites (5 observations per site); were then analyzed through MS Excel 2021 (version 2304) to determine the results.

Utilizing the total number of each individual species in point count, the species evenness, species richness and Shannon-Wiener diversity index were computed (Krebs, 1998).

The observed air pollutants were assessed and through the sum of the recorded observations for each selected location, the mean of different pollutant parameters (namely HCHO, TVOC, PM 2.5 and PM 10) was determined (Table 1). To evaluate the association between pollutants (viz. PM 2.5 and HCHO) and the diversity of birds, the correlation coefficient was computed following the calculation of the species richness, pollutant entities and Shannon-Wiener diversity index.

The metric of the correlation coefficient is used to ascertain the relation between two variables or entities and consequently, there is an association between air pollution and biodiversity (Tanveer *et al*., 2002).

Results

Air pollutants

The following interpretation can be made using the statistical, tabular, and graphic examination of the collected pollutant data:

All 5 of the examined sites had mean HCHO levels ranging from 0.025 to 0.074 mg/m^3 (Fig. 6) and TVOC levels ranging from 0.111 to 1.243 mg/m^3 (Fig.7).

Table 1. Mean of observed air pollutant level at selected sites.

Site	Pollutants			
	HCHO (mg/m^3)	TVOC (mg/m^3)	PM 2.5 (µg/m^3)	PM 10 (µg/m^3)
I	0.025	0.111	32	36
II	0.058	0.338	63	66
III	0.074	1.243	88	101
IV	0.028	0.182	36	40
V	0.064	0.528	66	79

The selected 5 sites' mean concentration of PM 10 (in µg/m^3) ranges from 36 to 101 (Fig.8), while the mean concentration of PM 2.5 (in µg/m^3) ranges between 32 to 88 (Fig. 9).

Site I and Site IV are the least polluted, respectively, as these sites have dense foliage covering which results in the minimum level of pollutants.

Site III is the most polluted site, followed by site V and site II, because these sites have minimal greenery and poor vegetation cover resulting in a high concentration of pollutants.

Bird diversity and richness

There was a total of 230 birds from 10 distinct families recorded (Fig.10). Site I (the site with a maximum green cover and least pollution) recorded the most individuals (i.e., 61), while site II recorded the subsequent highest number of bird individuals (i.e., 52). Site IV had the least documented population of birds (Table 2). From the total number of birds that were documented, birds from 06 different families were prevalent across all five sites.

The index value of species richness falls between 2.350 (site III) to 1.716 (site IV).

Table 2. Total number of birds from each family at different sites.

Family	Sites					Total
	I	II	III	IV	V	
Accipitriformes	03	01	06	02	06	18
Ardeidae	04	02	02	00	02	10
Columbidae	16	08	12	10	05	51
Coraciidae	05	04	03	03	01	16
Cuculidae	04	03	01	01	02	11
Dicruridae	05	03	02	03	02	15
Muscicapidae	03	04	02	00	03	12
Psittaculidae	06	08	04	04	00	22
Pycnonotidae	07	05	02	00	00	14
Sturnidae	08	14	12	10	17	61
Total	61	52	46	33	38	230

The value of species evenness ranges from 0.81 to 0.94 and the value of the Shannon-Wiener diversity index stretches from 1.68 to 2.16 (Table 3). The study found a moderately negative relation between the Shannon-Wiener diversity index for avian diversity and air contaminants (viz., PM 2.5 and HCHO). The correlation coefficient's negative value implies an inverse relation between the two entities, i.e., as the value of the first variable rises, the other variable's value falls correspondingly. So, with the rise in the concentration of pollutants at a site, the bird diversity at that particular site decreases. In Tables 4 and 5, the degree of the relationship is shown. The city of Bilaspur has meager vegetation and greenery (Fig.11), which results in a reduction in bird species diversity.

Table 3. Species Richness, Species Evenness and Shannon-Wiener index of selected sites.

Site	Parameters		
	Species Richness	Species Evenness	Shannon-Wiener Index
I	2.189	0.94	2.16
II	2.270	0.90	2.08
III	2.350	0.86	1.99
IV	1.716	0.87	1.69
V	1.924	0.81	1.68

Discussion

The survey recorded 230 birds from 10 distinct families over the span of 5 specified sites in Bilaspur city. In comparison to the sites with adequate greenery and vegetation cover along with low automobile traffic, sites with little and poor vegetation with heavy traffic disturbance have worse air quality.

Table 4. The PM 2.5 degree of correlation with the Richness index and Shannon-Wiener Diversity index.

Air Pollutant (PM 2.5) Correlation With	
Richness Index	r = 0.5342
Shannon-Wiener Diversity Index	r = - 0.0976

As per the Shannon-Wiener diversity index, aviandiversity is highly valued in sites having rich vegetation, ample green cover with less pollution and comparatively less diversity of birds in highly polluted sites with little or no vegetation and green cover which shows that the avian community avoids the

areas with sparse vegetation and high air pollution and poor air quality. Due to the fragmentation of the natural environment, urban green zones and parks can be crucial and worthy resources for sustaining and preserving biodiversity in the aspect of the urban area (McDonnell and Pickett, 1990).

Table 5. The HCHO degree of correlation with the Richness index and Shannon-Wiener Diversity index.

Air Pollutant (HCHO) Correlation With	
Richness Index	r = 0.4784
Shannon-Wiener Diversity Index	r = - 0.0682

Air pollution, however, did not have a significant impact on the evenness of the avian community. At all the studied sites, the species' relative abundance within a community was almost uniform.

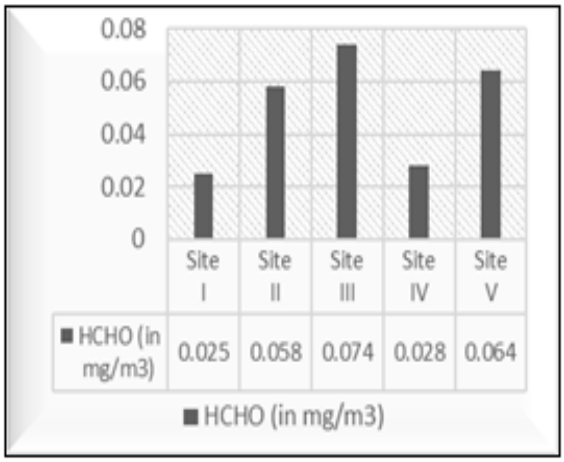

Fig. 6. Mean value of HCHO (in mg/m³) of each selected site.

Based on the correlation test, species richness and air pollution contaminants (viz., PM 2.5 and HCHO) are moderately positively correlated, showing that the alterations in air pollution levels do not significantly impact the richness of the bird community.

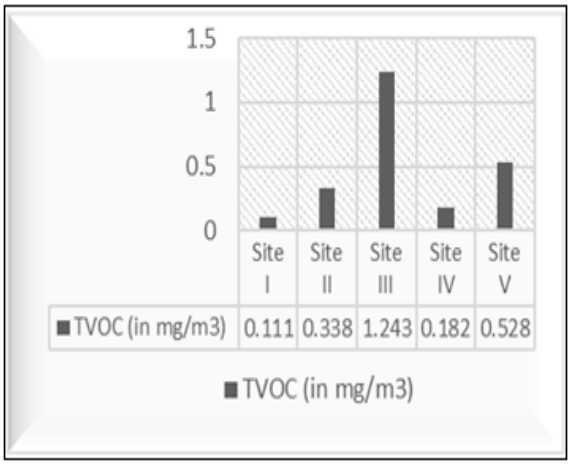

Fig. 7. Mean value of TVOC (in mg/m³) of each selected site.

However, the primary finding of the study displays the inverse correlation between avian diversity (Shannon-Wiener diversity index) and air pollution (viz., PM 2.5 and HCHO) which shows that the diversity of avian species in a certain habitat reduces and vice versa as the degree of vegetation cover in an urban area fall coupled with a rise in the concentration of air pollutants in that habitat.

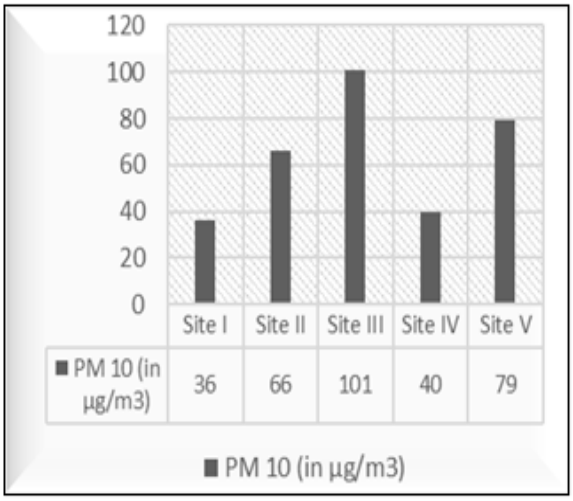

Fig. 8. PM 10mean value (in µg/m³) of each selected site.

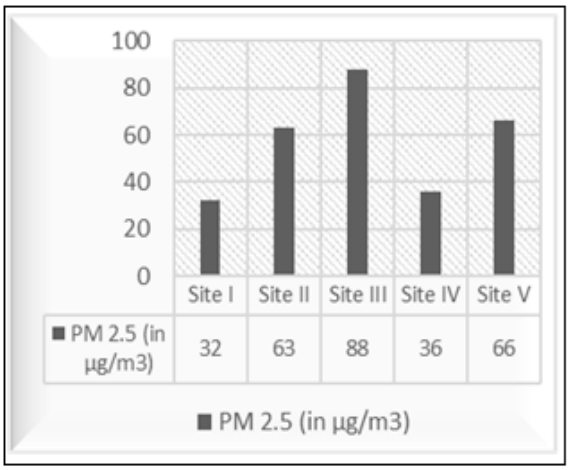

Fig. 9. PM 2.5mean value (in µg/m³) of each selected site.

The two variables have an inverse relationship when there is a negative correlation, implying a decrease in the degree of one variable as the degree of the other variable increases. The 'Ardeidae' family birds, namely, Intermediate Egret *(Ardeaintermedia)* and Cattle Egret *(Bubulcus ibis),* were documented least at the city site, followed by the 'Cuculidae' family birds; Greater Coucal *(Centropussinensis)* and Asian Koel *(Eudynamysscolopaceus).*

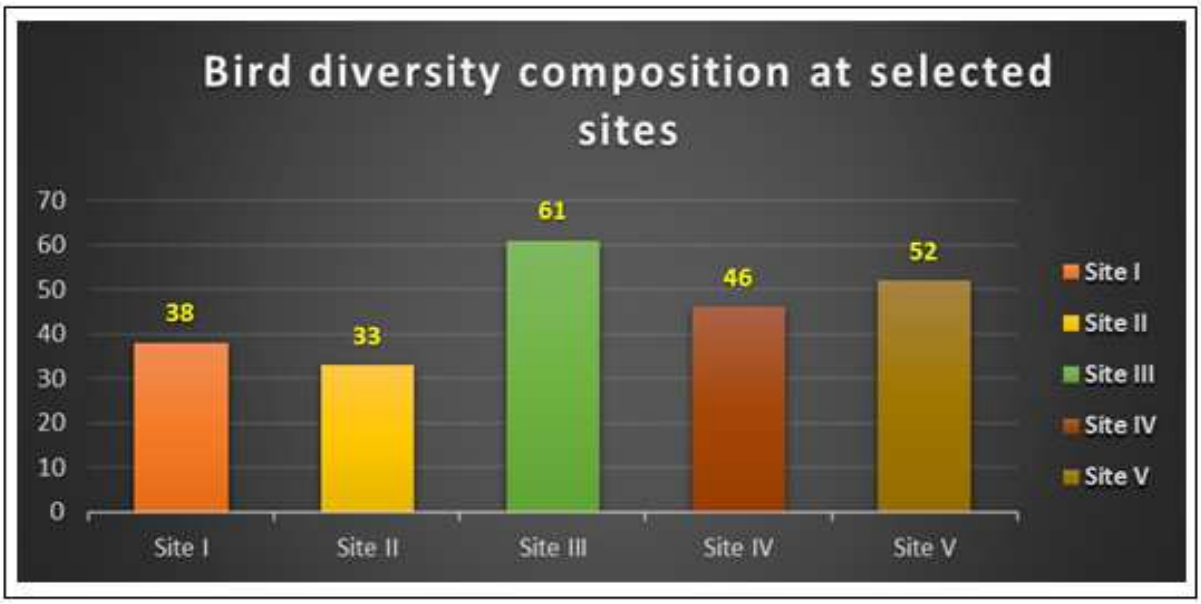

Fig. 10. Graph depicting the percentage distribution of birds ofdifferent families observed at each site.

The research further demonstrates the strikingly high population of birds fromthe 'Columbidae' family, viz., the Laughing Dove *(Spilopeliasenegalensis),* Spotted Dove (*Spilopeliachinensis*) and Rock Pigeon *(Columba livia),* as well as birds from the 'Sturnidae' family, viz., the Common Myna *(Acridotherestristis)* and Asian Pied Starling *(Gracupica contra)* in the areas with high levels of pollution. It supports the fact that these birds have evolved to thrive in sites with significant air pollution.

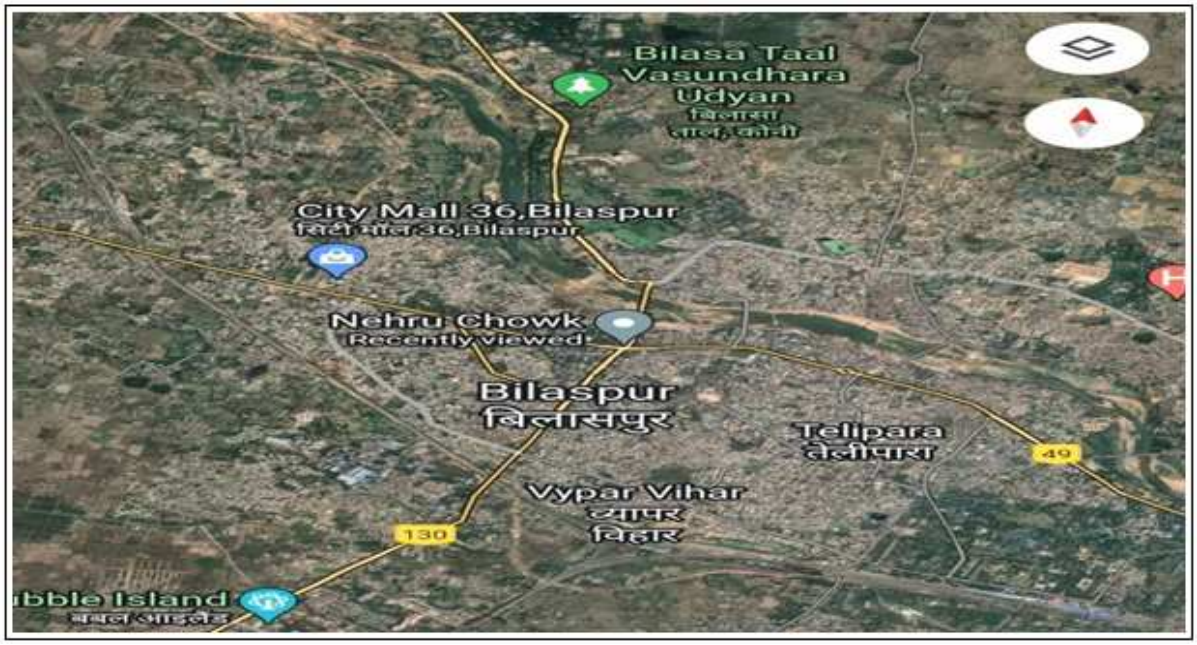

Fig. 11. Map showing the highly crowded urban core of Bilaspur City devoid of green cover and vegetation.

These birds can be referred to as "Urban Exploiters" since they use constructions for feeding, roosting and nesting and are often undisturbed by human activity and noise (Mohring *et al.*, 2021). All around the city, sufficient numbers of the other bird species, including the Rose Ring Parakeet *(Psittaculakrameri)*, Black Drongo *(Dicrurusmacrocercus)*, Indian Roller *(Coraciasbenghalensis)* and Black Kite *(Milvusmigrans)* were observed. Birds like the House Sparrow *(Passer domesticus)* and House Crow *(Corvussplendens)*, which are strongly associated with humans, were not recorded in the city, as synthetic foundation materials like cement, gravel and turf substitute the natural vegetation and green cover (Turrini *et al.*, 2015).

Several genera of birds exhibit a significant reliance on the vegetative cover for foraging and nesting, so a decrease in the green cover results in the decline of bird diversity and abundance (Lancaster and Rees, 1979). As urbanization and industrialization are accelerating quickly, the greenery and vegetation cover is shrinking and the bird diversity of the city is decreasing primarily due to the city's deteriorating air quality (Anthony *et al.*, 2022). So, urban parks with rich and diverse floral composition are vital for maintaining avifaunal diversity (Chaiyarat *et al.*, 2019). Thus, urban green parks with adequate food resources and safety aid brace the bird community (Dale, 2018).

Conclusion

The bird species flourish well in the green realm of the urban environment as these regions with abundant vegetation provide food, shelter and security to the avifaunal community. Thus, the avian community inhabiting the urban area depends strongly on urban parks. The analysis has demonstrated the negative correlation between air pollution and vegetation cover along with the diversity of birds. The green parks, gardens and dense foliage in the urban area promote and conserve the diversity of birds, while the poor and scanty vegetation, along with the excessive pollution concentrations in the air reduces the bird diversity in that region. Thus, expansion, improvement and preservation of the green cover and vegetation in urban areas should be promoted. Emphasis should be given to the protection of native trees and vegetation.

Plantation in urban areas should be encouraged and strong measures must be taken to track and mitigate air pollution while the biodiversity, vegetation and green cover of the urban environment must all be positively enhanced.

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