

(*Panthera pardus*) is augmented by the presence of Morni Reserve Forests in adjoining Haryana and the presence of woodlands in neighbouring Shivalik hills.

In Chandigarh UT, the Capital of Punjab (Development and Regulation) Act, 1952 and the Punjab New Capital Periphery (Control) Act, 1952 are the two specific laws passed to guarantee the development of Chandigarh as per the 'edict'. Both the Chandigarh Plan and the 'Edict of Chandigarh' strove to preserve the city's proximity to nature by prohibiting any development to the North of the city, leaving the hills ecologically and visually undisturbed. The Periphery Control Act mean similar i.e., to maintain a clear rural-urban dichotomy and prevent unregulated urban development within a radius of 16 km around the city (Chandigarh Master Plan 2031). However, the emergence of satellite towns of Mohali, Zirakpur, and Panchkula have adversely affected the greenery and local ecology around Chandigarh UT and has violated the laws enacted against unplanned development and thus the sanctity of the 'Edict of Chandigarh' (Chandigarh Master Plan 2031). However, the change in land-use patterns, encroachment in & around natural rivulets, siltation, frequent wetlands drying up like Sukhna lake, degrading forest resources and human-wildlife conflict are the significant challenges that threaten the fragile ecosystems in the UT (Chandigarh Master Plan 2031). It calls for urgent action to prevent further degradation of these bio-diverse forests and inculcate a sustainable lifestyle amongst the people. Notifying eco-sensitive zone around wildlife sanctuary, securing the entire catchment of Sukhna lake, protecting natural choes (rivulets) and other small wetlands, enhancing the value of existing green spaces via plantation of indigenous trees. With the increasing population it is important to consider planned expansion in the UT by bringing their development under the Punjab New Capital Periphery (Control) Act, 1952 in consultation with the State Governments of Punjab and Haryana to ensure sustainable development.

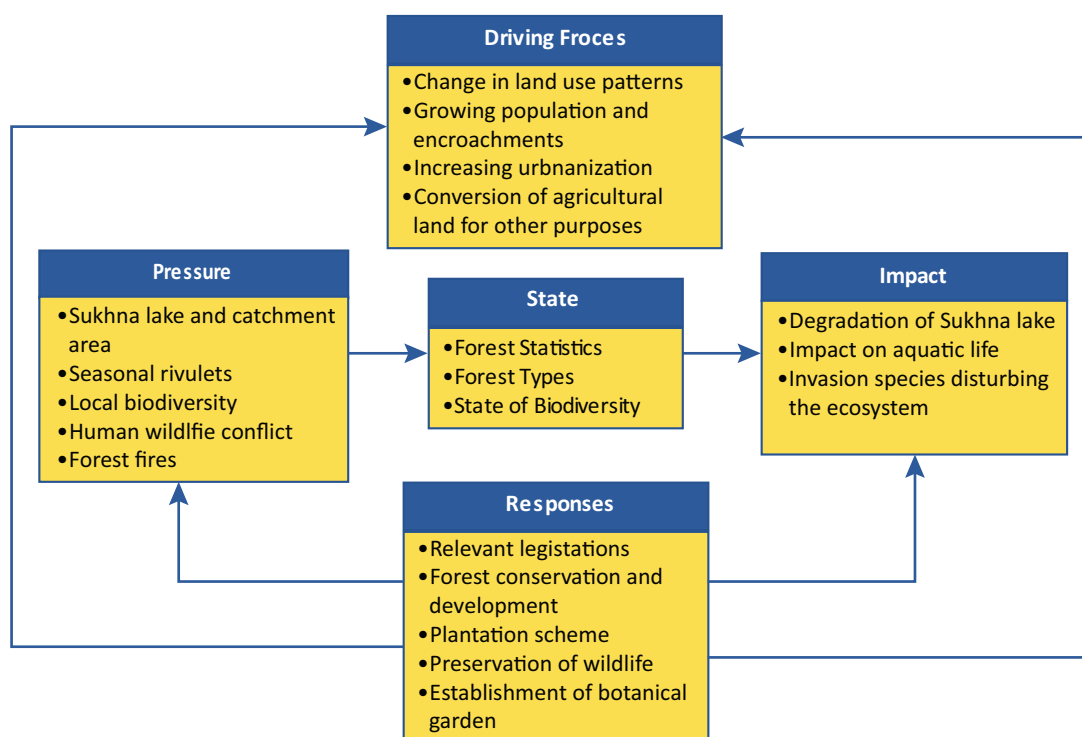


Figure 9: Diagram illustrating the contents of each step for the components of the DPSIR framework



2. State

2.1 Forest Statistics of Chandigarh UT

The forest cover in the state is about 22.88 sq km, which is 20.07% of the state's Geographical Area. The forest cover details are as follows Table 7.

Table 7: Forest Cover in Chandigarh based on different Forest Classes

Class	Area	% Of GA
Very Dense Forest	1.36	1.19
Medium Dense Forest	13.51	11.85
Open Forest	8.01	7.03
Total	22.88	20.07
Scrub	0.38	0.33

Source: India State of Forest Report, 2021

As per above table 7, the forest cover based on different classes included 1.36 sq. km under Very Dense Forest (VDF), 13.51 sq. km under Moderately Dense Forest (MDF), 8.01 sq. km under Open Forest (OF) and Scrubs having 0.38 sq. km of area in UT as per (ISFR, 2021). The forest cover in the above table excludes the forest cover of Sukhna Wildlife Sanctuary (SWS) having an area of 26.1 sq. km (Management Plan Sukhna Wildlife Sanctuary, 2018). The total forest cover of Chandigarh including (SWS) is 48.98 sq. km.

Table 8: Change in Forest Cover from 2011 to 2021

Forest Class	Year					
	2011	2013	2015	2017	2019	2021
Very Dense Forest	1.35	1.36	1.36	1.36	1.36	1.36
Moderately Dense Forest	9.55	9.66	14.09	13.82	14.24	13.51
Open Forest	5.88	6.24	6.58	6.38	6.43	8.01
Total Forest Cover	16.78	17.26	22.03	21.56	22.03	22.88

Source: India State of Forest Report, 2011, 2013, 2015, 2017, 2019, 2021

As we can see from the above table that the area under Very Dense Forest over the years from 2011 to 2021 has only increased by 0.01 sq. km. Whereas the area under Moderately Dense Forest and Open Forest has increased from 9.55 sq. km to 13.51 sq. km and 5.88 sq. km to 8.01 sq. km respectively. The comparative increase in the area under different Forest Classes can be seen in the Figure 10 below.



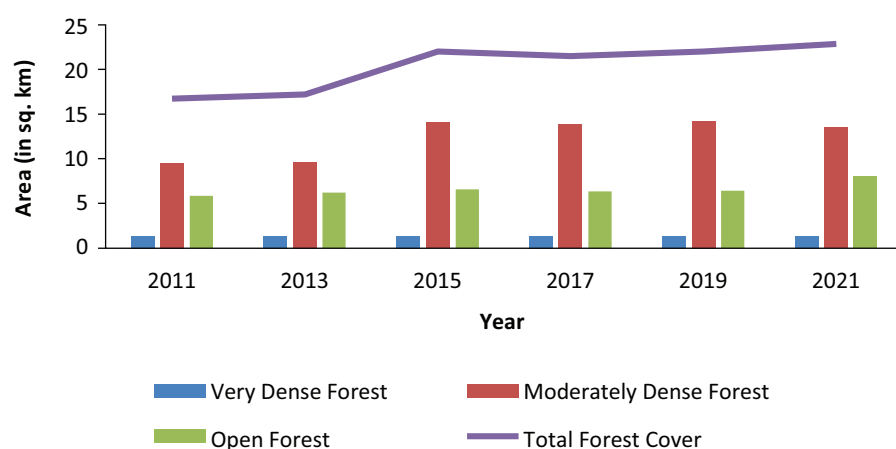


Figure 10: Change in Forest Cover from 2011 to 2021

Source: India State of Forest Report, 2011, 2013, 2015, 2017, 2019, 2021

Further segregation of forest cover inside and outside the Recorded Forest Area (RFA) is provided in Table 9.

Table 9: Segregation of Forest Cover inside and outside the Recorded Forest Area (RFA)

Forest Cover inside the RFA (or Green Wash)				Forest Cover outside the RFA (or Green Wash)			
VDF	MDF	OF	Total	VDF	MDF	OF	Total
1.29 sq km	5.08 sq km	2.34sq km	8.70 sq km	0.08sq km	8.43 sq km	5.67 sq km	14.18 sq km
14.71%	58.39%	26.90%		0.56%	59.45%	39.99%	

Note: VDF—Very Dense Forest; MDF—Moderately Dense Forest, OF—Open Forest

Source: India State of Forest Report, 2021

The UT has reported the extent of recorded forest area (RFA) as 35 sq. km, out of which 3 sq km is Unclassed Forests and 32 sq km is Reserved Forest (ISFR, 2021). The details are provided in following Table 10. In Chandigarh UT, the VDF type of forest can be found mainly within Reserve Forest in Daria, CGA Golf Club and in and around Sukhna Wildlife Sanctuary. In contrast, the MDF type of forest can be found as a part of the urban forest initiative within the UT. It consists of Nagar Van/ City Forests such as Leisure Valley, Rock Garden, Amrut Van, Shivalik Arboretum, Butterfly Park, Peacock Park, City Bird Sanctuary, Botanical Garden etc. Thus, it is evident that the forest cover outside the RFA is more remarkable in area than the actual area within the RFA and hence the urban forests in the UT are of utmost importance to balance the local ecology of Chandigarh. The forest cover map of the UT is provided in Figure 11.



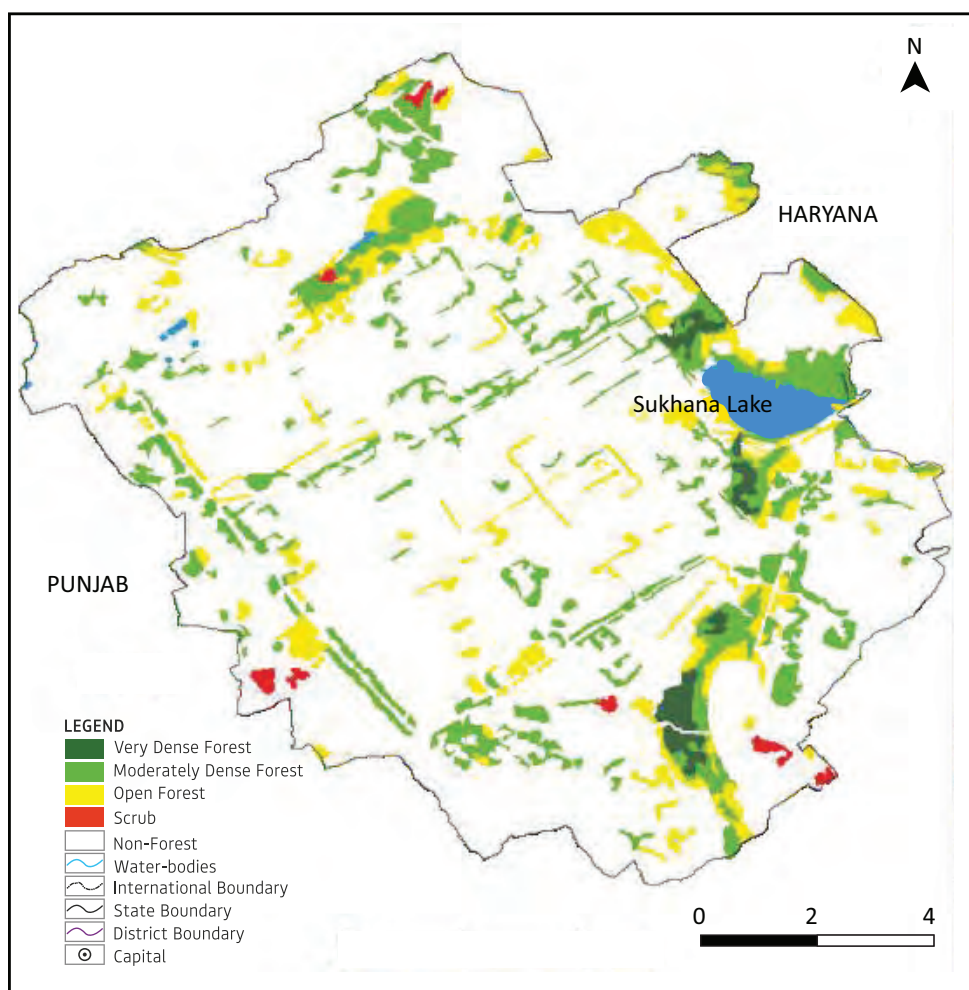


Figure 11: The forest cover map of Chandigarh UT

Source: India State of Forest Report, 2021

As per Chandigarh Forest Department, the total forest area in UT is 35.80 sq. km. The details are provided in following Table 10.

Table 10: Total Forest Area in Chandigarh

Forest Area	Area (In sq. km)
Forest Area Under Manimajra Beat	2.83
Forest Area Under Hallomajra Beat	1.10
Lake Forest Area	1.92
Patiala-ki-rao Forests	1.91
City Bird Sanctuary	0.029
Forest Area of Sukhna Wildlife Sanctuary	26.10
Southern Sector Forest Area	1.17



Forest Area	Area (In sq. km)
Botanical Garden	0.71
TOTAL	35.8

Source: Department of Forests and Wildlife, Chandigarh Administration, 2023

As per the Chandigarh Forest Department, other areas maintained by the Forest Department includes plantation of 1.17 sq. km and a Botanical Garden having an area of 0.71 sq. km. Other than the forests, wetlands are of prime importance to the UT of Chandigarh as they provide several ecosystem services such as groundwater replenishment, water purification, sediment & nutrient retention, biodiversity conservation, recreation and ecotourism. The wetlands inside the Recorded Forest Area (or Green Wash) in Chandigarh UT is depicted in Table 11.

Table 11: Wetlands inside the Recorded Forest Area (RFA) in Chandigarh

Wetland Category	No. of Wetlands	Total Wetland Area (In ha)
Lake/Pond	1	12
River/Stream	3	48
Total	4	60

Source: India State of Forest Report, 2019

However, the main wetland in the UT is Sukhna lake has an area of 1.995 sq. km while the extent of catchment area falling within the Chandigarh UT amounts to 29.08 sq. km (Department of Forest and Wildlife, Chandigarh, 2020). The forest cover change matrix for 2019 comparing it with the 2021 is provided in Table 12.

Table 12: Forest Cover Change in Chandigarh from 2019 and 2021

Forest Class	2019 Area (in sq. km)	2021 Area (in sq. km)	Percentage change
Very Dense Forest	1.36	1.36	0.00
Moderately Dense Forest	14.24	13.51	-0.05
Open Forest	6.43	8.01	0.25
Grand Total	22.03	22.88	0.04

Source: India State of Forest Report, 2021

Notes: VDF Very dense forest; MDF Moderately dense forest; OF Open Forest; NF- Non-Forest

As evident from Table 12 from 2019 to 2021, there has been a marginal decrease in the moderately dense forest by 0.05%, increase in the open forest by 0.25%. Overall, there has been an increase in forest cover of 0.04% as compared to the previous assessment reported in ISFR 2019. The growing stock for forest as well as trees outside forest (TOF) at state level is provided in Table 13.

Table 13: Growing stock of Forest and TOF in Chandigarh

Sr. No	Growing Stock for Chandigarh	(in million m ³)
1.	Growing Stock in Recorded Forest Area	0.21
2.	Growing Stock in TOF	0.29

Source: India State of Forest Report, 2021



As depicted in Table 13 the growing stock in Trees Outside Forest (TOF) is slightly higher than the Recorded Forest Area (RFA). This is again because Chandigarh UT is the greenest planned urban centre with special focus on urban forestry through roadside plantations and avenues, green belts around building complexes in each sector, parks, and other green areas.

2.2 Forest Types in Chandigarh UT

Chandigarh UT has a sub-tropical monsoon climate characterized by a seasonal rhythm, hot summers, cool winters, unreliable rainfall, and great variation in temperature (0°C to 44°C). The UT is classified into two forest types based on the classification made by (Champion & Seth Classification of Forest Types, 1968).

Northern Dry Mixed Deciduous Forest (5/DS1)

This type of forest is mostly found on plains and low hills, being particularly associated with eroded hillsides and alluvial terraces. Vegetation is predominantly xerophytic with preponderance of species like *Senegalia catechu*, *Vachellia nilotica*, *Vachellia leucophloea*, and *Terminalia anogeissiana* with the scrub of *Carissa spinarum*, *Grewia optiva*, *Justicia adhatoda*, etc.

Dry Deciduous Scrub (9/C2)

This type consists of low broken soil cover of shrubby growth 3 to 6 m high including some trees species reduced to similar conditions, usually many stemmed from the base. The predominant species include *Senegalia catechu*, *Dalbergia sissoo*, *Bombax ceiba*, *Phyllanthus emblica*, *Lannea coromandelica*, *Toona ciliata*, *Cassia fistula*, etc.

As per ISFR 2021, the top species observed under RFA include *Dalbergia sissoo*, *Leucaena leucocephala*, *Senegalia catechu*, *Azadirachta indica*, and *Populus species* while the top species observed outside RFA include *Eucalyptus*, *Dalbergia sissoo*, *Morus species*, *Vachellia nilotica*, and *Leucaena leucocephala* in rural parts and *Mangifera indica*, *Morus species*, *Monoon longifolium*, *Terminalia arjuna*, and *Cassia fistula* in urban areas managed as plantations.

Trees Outside Forest (TOF)

The Tree outside Forest (TOF) including agroforestry are one of the major areas for increasing the green cover in the country and play important roles for supply of various ecosystem services. TOF may be seen in form of small wood lots and block plantations, along linear features such as roads, canal bunds etc. and scattered trees on farmlands, homesteads, community lands in rural areas and roadside plantations and avenues, green belts around building complexes in each sector, parks and other green areas in urban areas. According to the ISFR 2021, TOF comprises of 36.18% of total Forest and Tree cover of the country. Chandigarh being a small Union territory having geographical area of 114 sq km have more than 25% of its geographical area under TOF. This constitutes an extent of area 29 sq km which is 77% of total forest and tree cover of the Chandigarh. This include 15 sq km as Tree Cover. Considering the percentage of geographical area of State/UTs, the UT of Chandigarh show highest percentage of tree cover (13.16%) of its geographical area, followed by Delhi (9.91%), Kerala (7.26%) and Goa (6.59%). The dominant tree species in Tree Outside Forests (TOF) include *Eucalyptus*, *Ficus populifolia*, *Ficus benghalensis*, *Magnifera*, *Neltuma juliflora*, *Morus*, and *Dalbergia sissoo* in rural areas whereas *Magnifera indica*, *Monoon longifolium*, *Morus*, and *Alstonia scholaris* in urban areas of Chandigarh.

The percentage area under different forest types of Chandigarh UT is provided in Table 14 below:

Table 14: Percentage area under different forest type of Chandigarh



	Forest Type	% of forest cover
1.	5B/C2 Northern Dry Mixed Deciduous Forest	46.09
2.	5/DS1 Dry Deciduous Scrub	0.23
3.	Plantation/TOF	53.68
	Total	100

Source: India State of Forest Report, 2021

As evident from Table 14, the dominant forest type falling under RFA is the Northern Dry Mixed Deciduous Forest while the area under Dry Deciduous Scrub is comparatively very less. In addition, a larger area is under plantations promoted and managed by the Forest Department in the UT. The forest type map of Chandigarh UT is provided in Figure 12 below: -

As part of increasing the number of trees outside forest the “Greening Chandigarh Action Plan” introduced measures to improve the forest cover through awareness generation, sensitization, plantation, etc.

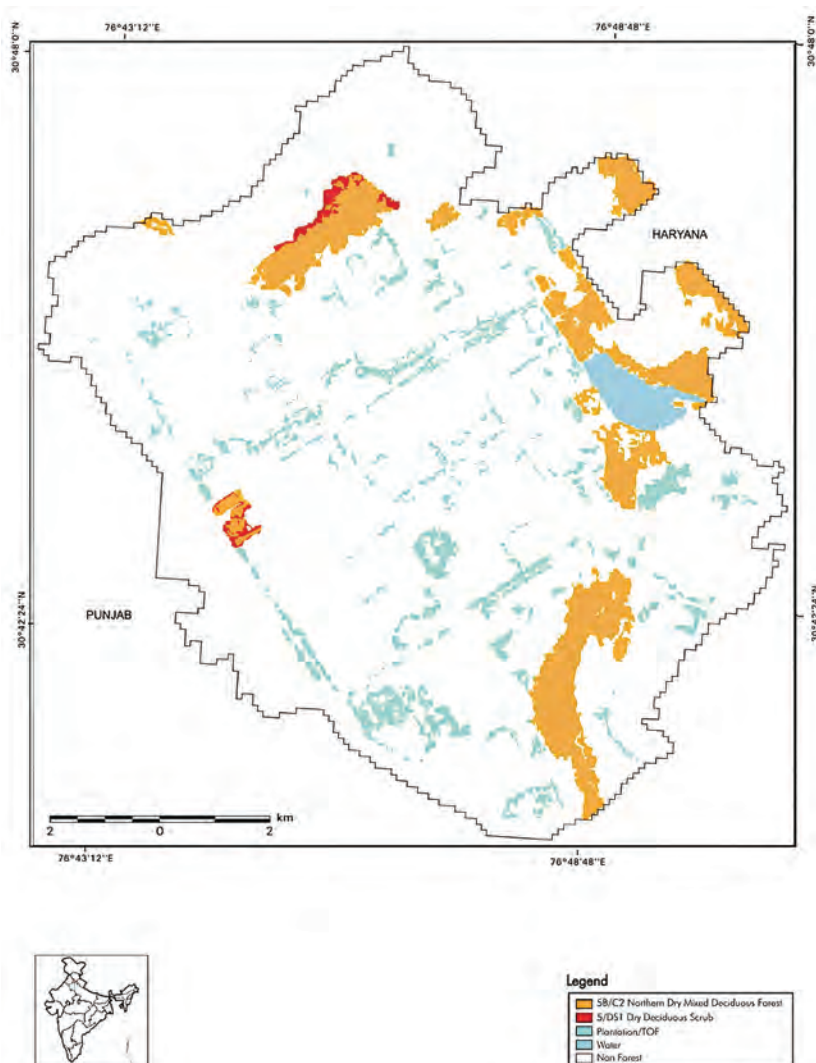


Figure 12: Forest type of Chandigarh

Source: Forest Survey of India, 2021



2.3 State of Biodiversity

India, a megadiverse country with only 2.4% of the world's land area, harbours 7–8% of all recorded species (MoEFCC, 2021). Four of the 36 global biodiversity hotspots are present in India, represented by the Himalayas, the Western Ghats, the North-East, and the Nicobar Islands (MoEFCC, 2021).

The UT of Chandigarh, though dominated by urban land use, is still endowed with rich biodiversity. It possesses a rich tree cover due to well-established urban forestry. The choes with their broad, shallow, and dry sandy beds; the peripheral cultivated land parcelled into consolidated irregular, tiny fields, and the proximity to Shivalik hills and lower Himalayas lying in the adjoining State of Himachal Pradesh is the main reasons that enhance the existing biodiversity.

A total of 841 species (both wild and cultivated) belonging to 469 genera and 117 families (97 Dicot and 20 Monocot) have been reported from the UT. The family Poaceae is the most dominant family in Chandigarh, with about 120 species (Sharma and Khosla, 1989). Family Cactaceae has 102 species (mostly cultivated as ornamentals). There are about 26 ornamental and 31 evergreen trees, which grow along roadside and as avenue trees. A total of 182 species of shrubs have been observed to grow in the UT. Many climbers of ornamental value have been grown in the various gardens of the city and in home gardens. A total of 523 species of herbaceous angiosperms have been reported from the area (both wild and cultivated), many of which include species of medicinal and ornamental importance. A total of 166 species of plants of medicinal value grow during different seasons of the year besides plants, which are source of edible and aromatic oils. The flora also includes many aquatic plants (both free floating and submerged), which grow in various water bodies of Chandigarh.



Figure 13: Major mammals of Chandigarh UT

(Spotted Deer- Top L, Nilgai or Blue Bull- Top R, Black-naped Hare- Bottom L and Sambar deer Bottom R)

Source: Biodiversity Strategic Action Plan (BSAP), 2001



From viewpoint of bio-aesthetics plantations have been done in Leisure valley, Rajindra Park, Raj Bhawan Gardens, Sukhna Lake and other public parks within the Chandigarh city. Forest Department of Chandigarh have made large-scale plantations in Sukhna Lake-High Court area -Acacia with principal species being *Dalbergia sissoo*, *Senegalia catechu*, *Vachellia nilotica*, and *Senegalia modesta*. Afforestation operations carried during the last 25 years consisted mainly in *Senegalia catechu* in contour trenching and plantations of Eucalyptus in choe valleys with later mixing of *Bombax ceiba*, *Lannea coromandelica*, *Moringa oleifera*, *Senegalia modesta*, and *Albizia lebbeck* in the reserve forest of Sukhna catchment area. Thus the main trees in Chandigarh UT include *Senegalia catechu* (Khair), *Senegalia modesta* (Phulai), *Vachellia nilotica* (Kikar), *Vachellia leucophloea* (Raeru), *Dalbergia sissoo* (Shisham), *Terminalia anogeissiana* (Dhaura), *Azadirachta indica* (Neem), *Bombax ceiba* (Semal), *Butea monosperma* (Dhak), *Bauhinia variegata*(Kachnar), *Phyllanthus emblica* (Amla), *Morus alba* (Shatut), *Lannea coromandelica* (Jhingan), *Diospyros melanoxylon var. tupru* (Kendu), *Bergera koenigii* (Kari patta), *Neltuma juliflora* (Mesquite), *Cassia fistula* (Amaltas), *Ziziphus mauritiana var. mauritiana* (Ber), *Vitex negundo* (Bana or nirgundi), *Carissa spinarum* (Karaunda), *Justicia adhatoda* (Vasaka), *Tripidium bengalense* (Moonj), *Tinospora cordifolia* (Giloye), and *Abrus precatorius* (Rati) (BSAP Chandigarh, 2001).

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Amongst faunal diversity, around 20 mammal species, 262 bird species in which conservation status of some birds are Grey-crowned Prinia (*Prinia cinereocapilla*) (Vulnerable), Cinereous Vulture (*Aerypius monachus*) (Near Threatened), Red headed Vulture, (*Sarcogyps calvus*) (Near Threatened), Darter (*Anhinga melanogaster*) (Near Threatened), 11 reptiles and 67 butterflies have been reported from the UT, covering mainly the rich forests of Sukhna sanctuary and other green spaces within the city limit. As per the latest report, around 368 bird species were spotted in the UT in 2021, with over 100 migratory birds visiting Sukhna lake, a total inventory on invetebrates of Chandigarh has not been provided but few invertebrate reported are *Gelechiidae sp*, *Fucoceros cercariae*, *Physa acuta*, *Gyrarulus euphraticus*, *Radix persica*, *Radix lutcola* and *Annopheles annularis*. In addition, approximately 37 species of fish were reported from the aquatic habitats present in the UT. The mammalian diversity is dominated by Sambar (*Cervus unicolor*), Nilgai (*Boselaphus tragocamelus*), Wild pig (*Sus scrofa*), Spotted deer (*Axis axis*), Monkey (*Rhesus macaque*), Common Langur (*Semnopithecus entellus*), Jackal (*Canis aureus*), Indian Hare (*Lepus nigricollis*), Porcupine (*Hystrix indica*) and Jungle Cat (*Felis chaus*). Occasional sightings of Leopard (*Panthera pardus*) are augmented by the presence of Morni Reserve Forests in adjoining Haryana and the presence of woodlands in neighbouring Shivalik hills.





Figure 14: Other lesser faunal diversity

(Monitor lizard- Top L, Python- Top M, *Gasteracantha hasselti* spider- Top R, *Hottentotta* Scorpion- Bottom L, *Scolopendra* Centipede- Bottom R)



Figure 15: Migratory birds of Sukhna lake

(Common Pochard and Common Coot in Sukhna waters, Common Pochard male and female - Bottom L and Lesser Scaup- Bottom R)

Source: Punjab Envis Newsletter, PBCST, 2012

Due to increasing urbanization and conversion of agricultural fields into plots for residential purposes, the area under agriculture has decreased considerably in Chandigarh UT. But in many villages, enterprising



farmers are carrying on the tradition of monoculture plantations of wheat and rice may be primarily seen in the entire belt. The other crops grown are cereals, pulses, potatoes and oil seeds such as rapeseed. However, the production of rice, wheat and potato has been increasing continuously over the years, which has resulted in declined production of oil seeds, and pulses considerably. Before the green revolution, 41 varieties of wheat, 37 varieties of rice, 4 varieties of maize, 3 varieties of bajra, 16 varieties of sugarcane, 19 species/varieties of pulses, 9 species/varieties of oil seeds and 10 varieties of cotton were reported to be in use in the UT and adjoining states of Punjab and Haryana. However, data indicates that out of 49 types of wheat, only 3 are widely used post green revolution as released by PAU. Similarly, out of 27 varieties of rice released, only 9 are currently in use.

2.4 Faunal Diversity Rich Spots

Sukhna Wildlife Sanctuary

Sukhna Wildlife Sanctuary, spread over an area of 2600 ha is situated at 1 km from North-East of Sukhna Lake. It forms the part of Sukhna lake catchment area falling in Shivalik hills. Despite being officially established as a protected wildlife sanctuary in March 1998, the catchment areas undertook a more organised and extensive afforestation programme, which led to the development of an even better forest cover. A wide range of animals and plants can be found living in the deep forest area, which expanded in size over the course of five decades. The Sukhna Wildlife Sanctuary is home to a wide range of plants and animals and has an abode of wide variety of mammals, birds, reptiles and butterflies. It consists of 40 tree species, 28 shrub species, 28 herb species, 16 grass species, 20 species of mammals, 10 species of reptiles, more than 120 species of birds, 3 species of amphibians, 3 species of fish and 30 species of invertebrates (insects) (Department of Forests and Wildlife). It is well known that there are more sambar in the sanctuary than everywhere else in the nation when located in a group or cluster. Many birds and reptiles live there, including different sparrow species and jungle fowl. The sanctuary is home to a wide range of trees, shrubs, herbs, grasses, and climbers, including the *Azadirachta indica* (Neem), *Dalbergia sissoo* (Shisham), *Terminalia anogeissiana* (Dhaura), *Senegalia catechu* (Khair), *Vachellia nilotica* (Kikar), *Butea monosperma* (Dhak) (The official website of the Chandigarh Administration, 2022)

Butterfly Park

Butterflies are small yet beautiful creatures that steal hearts. They are part of the life on Earth and an important component of this rich biodiversity. They are amongst the first evolved species. In cities, it is now difficult to see these beautiful winged creatures due to loss of habitat but with the fruitful efforts of UT Forest Department, sighting of different butterflies within the city has become possible. The Department has developed Butterfly Park in Sector-26, Chandigarh, spread over an area of 7 acres which has been designed to facilitate an ideal environment for the breeding of butterflies (Department of Forests and Wildlife).

3. Pressures and Impacts

3.1 Pressure on Sukhna lake and its catchment area

The Sukhna lake and its catchment area is the city's lifeline as it acts as a 'green lung' to the congested and heavily populated capital of both Punjab and Haryana and the seat of UT administration. In addition, it also attracts vast flocks of migratory birds each year that feed and thrive in the vicinity of the lake. Out



of the total lake's catchment area of 42.07 sq. km, only 66% of the catchment area (i.e., 33.12 sq. km) lies in the hills. Out of this area, about 7.70 sq. km falls in Haryana. Most of the remaining 8.95 sq. km of the catchment area in the plains is under agricultural use and habitations and falls partly in Punjab (Kansal village), Haryana (Saketri Village) and the UT of Chandigarh (Kaimbwala village, a part of the Capitol Complex and the Rock Garden).

Despite its importance, the lake has faced several pressures over the years, leading to its deterioration. By the year 1988, about 66% of the original water holding capacity of the lake was lost due to the situation of silting. Following this, check dams were constructed in the catchment area. Mushrooming of illegal & unauthorized commercial and residential structures constructed in the catchment falling in of Punjab, Haryana, & Chandigarh discharge of pollutants from the neighboring states of Punjab and Haryana, overgrazing due to livestock, drying up of the wetland and unregulated tourism pose to be significant challenges leading to degradation of Sukhna lake and its catchment area (Management Plan Sukhna Wildlife Sanctuary, 2018). In addition, the local biodiversity is also threatened due to illegal feeding of fish and migratory birds by tourists and proliferation of invasive plant species. The UT has an Eco-sensitive Zone varies from 2.0 kilometres to 2.75 kilometres from the boundary of the Sukhna Wildlife Sanctuary in the Union territory of Chandigarh; the Union territory Administration of Chandigarh has divided the Eco-sensitive Zone in two zones i. e., Zone-I and Zone-II and the extent of Zone-I is upto 0.5 km of from the boundary of the Sukhna Wildlife Sanctuary and the balance area shall be in Zone-II and this has been done with the purpose of having stricter norms in Zone-I for protection of wildlife habitat; the area of Eco-sensitive Zone is 10.50 sq. km (on the side of Union territory of Chandigarh) (Chandigarh Forest Department, 2017).

3.2 Pressure on seasonal rivulets (Choes)

The three rivulets (locally known as choes) Patiala-ki-Rao, N Choe (converted into Leisure Valley Park) and the Sukhna Choe provide seasonal drainage for the surface water runoff from their catchments during the monsoons. Their sandy beds also recharge the deep sub-soil water aquifers, which provide the UT with about 20% of its water supply. Many of Chandigarh's tube wells are located in the beds of these choes (Chandigarh Master Plan 2031).

Despite their importance in carrying out ecological function, all the rivulets are under tremendous anthropogenic pressures, including mushrooming of slums and encroachments in their bed. In addition, the discharge of untreated sewage and solid waste has affected the water quality resulting in a lack of BOD & COD, the proliferation of invasive species like water hyacinth and a negative impact on aquatic life (Chandigarh Master Plan-2031).

Commercial use of natural water resources has also resulted in drying up of beds and low availability of fresh water in the rivulets. Rampant unregulated sand mining in adjoining states are threatening Patiala-Ki-Rao water recharging capacity. However, in contrast, the parts of Sukhna Choe and Patiala- Ki-Rao with notified Reserve Forests along their sides are in much better condition and support good biodiversity along with the ecosystem services (Chandigarh Master Plan-2031).

3.3 Pressure on local biodiversity due to invasive species

Fauna

Human disturbances and agricultural practices have influenced the introduction of invasive species. Invasive species are generally a matter of concern, as they threaten the native biological diversity of the



forest. The primary invasive species found in Chandigarh are *Lantana camara*, *Parthenium hysterophorus*, *Leucanea leucocephala*, and *Saccharum spontanem* (ISFR 2019). Despite measures to constrain their growth by Forest Department, the rapid growth of *Lantana camara* and *Parthenium hysterophorus* has been a huge challenge in Chandigarh. Weeds such as *Parthenium* and *Lantana* have a negative impact on the development of native species. *Amarbel*, a parasite that covers the whole foliage of a tree and eats it away, is also infecting trees in the city. As a result of such invasive species, there is a direct impact on the growth of palatable indigenous grass and herbaceous flora. The same shall impact the faunal diversity which is directly or indirectly dependent on such indigenous floral diversity in the long run.

3.4 Pressure due to Human Wildlife Conflict (HWC)

As per the Forest Department of Chandigarh there are very less cases of Human Wildlife conflicts in the regions. However, the raids of monkeys in the urban houses are a constant issue. Although there is no food shortage in the forests, monkeys still enter the urban habitats for easy access to food. As per the Forest Department, the monkey-raids will not stop as long as people do not stop feeding the monkeys.

3.5 Pressure due to Forest Fire

Forest Fire is a common phenomenon throughout the world. In India, approximately 54.40% of forests are prone to occasional fires, 7.49% to moderately frequent fires and 2.405 to high incidence levels, while 35.71% of India's forests have not yet been exposed to fires of any real significance (FSI, n.d.).

Although not very common, forest fires occur in Chandigarh's forests. As per Management Plan of Sukhna Wildlife Sanctuary, forest fires have broken mainly in Upper and Lower Nepli, Tootawali and Piplawala. Most of the fire incidents occurred due to the high-tension wires passing through these areas and fire originating in the Morni Hills area of Haryana and spreading thereafter (Management Plan of Sukhna Wildlife Sanctuary, Chandigarh UT, 2018-19 to 2027-28).

4. Response

4.1 Key & Relevant Legislations

Management of Chandigarh's natural resources is carried out under a broad umbrella of National, State and International laws and policies. The constitution of India contains specific provisions for environmental conservation (articulated in the directive principles of state policy (48a) & (51-A (g)) and fundamental duties (51-A). Numerous legislation (acts, rules, circulars and orders) relating to environmental protection as well as specific laws relating to forests, wildlife and biodiversity have been passed taking into account governmental and civil society concerns. Some key Central Government Legislations relevant to biodiversity are listed in table 15 below:

Table 15: Relevant key legislations in the state

Relevant key legislation	Key feature
Wildlife Protection Act, 1972	Deals with protection of wildlife and habitats and provides for the protection of wild animals, birds and plants and related matters, with a view to ensuring the ecological and environmental security of the country.



Relevant key legislation	Key feature
Indian Forest Act 1927	Designed for forest management and protection, the transit of forest and duty leviable on timber and other forest produce.
Forest Conservation Act 1980	Designed for the conservation of forest and related matters.
Biological Diversity Act 2002	Provides for conservation of biological diversity, sustainable use of its components, and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and related matters.
Biological Diversity Rules 2015	Deals with operationalizing the Biological Diversity Act.

Table 16: Relevant key policies in the state

Policies plans and strategies	Brief outline of priorities
National Forest Policy, 1988	Provides for national goals and guidelines relating to areas under forests, afforestation, social forestry and farm forestry, management of state forests, rights and concessions, diversion of forest lands for non-forest purposes, wildlife conservation, tribal people and forests, shifting cultivation, damage to forests from encroachments, fire and grazing, forest based industries, etc. the policy also covers forestry education research management survey and database legal support infrastructure development and financial support.
National Conservation Strategy and Policy Statement for Environment and Sustainable Development, 1992	Outlines the nature and dimensions of environmental problems of India as well as actions taken and constraints and agenda for action.
National Policy and Macro-Level Action Strategy on Biodiversity, 1999	Outlines a series of macro-level statements of policies, gaps and strategies needed for conservation and sustainable use of biodiversity.
National Livestock Policy, 2013	This policy facilitates coordination between states & various policy interventions needed for addressing challenges.
National Wildlife Action Plan (2016-2030)	Calls for adoption and implementation of strategies covering strengthening and enhancing the PA network, effective management of PAs, conservation of wild and endangered species and their habitats, restoration of degraded habitats outside PAs, control of poaching, and illegal trade in wild animal and plant species, monitoring and research ensuring peoples participation, awareness, wildlife tourism, domestic legislation and international conventions, enhancing financial allocation and integration with other sectoral programs.



Policies plans and strategies	Brief outline of priorities
National Environment Policy, 2006	Stated objectives include i) conservation of critical environmental resources ii) intra-generational equity: livelihoods security for the poor; iii) inter-generational equity; iv) integration of environmental concerns in economic and social development; v) efficiency in environment resource use; vi) environmental governance; and vii) enhancement of resources for environmental conservation.
Environment Impact Assessment (EIA) Notification 2006	Defines categorization schedule for activities/projects & procedures for category A/B1 projects for environmental clearance & monitoring
National Forestry Action Programme 2000-2020	Envisages developing coordinated programme for the sustainable management of forests and forest lands to meet the environmental, socio-economic, and cultural need of the present and the future generations.
Chandigarh Trees Preservation Order-1952	As per the order, cutting or destroying of any trees in any parts of the forestland, which has been shown in the zoning plan as “protected trees” or in “protected woodland areas” is forbidden without the permission of the Chief Administrator. The Chief Administrator has the authority to reject the application if he feels that the rejection for the betterment of the forest and the trees, which were to be cut down, holds important values. This order is not applied in operational lands.

4.2 Programmes taken up by Chandigarh Forest Department

The main thematic programmes taken up by Chandigarh Forest Department are as follows:

Forest Conservation & Development

The main objective of this scheme is to reduce the silt inflow to Sukhna lake by carrying out various kinds of soil conservation works. The works like construction of silt retention dams, masonry check dams, spurs/revetments, desiltation of dams, construction of grade stabilizers, planting of live-hedge and opening of *choe* bed etc. are being undertaken under this scheme.

Plantation Scheme

The main objective of this scheme is to provide a carpet of vegetation in open patches/hill tops to reduce soil erosion by planting/sowing of seeds. Plants raised in the newly acquired land as well as the southern Sectors are also being maintained. The works like plantation, patch-sowing & installation of chain link fencing etc. are being undertaken under this scheme.

In situ Conservation Preservation of Sukhna Wildlife sanctuary

Sukhna Wildlife Sanctuary, spread over an area of 2600 ha is situated at 1 Km from North-East of Sukhna Lake. The Sukhna Wildlife Sanctuary is home to a wide range of plants and animals and has an abode of wide variety of mammals, birds, reptiles, butterflies. It consists of 40 tree species, 28 shrub species, 28 herb species, 16 grass species, 20 species of mammals, 10 species of reptiles, more than 120 species of birds, 3 species of amphibians, 3 species of fish and 30 species of invertebrates (insects).



To protect, preserve and propagate the wildlife of the area by creating & improving natural habitats and promoting water facilities by constructing water holes, provision of salt licks etc. In addition to this, the department is maintaining two animal rescue centres in Nepli and Kansal area. Animals are treated here and being released in the sanctuary area. To increase mobility of the staff and for effective implementation of the provisions of the Wildlife (Protection) Act 1972, communication network is being developed. The works like raising of water holes, suppression of lantana/ pathenium etc. are being undertaken. Sukhna Wildlife Sanctuary is free from the menace of lantana.

Parrot Bird Wildlife Sanctuary

In 1975, Shri S.K. Sharma, Secretary, Environment Society Chandigarh observed that the Green Parakeets flying over old Ropar-Ambala Road in East - West corridor which happens to be passing over sector - 21 park, have found a new home there for roosting i.e., to settle for rest and sleep. Thus, Chandigarh Administration declared 2.9 hectare area of sector -21 park as Chandigarh City Bird Sanctuary on 29th September, 1988. There is wide variety of trees, shrubs, herbs, grasses and climbers. The prominent among them are *Senegalia catechu* (Khair), *Senegalia modesta* (Phulai), *Vachellia nilotica* (Kikar), *Vachellia leucophloea* (Raeru), *Dalbergia sissoo* (Shisham), *Terminalia anogeissiana* (Dhaura), *Azadirachta indica* (Neem), *Bombax ceiba* (Semal), *Butea monosperma* (Dhak), *Bauhinia variegata* (Kachnar), *Phyllanthus emblica* (Amla), *Morus alba* (Shatut), *Lannea coromandelica* (Jhingan), *Diospyros melanoxylon var. tupru* (Kendu), *Bergera koenigii* (Karipatta), *Neltuma juliflora* (Mesquite), *Cassia fistula* (Amaltas), *Ziziphus mauritiana var. mauritiana* (Ber), *Vitex negundo* (Chinese chaste), etc.

There are more than 262 varieties of birds including aquatic birds. Prominent among them are Peacock, Red jungle fowl, Grey partridge, Cuckoos, Night jays, Golden Oriole, Kingfisher, Swifts, Hoopoes, Hornbills, Barbets, Woodpeckers, Rollers, Barn owls, Parrots, Doves, Plovers, Coots, Hawks, Geese, Swan and Ducks (Department of Forests and Wildlife).

Ex situ Conservation

Establishment of Botanical Garden

Chandigarh Administration has established a Botanical Garden near village Sarangpur, Lahora and Dhanas. The total land acquired for the establishment of Botanical Garden is 0.71 sq. km. The works like raising & maintenance of nursery, raising of plantations (new), raising of shrubs, creation of lawns, land levelling, construction of check dams etc. has been undertaken.

There is a huge impetus on training and awareness building especially for citizens and for the staff. Some of the recent noteworthy activities carried out by the department include:

1. In 2019, a training course was organized in August 2019 for two days on "DSS and e- Green Watch and Forest Fire" by The Forest Survey of India, Dehradun for the Range Forest Officer, Nepli Range of Chandigarh department.
2. Training programme on "Health Assessment of Trees" was organized at the Botanical Garden for various Stakeholders and Eco-Clubs of Chandigarh on February 2020, by the Forest Department of Chandigarh, in collaboration with FRI, Dehradun.
3. In 2019-20, about 2, 56, 311 saplings were planted, 1, 50, 000 stem cuttings of Arundo- donax plants were done and 3, 00, 000 patch-sowing (seed sowing) was conducted.



4. Celebration of the Vanmahotsava festival in 2018, to foster awareness about the importance of tree plantation. Various plantation programmes were undertaken as a part of this festival.
5. Establishing of a “Nagar Van-City Forest” under the Nagar Van Udyan Yojana, which was inaugurated on 24th April 2018, to protect the flora and fauna of the forest near the lake catchment.
6. The Ministry of Forests, Environment, and Climate Change (MoEF&CC), New Delhi, began the School Nursery Yojana in August of 2015. Under this scheme, the Department of Forests and Wildlife, Chandigarh, intends to establish school nurseries in various schools with the goal of involving young students in growing plants in school nurseries. Now, of the 10 schools involved, all of them have begun the task of creating a nursery on their school grounds, and 8 of them have produced seedlings in Nursery Beds, Pots, and Polythene Bags, which has been distributed to schools and locals/residents.
7. The Chandigarh Administration has set up a Botanical Garden near the villages of Sarangpur, Lahora, and Dhanas. The entire amount of land obtained for the Botanical Garden is 176 acres. Works such as nursery raising and maintenance, plantation raising (new), shrub raising, grass creation, land levelling, check dam construction, and so on have been done.

Butterfly Park

Butterflies are small yet beautiful creatures that steal hearts. They are part of the life on Earth and an important component of this rich biodiversity. They are amongst the first evolved species. In cities, it is now difficult to see these beautiful winged creatures due to loss of habitat but with the fruitful efforts of UT Forest Department, sighting of different butterflies within the city has become possible. The Department has developed Butterfly Park in Sector-26, Chandigarh, spread over an area of 7 acres which has been designed to facilitate an ideal environment for the breeding of butterflies (Department of Forests and Wildlife).

Peacock Park

Department of Forests & Wildlife have developed a 5.7-acre green area in Sector-39 as Peacock Park. This area is full of vegetation and a promising habitat for peafowls. The area has been fenced from all sides to provide a secluded place for resting and breeding of the National Bird (Department of Forests and Wildlife).

Shivalik Arboretum

It is situated near the Transport Light in Sector-26, Chandigarh. This beautiful place is spread over an area of 11.115 acres. Shivalik Arboretum has got a collection of prominent species of plants found in the Shivalik region like Bael, Siris, Khair, Kachnar, Kikar, Amaltash, Kadam, Neem, Amla, etc. Department has developed earthen tracks for local people to walk and enjoy the healthy environment. Flowering plants planted along the tracks gives beautiful look to the Shivalik Arboretum (Department of Forests and Wildlife).

Highlights of the Greening Chandigarh Action Plan (2022-23)

8. Planting of 2, 80, 000 saplings in phased manner over locations such as the Sukhna Wildlife Sanctuary, Reserved Forests, Roadsides, Green Belts, Parks, Community land, Government offices, Residential Complexes and any other available free space.



9. 2, 20, 000 seeds of various forestry species will be sowed by the Department of Forests and Wildlife on the eroded hill slopes in Wildlife Sanctuary Area and blank patches of Reserved Forest Area.
10. Distribution of 80, 000 seedlings of Mango, Neem, Jamun, Arjun, Kusum, Peepal, Kachnar, Amaltas, along with medicinal plants to the educational institutions, NGO's, RWAs, farmers, and local residents by the Forest Department, free of cost.
11. Selling of 25, 000 fruit and ornamental trees on subsidized rates by the Horticulture Wing of the Municipal Cooperation and the Engineering Department.
12. Post plantation care of plantations will be done by the greening agencies and public by ensuring regular watering and proper protection.
13. Establishment of herbal gardens in Schools, Colleges and other institutions.
14. To prevent encroachment, chain link fence is being installed around the wooded area. Biodiversity enrichment planted at Lake Reserve Forest, Patiala-ki-Rao & Sukhna choe woods, and Lantana-parthenium clearance in forest area are all underway. Aside from the Lake Reserve Forest, Sukhna Choe Reserve Forest, and Patiala-ki-Rao Forests, the department maintains plantations on more than 1 sq. km of land in the southern sectors and the brick kiln areas located at the surroundings of Chandigarh.

5. Recommendations

5.1 Securing & Enhancing the Quality of Existing Green/Open Spaces

- Although the area under forest in Chandigarh is increasing but one of the crucial aspects is maintaining the quality of the forest. The reduction in the MDF (from 14.24 sq. km in 2019 to 13.51 sq. km in 2021) signifies the reduction in the quality of the forest. Miyawaki plantation in Open Forest and scrub can be done to increase the quality of the Forests.
- Land needs to be identified to be converted to forest. In order to maintain the environment and to keep the large ecological footprint under check, it is imperative to bring adequate area under tree cover.
- Planning process for green cover enhancement is very crucial. This involves avoiding monoculture plantations and promoting mixed plantations comprising of local/indigenous species. Species selection must be done keeping in mind the parameters like – location, site conditions like groundwater & soil, environment considerations like pollution abatement and ornamental & aesthetic requirements.
- Community participation should be encouraged to improve the quality of the forest as well as to increase the forest conservation measures.

5.2 Biodiversity Enhancement Interventions in Green Urban Landscapes

- More thematic parks like butterfly gardens and botanical gardens can also be set-up to compliment the ecosystem services. This would also help in conserving the threatened and economic plants of Chandigarh area and effectively spread environmental and educational awareness
- Household herbal gardens can be promoted by distributing medicinal plants like Ashwagandha, Ghritkumari, Giloy, Pudina, Sarpagandha etc. along with a description book about the uses of plants. Such program has been carried out in states like Delhi by TERI (The Energy and Resource Institute) and Bangalore by FRLHD (Foundation for Revitalisation of Local Health Traditions) and was supported by Ayush and NMPB (National Medicinal Plants Board).



5.3 Assessment of Biomass & Carbon Stock and its potential in Carbon Markets

- Increasing the amount of carbon sequestered by the forests by either promoting activities that reduce forest dependency or by increasing the biomass by planting trees and conserving forests.
- Implementing carbon finance projects- Apart from the environmental benefits and assisting in mitigating in climate change forests can aid in the economic benefit which provides a crucial funds for continuation of forest related activities. Planting of trees and implementing REDD+ activities can provide a crucial ground for establishing projects under Voluntary Carbon Markets (VCM) and obtaining Carbon Credits (Verified Emission Reductions) which can be traded in international carbon markets
- Training and capacity building of the forest department must be conducted for assessment of biomass and carbon stock.

5.4 Assessment of Ecosystem services in Chandigarh

- Sukhna lake has been recently classified as a wetland in 2020 thus an assessment should be carried out for identification of ecosystem services provided by the Sukhna lake. A better understanding of the economic value generated by Nature Based Solutions, and the Ecosystem Services they provide, can facilitate the adoption of efficient policies and measures to preserve and enhance them.
- One of the important functions of the ecosystem services provided by the green space is the reduction of urban heat island effect. Thus, a comprehensive study needs to be conducted on studying the impact of urban heat island effect and the benefits provided by the green spaces.

5.5 Securing the entire catchment of the Sukhna lake

- As most of the part of the Sukhna catchment area falls under the Punjab and Haryana a joint committee can be developed between the three states to ensure that no development activities can take place in the catchment areas.
- Although construction of check dams has been done by Chandigarh in Sukhna, it should also be ensured that regular monitoring of the storage capacity of the check dams is done to ensure regular flow of water into the lake.
- It must also be ensured that aquatic weeds are removed, there are no seepage losses, and that no wastewater/sewage flows into the water body.
- Eradication of invasive species must take place regularly so that the biodiversity of the area does not get affected.

5.6 Protecting the Choes

- The choes play a key role in the context of overall ecology of the city and its environment. Therefore, protection against the anthropogenic pressures and revitalization of these rivulets must be undertaken on high priority. This can be done by planned revegetation.
- Measures should be taken for demarcating and protecting the flood plains of choes against any kind of construction, mushrooming slums, sand mining and dumping of sewage and solid waste in them, to maintain their ecological integrity and natural drainage function.





II

**LAND DEGRADATION
AND DESERTIFICATION**

LAND DEGRADATION AND DESERTIFICATION

1. Introduction

Degradation of land is one of the most serious environmental problems confronting the world today. According to United Nations Environment Programme (UNEP), globally, degradation of land undermines the well-being of 3.2 billion people resulting in a 5% reduction in total global net primary productivity (IPBES, 2018). Land is a vital resource for producing food, preserving forests and biodiversity, facilitating the natural management of water systems and acting as a carbon store. Appropriate land management can protect and maximize these services for society. Not surprisingly, therefore, desertification, along with climate change and the loss of biodiversity were identified as the greatest challenges to sustainable development during the 1992 Rio Earth Summit. The United Nations Convention to Combat Desertification (UNCCD) is one of 3 Rio Conventions which focuses upon desertification, land degradation and drought (DLDD).

UNCCD defines land degradation as a “reduction or loss in arid, semi-arid, and dry sub-humid areas of the biological or economic productivity and complexity of rain-fed cropland, irrigated cropland or range, pasture, forest, and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns, such as: (i) soil erosion caused by wind and/or water; (ii) deterioration of the physical, chemical, and biological or economic properties of soil; and (iii) long-term loss of natural vegetation” (UN, 2007).

Land degradation in India has significant implications for ensuring India’s food security, land resilience and climate mitigation. The Space Applications Centre in 2016 estimated that India had 0.97 m sq. km under desertification and land degradation in 2011/2013 which constitutes almost one-third of India’s total land area, an increase of 1.87m ha since 2003/05 (SAC, 2016). Further, a study conducted by TERI in 2018 showed that the annual cost of land degradation in India is estimated to be Rs 3, 177 billion which is about 2.5% of India’s GDP in 2014/15 and about 15.9% of the Gross Value Added (GVA) from the agriculture, forestry and fishing sectors (TERI, 2018).

Realising the importance to mitigate land degradation, India has set a target to restore 0.21 m sq. km of degraded lands under Bonn Challenge. Further, Hon’ble Prime Minister of India while addressing the high-level segment of COP 14 of UNCCD on 9 September 2019 announced that “India would raise its ambition of the total area that would be restored from its land degradation status from 0.21 m sq. km to 0.26 m sq. km between now and 2030”. The target finalised by India shall soon be communicated to UNCCD.

The role of the states and union territories of India is, therefore, assumed a significant in the joint containment of regional socioeconomic disparities and spatial imbalances in land resources and environmental quality at large, considered at the base of any desertification process. However, it has been observed that despite multiple efforts taken, status of land degradation has not improved in many states.



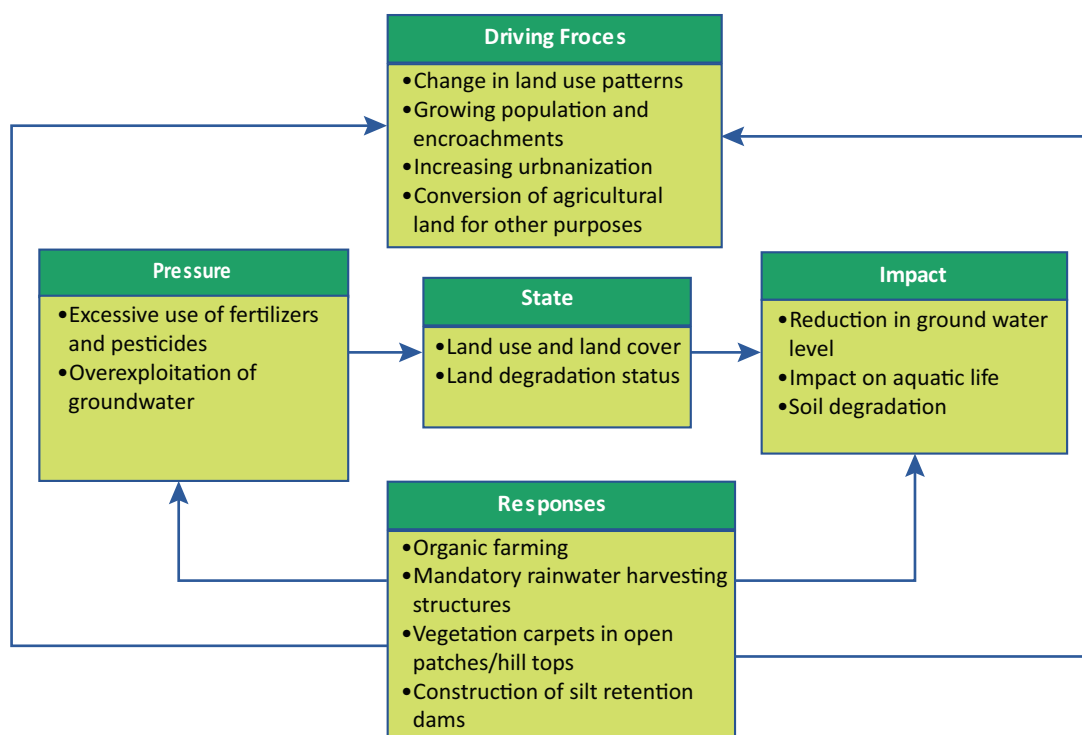


Figure 16: Diagram illustrating the contents of each step for the components of the DPSIR

2. State

2.1 Land Use/ Land Cover in Chandigarh

Although the terms “land use” and “land cover” are sometimes used interchangeably, each has its own distinct meaning. The term “land cover” refers to the surface cover of the ground, such as vegetation, urban infrastructure, water, bare soil, and so on. The identification of land cover provides the foundation for operations such as thematic mapping and change detection analyses. Land use, on the other hand, relates to the function of the land, such as agriculture, wildlife habitat or recreational purpose.

Chandigarh has an area of 114 square kilometres, in addition to this the Sukhna Wildlife Sanctuary spreads across 26 sq. km (Department of Environment, Chandigarh, 2021). The total area under agricultural crops has reduced to insignificance, as can be observed in Table 17. The city’s total green cover, including Sukhna Wildlife Sanctuary, is 35.7 percent, while the area under water bodies is 3.1 percent, with Sukhna Wetland accounting for 1.6% (Department of Environment, Chandigarh, 2021).

The distribution of total land of Chandigarh among the different LULC categories for the year 2018-19 has been depicted in Table 17.

Table 17: Category wise distribution of Land Use / Land Cover in Chandigarh

Land use classification	Area in 2015-16 (in thousand hectares)	Area in 2018-19 (in thousand hectares)
Forests	0	0
Area under non-agricultural uses	5	5



Land use classification	Area in 2015-16 (in thousand hectares)	Area in 2018-19 (in thousand hectares)
Barren and un-culturable land	-	-
Permanent pastures & other grazing lands	0	-
Land under misc. tree crops & groves (not incl. in net area sown)	0	0
Culturable waste land	-	-
Fallow lands other than current fallows	0	0
Current fallows	0	0
Net area Sown	1	1

Source: Directorate of Economics & Statistics, Department of Agriculture & Farmers Welfare, Ministry of Agriculture and Farmers Welfare, Govt, 2021

The above table clearly manifests those anthropogenic activities drive the land use pattern in Chandigarh. The growth in land used for non-agricultural purpose complimented by the no increase or decrease in the forest area signifies that commercialization in Chandigarh has had the greatest impact on agricultural land.

2.2 Land Degradation Status in Chandigarh

Land degradation and deterioration of land quality for agricultural production, industrialization and urbanization has become a matter of concern for land users (NAAS, ICAR, 2010). Wasteland, scrub land, barren/rocky land, salt effected land, sandy area, ravinous/ gullied land and mining area are some common types of degradation that are found in India. Wasteland are described as degraded lands which can be brought under vegetative cover with reasonable effort, and which is currently underutilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes (Department of Land Resources, Government of India). Wastelands are further categorized as follow:

1. Scrub Land- These areas possess shallow and skeletal soils, at times chemically degraded extremes of slopes, severely eroded or subjected to excessive aridity with scrubs dominating the landscape.
2. Gullied / Ravinous Land: Gullies are formed as a result of localized surface run-off affecting the unconsolidated material resulting in the formation of perceptible channels causing undulating terrain. Ravines are basically extensive systems of gullies developed along river courses.
3. Barren Rocky/Stony Waste: These are rock exposures of varying lithology often barren and devoid of soil and vegetation cover.
4. Sandy Area: Desert sands are characterized by accumulation of sand developed in situ or transported by Aeolian processes. Coastal sands are the sands that are accumulated as a strip along the sea-coast. Riverine sands are those that are seen as accumulations in the flood plain as sheets which are the resultant phenomena of river flooding.
5. Salt-Affected Land: Generally characterized as land that has excess salt in the soils with patchy growth of grasses (NRSC, 2019)
6. Mining Areas: These are the areas subjected to removal of different earth material (both surface and sub-surface) by manual and mechanized operations. Large scale quarrying and mechanizations results in mining and mine dump (NRSC, 2019).



2.3 Land Degradation Statistics of Chandigarh

As per NAAS ICAR 2010 the total area under degradation in Chandigarh is 45.6%. The total geographical area of Chandigarh is 114 sq. km, which means around 0.57 sq. km of the area is under degradation (NRSC, 2019). Figure 17 depicts land degradation map of Chandigarh for the year 2015-16.

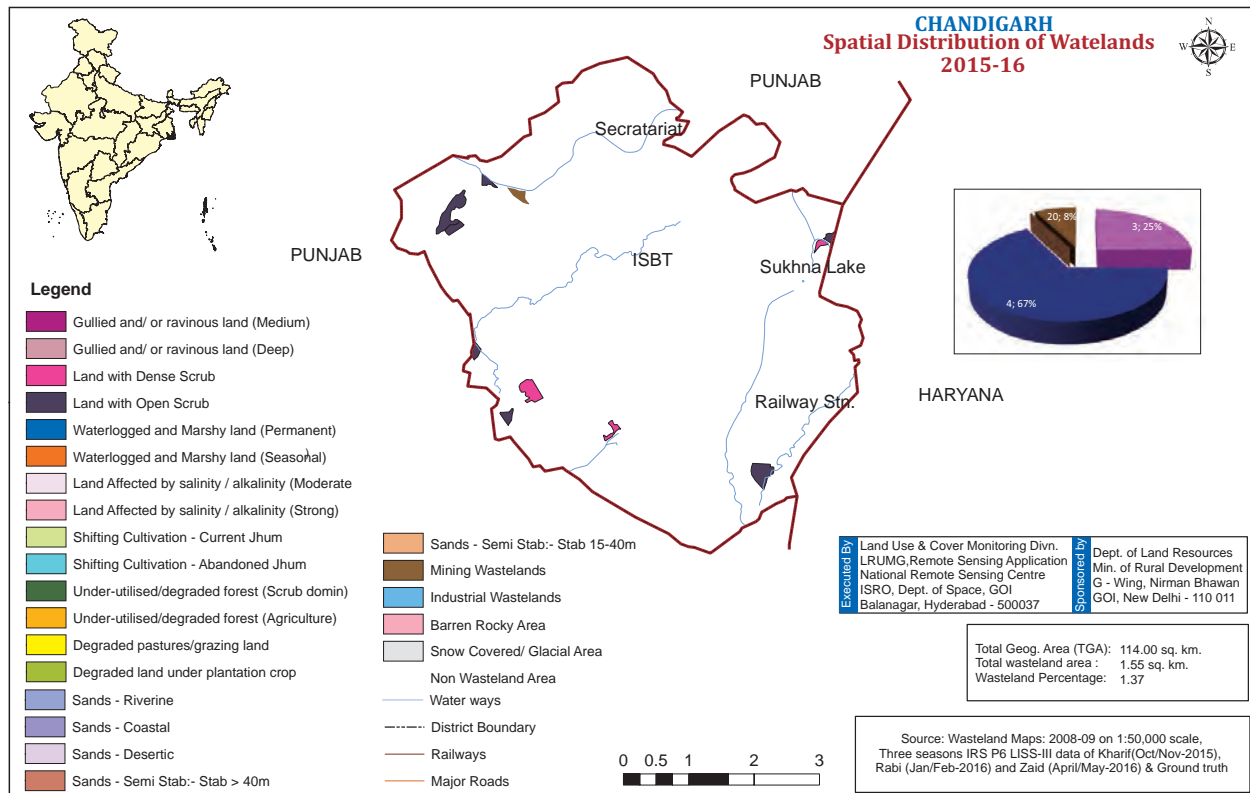


Figure 17: Land degradation map of Chandigarh

Source: Department of Land Resources, 2016

From the above map it can be observed that Water Erosion is the most significant and dominant process of land degradation in the country as well as in Chandigarh. It causes displacement of soil material which results in either loss of Topsoil terrain deformation or both. There are seven land degradation classes that fall under Water Erosion –

- Sheet Erosion- Slight
- Sheet Erosion- Moderate
- Sheet Erosion- Severe
- Rills
- Gullies
- Ravines- Shallow
- Ravines- Moderately deep to deep



However, sheet erosion due to water is one of the major forms of erosion that is predominant in Chandigarh. Sheet Erosion (Slight/Moderate/Severe) is responsible for extensible soil loss in both cultivated and non-cultivated environments. In 2015-16, about 0.38 sq. km of land was under slight sheet erosion, whereas about 0.19 sq. km of land was under moderate sheet erosion in Chandigarh (NRSC, 2019).

Status of Fallow Lands

Fallow has been characterized as a farming method in which no crop is grown and all plant development is controlled by cultivation or pesticides during a crop-growing season. Fallow cropping methods usually have a negative influence on soil organic matter, owing to decreased crop residue production as well as tillage employed for weed control during the fallow season. Tillage for weed control during the fallow season has been shown to have varied impacts on the surface layer soil bulk density (Nielsen et. al., 2011). The fallow land in Chandigarh has remained unchanged for the last five year. Currently, as per the Department of Environment, Chandigarh, the current fallow lands constitute about 0.03 sq. km, whereas fallow land other than current fallow land is 0.50 sq. km (Department of Urban Planning, Chandigarh Administration, 2021)

Status of Scrub Lands

Scrub lands are the type of land that is prone to degradation due to erosion. Land with thick scrub and land with open scrub might be divided into two sub-classes based on the presence of plant cover. Land with thick scrub has shallow and skeletal soils that are sometimes chemically damaged, extreme slopes that are extensively eroded, and is prone to excessive aridity, with scrubs dominating the landscape. They have a proclivity to intermix with croplands (NRSC, 2019). Land with open scrub is similar to the previous one, except it has scant vegetative cover or is free of scrub and has thin soil coverings (NRSC, 2019). In Chandigarh, there has been an increase in the areas under scrub from 2017 to 2019. As per the ISFR reports, in 2017, area under scrubs was 0.02 sq. km., in 2019, the area increased to 0.10 sq. km and the latest ISFR 2021 report the area under scrub is 0.38 sq. km (ISFR, 2021).

3. Pressures and Impact

3.1 Fertilizer and Pesticides Usage

Heavy usages of pesticides and fertilizers have been seen as the one of the primary reasons behind soil degradation. In order to increase the productivity of the crop and achieve better yield, farmers resort to heavy usage of pesticides and chemical fertilizers, which ultimately affects the soil microbes and thereby reduces the soil fertility. Since there are limited agricultural areas in Chandigarh, the usages of pesticides are very less. In Chandigarh insecticides is used in production of vegetable and food grain crops. As per the Department of Agriculture, Chandigarh, 2019-20, the consumption of insecticide was 0.14 MT, which further increased to 0.16 MT of insecticide in 2020-2021. However, Chandigarh is one of the Union Territories in India which has shown a negative growth rate of pesticide consumption (0.59 MT insecticide in 2004-05 to 0.16 MT insecticide in 2020-21).

3.2 Over Exploitation of Groundwater

As per the Central Groundwater Board, UT Chandigarh, 2021, groundwater in Chandigarh has decreased considerable. The level of shallow unconfined Aquifer Pre monsoon and post monsoon 3.56-16.07 mbgl (metres below ground level) and 2.80-14.90 mbgl in 2004. The level improved considerably and by 2010



the level reached 0.58-22.12 and 1.89-21.97 mbgl for pre- monsoon and post-monsoon respectively. But the groundwater level has decreased in 2021 to 2.47-53.54 mbgl and 2.80-51.31 mbgl. Although the amount has decreased from 2010 the recent trends show that from year 2016 to 2021 the groundwater level has improved considerable from 3.09-30.97 mbgl to 2.74-53.54 mbgl for pre-monsoon and 2.82-28.85 mbgl to 2.80-51.31 mbgl respectively.

Also, the level of deep confined Aquifer pre-monsoon and post-monsoon was 33.16-100 mbgl and 32.84-100 mbgl respectively in 2019. This value has further improved to 15.90-100.82 mbgl and 10.15-101.30 mbgl respectively. This rapid depletion of water is mainly due to the increase in the demand of water, caused due to urbanization and population excess. Reduction in groundwater leads to loss of soil moisture, which in turn makes the soil less productive supporting degradation.

4. Responses

4.1 Initiatives taken by the Chandigarh Administration

Although the intensity of soil degradation is not as severe in Chandigarh as in other parts of India, it is imperative to address the issues that are already in place pertaining to soil runoff and pollution. The government of Chandigarh have already undertaken many initiatives to curb the further degradation of soil.

Despite land under agriculture in Chandigarh is significantly less, the UT government is encouraging the farmers in Chandigarh to practice organic farming. According to the action plan formulated by the Director of Agriculture, Chandigarh, organic crops would be planted on 920 hectares in all villages within the jurisdiction of the UT Administration, under the Paramparagat Krishi Vikas Yojana (PKVY) (Tribune India, 2018). Groups of land held by small and marginal farmers have been developed as part of the concept, where organic crops are being grown. Under this initiative, farmers will be getting financial support regarding organic production, PGS certification, packaging and branding, and delivery. Farmers Markets have also been organised at every week near the Sukhna Lake where produced organic crops are sold.

To address the issue of water logging, the Chandigarh Administration has taken the following measures:

1. Zero drainage of storm water has been undertaken for large development sites that have >30 acres area.
2. Mandatory rainwater harvesting structures to be built in all new buildings, commercial complexes and industrial establishments and installation of rainwater harvesting structures in existing buildings.
3. Recharging of aquifers in all housing complexes and commercial complexes.
4. Reduction of paving on unbuilt areas such that paving should not exceed 25% of unbuilt areas and where possible grass pavers should be used (Department of Environment Chandigarh, 2018).

The Municipality has also agreed to conduct a trial of systematic rainwater collecting in Sector 26 in accordance with a comprehensive rainwater harvesting plan established by the Centre for Science & Environment (CSE) in New Delhi. This concept proposes recharging the deep aquifers by building recharge structures alongside the city's storm water drain network and tapping the rainwater that flows through it. This should be integrated with the construction of surface or subsurface water storage structures for landscaping/horticultural purposes. The city's construction codes currently demand rainwater collecting for any new structures above 5.06 x 10⁻⁴ sq. km.



The government has also implemented schemes to provide vegetation carpets in open patches/hill tops, to reduce soil erosion. Activities such as plantation, patch-sowing & installation of chain link fencing etc. have been being undertaken under this scheme. The Department of Forests and Wildlife have sown 3, 00, 000 no. of seed of different species on those hill slopes which are severely eroded in Wildlife Sanctuary Area and in the blank patches of Reserve Forest Area to reduce the soil runoff during the monsoon season. In addition to that, activities such as construction of silt retention dams, masonry check dams, spurs/revetments, desiltation of dams, construction of grade stabilizers, planting of live-hedge and opening of choe bed etc. have been undertaken to prevent the silt inflow to Sukhna Lake.

5. Recommendations

- Various organic insecticides can be used by the farmers such as vegetable and horticulture oils, neem, microbial extracts like Spinosad, and natural pyrethrin.
- A comprehensive study is lacking on the issue of land degradation in Chandigarh. Hence, it is imperative to conduct in-depth studies regarding soil fertility, soil salinity level and current areas under degradation in Chandigarh.
- The government should encourage planting of those trees which has the potential of Phyto stabilization. Such plants are capable of absorbing contaminants, which helps in enhancing the fertility of the soil.
- The drainage system of the city needs special attention. Along with the harvesting of the rainwater, it is also imperative to ensure that the drains are cleaned regularly, especially during the monsoon period. New structures like inlets, open channels, linear drainage channels should be created.
- Recycled water, along with the harvested rainwater should be encouraged to be used for domestic work (like gardening, cleaning, etc) as well as industrial processes. This would ease the overexploitation of groundwater.





III

AIR AND NOISE POLLUTION

AIR AND NOISE POLLUTION

1. Introduction

1.1 State of the Air

Outdoor air pollution is one of the leading causes of health impacts globally. Along with the impacts on human health, agriculture and buildings, ambient air pollution has an adverse impact on the economy. The deterioration of air quality, particularly in the urban areas, is a matter of serious concern in India. Both natural and anthropogenic activities release several air pollutants in the atmosphere. Major anthropogenic sources such as industries, power plants, vehicular traffic, road dust, construction activities, diesel generator (DG) sets, domestic cooking and lighting related activities, pollen, and so on significantly contribute to air pollution. Other than the sources present within the cities, there are various sectors such as biomass burning, use of fertilizers, brick kilns which contribute to pollution in cities from outside. The main pollutants include particulate matter (PM) of different size ranges (PM_{10} , $PM_{2.5}$, etc.), sulphur dioxide (SO_2), oxides of nitrogen (NO_x), carbon monoxide (CO), hydrocarbons (HCs), volatile organic compounds (VOCs), methane (CH_4), benzene (C_6H_6), and so on. All these pollutants are released as primary pollutants from various sources but atmospheric and meteorological processes may transform them to secondary pollutants, such as ozone (O_3), which is generated as a result of photochemical reactions in the lower atmosphere.

In order to tackle the problem of air pollution at national scale, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, has recently launched the national clean air framework i.e., National Clean Air Program (NCAP), in which 131 non-attainment cities have been identified, which have not met the annual average national ambient air quality standard for particulate matter in the last five years. Under NCAP, it has been envisaged to formulate clean air action plans for all identified non-attainment cities, with a goal to meet the prescribed annual average ambient air quality standards at all locations in the country and with an interim national level target of 20-30% reduction of $PM_{2.5}$ and PM_{10} concentration by 2024.

Chandigarh is one of those non-attainment cities and is located in the heart of Indo-Gangetic Plains, which is a hotspot of air pollution due to biomass burning in rural areas, crop residue burning in agricultural fields and due to other industrial activities. The geographical location and meteorological parameters such as temperature, solar radiation, wind speed, atmospheric pressure, etc, also plays a significant role in the building of air pollution in the region.

In this chapter, we analyse the status of quality of air in Chandigarh. The section on drivers and pressures discusses the possible major sources of air pollution in Chandigarh such as vehicular emissions, road dust, pollens, and emissions from industries. Wherever possible, it has been attempted to quantify the



intensity at which these activities are operating in Chandigarh. The annual trends of concentrations of major air pollutants – particulate matter, oxides of sulphur, and nitrogen have been reported to describe the status of air quality in the UT. Initiatives by the state and central government to address the issue of rising levels of air pollution are also examined. Finally, a set of recommendations to the state government in order to improve the air quality of the state have been suggested.

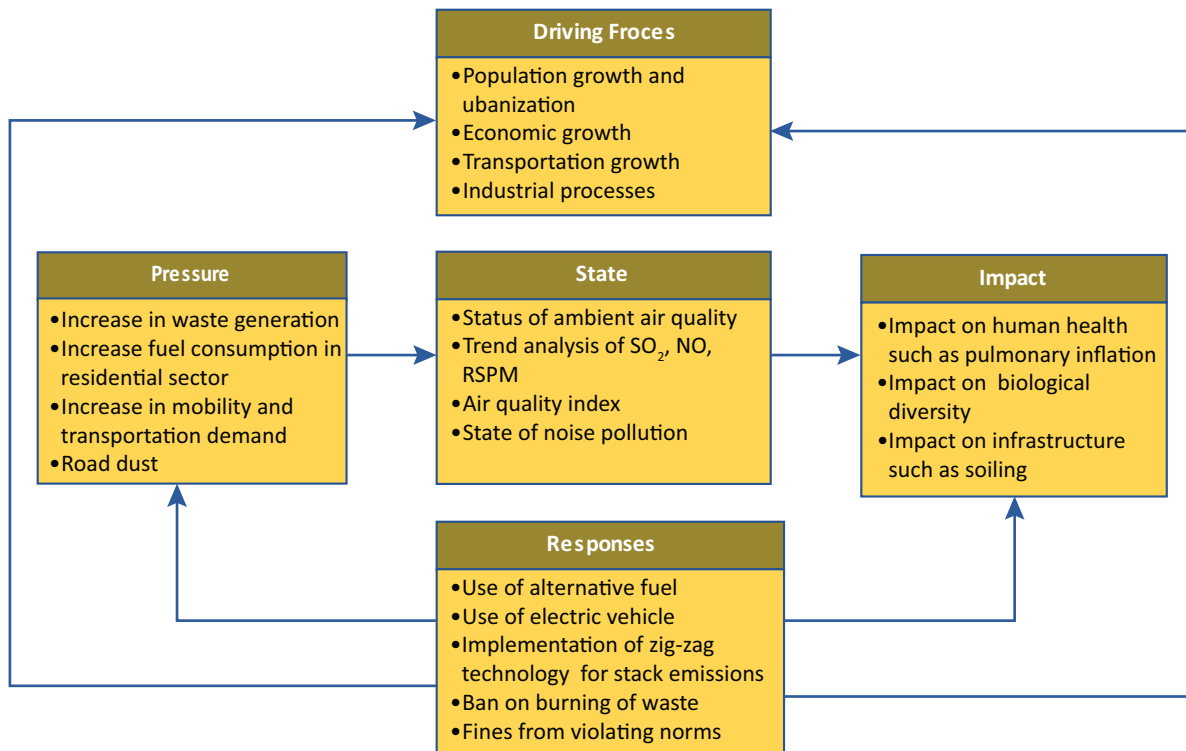


Figure 18: Diagram illustrating each component of DPSIR Framework

2. Drivers and Pressures

The pressure on air quality is due to the emissions of pollutants, such as particulate matter, oxides of nitrogen (NO_x), sulphur dioxide (SO₂) in the air. The following points discuss various activities responsible for emissions of pollutants affecting the air quality of Chandigarh.

- **Population growth and Urbanization:** The Master plan prepared by Le Corbusier for Chandigarh was planned for a finite population of five lakh. However, during the last six decades (1951-2011), Chandigarh has witnessed a manifold population increase, crossing ten lakhs mark as per the 2011 census (Figure 19). The city population has been estimated to be 13, 60, 000 by 2036, showing an increase of ~29% (from 2011 census population). Yet, Chandigarh shall continue to record higher densities with further population growth as projected, which is the estimated holding capacity of the city, and this poses a challenge for maintaining the quality of life and providing essential services even to its poorest residents, as envisioned by the city's planners (Chandigarh Master Plan – 2031).



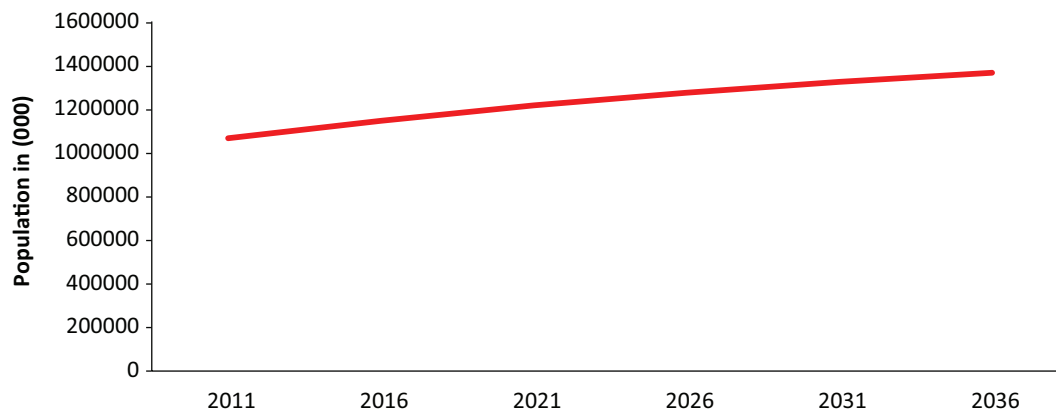


Figure 19: Proposed Population Projection

Source: Census of India. November, 2019. Population Projections for India and States 2011- 2036. National Commission on Population, Ministry of Health and Family Welfare

This is supported by a high birth rate, especially in the previous years of 11.15 in 2018, 11.38 in 2019 and 10.75 in 2020 (as per data provided by UT Departments). The rate of urbanization of the UT has also been increasing over the past decades, with 97.30% being urban population (2011 census), which will now be 100%, considering the complete urban transformation of the city. Growing population and increasing urbanization are directly linked with fuel consumed in the residential sector. Households in urban slums and rural areas surrounding cities still depend on biomass for cooking. Waste generation (which is sometimes burnt later) is another activity driven by population and urbanization levels.

- Economic Growth:** Chandigarh is characterized as a regional hub in the areas of service industry, education, health, information technology, food and vegetable processing etc. Over the past few years, Chandigarh has made efforts for ensuring sustainable growth, by augmenting better fiscal consolidation and economic development. Chandigarh's Net State Domestic Product (NSDP) for the financial year 2020-21 being INR 35, 216 crores, showing an annual growth of 18.7%. This translated to a per capita NSDP for FY 2020-21 being INR 2.92 lakh (Economic Survey, 2023). Population along with economic growth in Chandigarh has also led to increase in mobility and transportation demands, paving way for increased air pollution.
- Transportation Growth:** Chandigarh has shown phenomenal growth in certain sectors in the last two decades. With this, the mobility demands have also grown many folds. The numbers of personalized vehicles in Chandigarh have increased tremendously during the last few years. The data of motor vehicle registrations in Chandigarh city was collected from the Registration and Licensing Authority of Chandigarh (RLA), and it shows a steep increase in the vehicular population. Figure 20 show the growth of vehicle number in Chandigarh. The city had 1, 256, 081 numbers of registered vehicles till the year 2020, which increased many folds from the year 1967 when it had only 940 vehicles. The increasing trend of air pollution in the city can be linked with a substantial increase in vehicle numbers



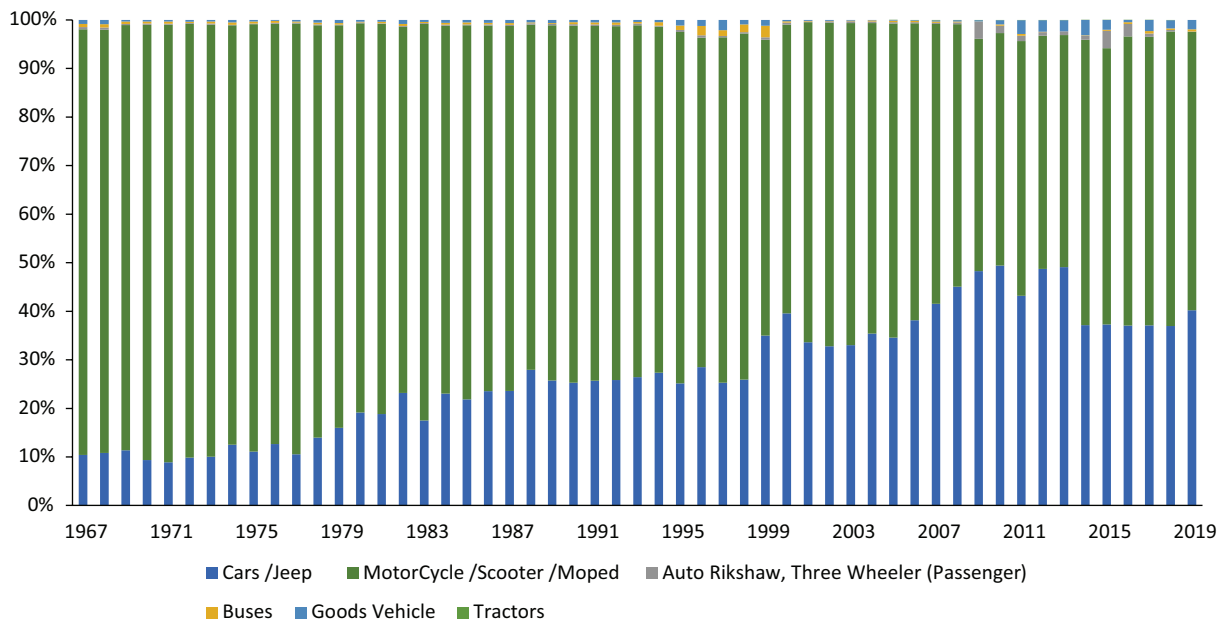


Figure 20: Percentage composition of the number of registered vehicles in Chandigarh from 1967-2019

Source: Registration and Licensing Authority of Chandigarh (RLA)

- The number of all types of vehicles in Chandigarh has increased from 602, 735 (in the year 2005) which includes 162, 263 Cars/Jeep, 431, 063 Motorcycle/Scooter/Moped Auto Rikshaw, 1178 Three-Wheeler (Passenger), 3871 Buses, 3744 Goods Transport Vehicle, 6 Tractors to 1, 256, 081 (in the year 2020) where the different vehicle number reaches to 594, 248, 627, 285, 6, 857, 1, 855, 24, 875 and 806 respectively. Figure 20 indicates high ownership of cars and two wheelers in the city. Chandigarh has highest per capita number of cars in India. The current status of road transport in the city reveals that Chandigarh's Road network is under intense pressure due to increase in population, explosive growth in the number of personalised vehicles, partly due to the absence of an efficient and reliable public transport system.
- Moreover, the city is connected to the major cities in Punjab, Haryana and Himachal Pradesh by road and is linked with the national capital by NH-5 which goes through the city. There is now a lot of intercity vehicular traffic from the neighbouring states which have strong daily interaction with the city and correspondingly, increase the pollutant concentration. The amount of pollutants emitted from the vehicles also depends on the technology, emission control devices, and the quality of fuel available. India has been progressively tightening the emission control standards both for the vehicle technology and the fuel quality. The fuel quality in Chandigarh currently complies with Bharat Stage VI. Since April 2020, India, including Chandigarh, has moved to Bharat Stage VI norms.
- **Road Dust:** Road dust describes those solid particles made by any mechanical processing of materials. Due to the vehicular movement dust becomes airborne by the friction on dust covered paved roads, most of the non-inhalable fraction of road dust are further disintegrated into finer fraction. Huge traffic congestion tends to re-suspend the dust onto the roads and air. Thus, road dust plays a prominent role in deteriorating ambient air quality. The pollution from road dust can



be controlled with re-carpeting of roads in accordance with the measures as per the governmental norms, maintenance of potholes free roads for free-flow of traffic, water sprinklers, mechanical sweeping of roads, creation of green buffers along the road sides, water fountains at major traffic intersections etc.

- Industrial process:** The industrial sector is one of the most dynamic sectors of the economy and plays an essential role in economic development. Manufacturing of products in industries requires energy which is often met through burning of fossil fuels, such as coal, diesel, and natural gas. These burning activities often lead to emissions of criteria pollutants—PM, NO_x, SO₂, from the exhaust. The amount of pollutants released also depends upon the quality of the fuel used and the process used for burning the fuel. More particulate matter is expected to be released from the processes if the ash content in the fuel is high; on the other hand, NO_x content is higher if the fuel is combusted at a higher temperature.

The Central Pollution Control Board (CPCB) has directed the highly polluting industries to use emission control devices. State Pollution Control Board has categorized industries into four categories namely Red, Orange, Green, and White keeping in view their pollution potential. The red category industries require environmental clearance from competent state authorities. Many of these industries use coal or diesel as fuel. Together these contribute to suspended particulates, oxides of nitrogen, and sulphur, organic compounds and other pollutants in the air. However, not all red category industries requires environmental clearance, industries having a pollution index score as 60 would require clearance from competent authorities. Figure 21 shows the distribution of industries under white, green, orange, and red categories. As per data provided by CPCC, Chandigarh has very few air polluting units. Major industrial units in Chandigarh are mainly ancillary in nature and include small scale foundries, manufacturing of sanitary fittings, paper products, printing, industrial fasteners (nuts, bolts and screws), repairing and servicing of cars etc.

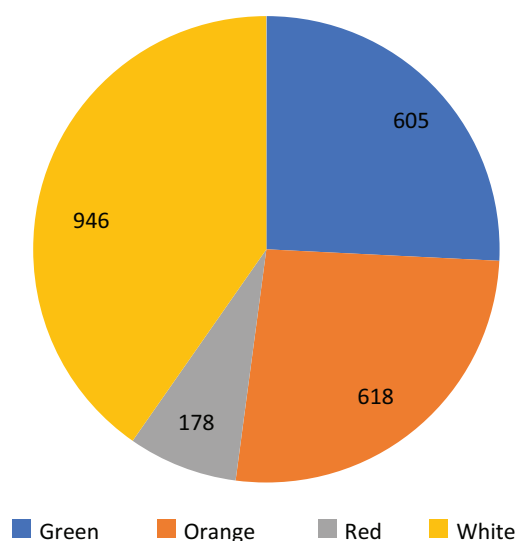


Figure 21: Categories of Industries in UT

Source: CPCC

To ensure a pollution free environment in the industrial area only non-polluting industries are permitted and the area is segregated from the rest of the city by a green belt of mango trees.



Moreover, Chandigarh's industrial area is located on the south - eastern side of the city, in the leeward wind direction to minimize air pollution within the city. Thus, most of the city's industrial contribution to deterioration of air quality can be attributed to the industries located in the Mohali and Panchkula industrial area, which is located outside the political boundary of Chandigarh. Apart from existing industrial units, there is no scope for expanding of new industry because of the limited land proposed during the original planning of city. However, several brick kilns are present at the border of Chandigarh in Punjab state.

- **Airborne pollen:** The Trees outside Forest (ToF) in Chandigarh is high, and the role of pollens cannot be neglected. Pollen is the most abundant primary biological airborne particles (PBAPs) among different atmospheric bio-aerosols. These bio-aerosols are considered as the most common outdoor allergen responsible for exacerbating respiratory illnesses, majorly asthma and chronic obstructive pulmonary diseases. The airborne pollen release and dispersal is influenced by weather conditions, i.e., temperature, precipitation, relative humidity, wind speed and direction, etc. As the air pollution is increasing, the pollen (biological particles) and air pollutants (non-biological particles and gases, for example, particulate matter (PM), ozone (O₃), nitrogen oxide (NO₂), etc.) co-exist in nature with more potential to interact with one another and exacerbate their adverse effects on human health (Khailwal et al., 2021). Pollen's contribution to air pollution may not be significant, but it can cause respiratory illnesses. According to Integrated Disease Surveillance Programme (IDSP) report, in 2020, 107, 149 cases of Acute Respiratory Infections (ARI) (As per P-Form of IDSP) and 2996 cases of Pneumonia (As per P-Form) were found in Chandigarh. Hence, it is crucial to plan air pollution mitigation policies to minimize public health and climate risks.
- **Burning of Garbage, Agriculture & other Biomass:** Chandigarh administration has banned garbage burning practices but a few miscreants find burning effortless as compared to making compost from the same. Chandigarh city shares its borders with Punjab from the north, west as well as south. While its boundary touches Haryana in the east. The city is surrounded by rural regions of both the states where agricultural activities are carried out. Open (in-situ) burning of agricultural crop residue (paddy stubble burning) is practiced there for quick preparation of the land for the next crop, which leads to emissions of pollutants. Other than this, agricultural activities such as tilling for soil cultivation and crop harvesting also contribute to generation of dust. Exposure to these pollutants is linked to an increase in respiratory diseases. Besides leading to loss of soil fertility, it causes severe air pollution especially during the months of March-April and October-November. The smoke also impairs visibility which can cause road accidents. Though LPG is the main source of domestic fuel in urban areas of the city, however, cow dung cakes and wood are still used in rural areas and slums.
- **Diesel generator sets:** DG sets are one of the major sources of air pollution as well as noise pollution. These emit oxides of nitrogen, carbon monoxide and particulate matter. These emissions are directly released into the atmosphere and tend to substantially reduce the quality of air. Standards have been laid by the government in terms of noise levels, emission levels and other guidelines for manufacturers and buyers. Unlike the engines of vehicles, the norms for control of emissions from DG sets are not stringent and as a result, DG sets end up releasing more pollutants, such as PM, NO_x and SO₂. As per the data provided by the Chandigarh Pollution Control Committee (CPCC), there are 1368 units of DG sets running in Chandigarh in 2021. The enforcement wing of the Chandigarh administration has started a drive to seal DG sets which are running without adhering to pollution norms and polluting the environment.



3. State of Air Quality

Continuous monitoring of the air pollutant becomes a very important task to substantiate the effectiveness of the control measures and for the detection of atmospheric pollutant concentrations in the ambient air. Ambient air monitoring is an integral part of an effective air quality management system as it helps in assessing the extent of pollution. It helps in providing air pollution data to the general public in a timely manner. The main objective of air quality monitoring is to assess air quality concentration and to capture the level of pollutant load in the ambient environment.

- National Ambient Air Quality Monitoring (NAAQM) programme:** The basis of the present ambient monitoring programme in India was established by National Environmental Engineering Research Institute (NEERI) in 1967 which was later launched as National Ambient Air Quality Monitoring (NAAQM) programme by CPCB in 1984-85. The primary aim of NAAQM was to establish the status of ambient air quality across the country and formulate ways to manage and reduce concentrations of selected air pollutants to within permissible limits. The programme started with just seven monitoring stations in Agra and Anpara in Uttar Pradesh. Subsequently the programme was renamed as National Air Quality Monitoring Programme (NAMP). The current NAMP network is operating through 804 monitoring stations in 344 cities/towns in 28 states and 6 Union Territories. Initially NAMP had its focus on four air pollutants viz., Sulphur Dioxide (SO_2), Oxides of Nitrogen as NO_2 and Respirable Suspended Particulate Matter or Particulate Matter of less than 10μ size (commonly called PM_{10} or RSPM). Other pollutant parameters included Carbon Monoxide (CO), Ammonia (NH_3), Respirable Lead, Hydrogen Sulphide (H_2S) and Polycyclic Aromatic Compounds (PAHs) which were monitored at selected stations across the country. Meteorological parameters such as wind speed and wind direction, relative humidity (RH) and temperature were also monitored along with air quality parameters. In 2009, a revision of National Air Quality Standards of India was published by MoEF&CC with the aim of redefining NAMP as a health centred initiative (CPCB Revised National Ambient Air Quality Standards, 2009). The revised standards, presented in Table 18, merged industrial, residential and rural areas with a uniform air quality standard as opposed to lower permissible limit for industrial locations in the previous version. This change was accompanied by addition of a second category of location which was designated as ecologically sensitive areas. Additionally, other pollution parameters such as $\text{PM}_{2.5}$, Ozone, Ammonia (NH_3), Benzene, Benzo (a) pyrene (BaP), Arsenic (As) and Nickel (Ni) were



Figure 22: Inauguration of continuous ambient air quality monitoring station in Chandigarh

Source: CPCB



added to the existing list considering toxic nature of these pollutants. In the same year 2009, CPCB launched a real time monitoring network under NAMP which could generate continuous data, but at limited monitoring stations in selected cities. The stations are equipped with relevant continuous monitoring instruments for measuring concentrations of SO₂, NO-NO₂-NO_x, NH₃, CO, O₃, BTX, PM₁₀, PM_{2.5}, THC and meteorological parameters. The data from these stations is available to the public on the CPCB web portal.

- **Status of ambient air quality in Chandigarh:** There are three real time ambient air quality monitoring stations installed by Chandigarh Pollution Control Committee at sector 25, 22 and 53 to monitor the ambient air pollutants in the city (Figure 22). Additionally, there are five manual monitoring stations installed in different locations of the city. An Air Quality Monitoring Committee (AQMC) has been constituted in Chandigarh to monitor the air quality management under National Clean Air Programme. Details of the monitoring location are presented in Table 18. The monitors measure all the criteria pollutants e.g., NO₂, SO₂, PM₁₀ and PM_{2.5} along with other meteorological parameters.

Table 18: Monitoring stations under NAMP Programme in Chandigarh

Station Name	Station Type
Sector 17+	Commercial
Industrial Area	Industrial
Punjab Engineering College	Institutional
Kaimbwala village	Rural
IMTECH	Residential

*Three continuous monitoring stations are at Sector -22, 25 and 53 in Chandigarh

Source: Chandigarh Pollution Control Committee (CPCC)



Figure 23: Locations of monitoring stations in Chandigarh

Source: CPCC



As per the CPCB guidelines, at least 104 monitoring readings spread across the year must be recorded. The Chandigarh Pollution Control Committee claims to take at least two readings every week and meet the guideline

- Trend Analysis:** Based on air quality monitoring data generated from air quality monitoring stations under NAMP, the trends in annual average concentration of Sulphur Dioxide (SO₂), Nitrogen Dioxide (NO₂) and Respirable Suspended Particulate Matter (RSPM) in Chandigarh have been derived and presented below:

SO₂ concentration trends: Atmospheric Sulphur is primarily in the form of SO₂. The atmosphere of the city is very clear as far as the concentration of SO₂ is concerned. Although, the single largest pollutant of sulphur are the coal fired power stations. Coal based industries, in particular, emit maximum sulphur content in the air. Exploitation of coal, oil and gas for electricity power generation is other factors contributing to increased level of sulphur in the atmosphere. In addition to severe health hazards like bronchitis and other respiratory ailments, sulphur dioxide acts as a precursor to smog formation and accelerates the process of acid rain. Fortunately, industries in Chandigarh are primarily small-scale industries because of which the emissions of SO₂ are well within limits. The annual limit for sulphur dioxide is 50µg/m³. The graph shows that sulphur content has thus attained a below detection limit since the year 2011 (Figure 24).

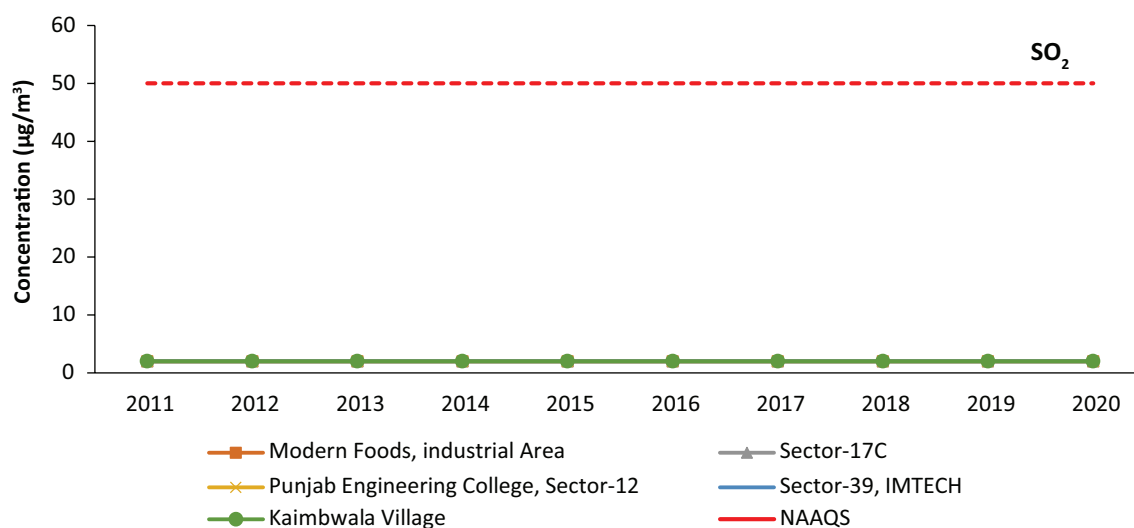


Figure 24: Trend in annual average SO₂ levels in Chandigarh during 2011-20

Source: CPCC

NO₂ concentration trends: With increase in vehicular traffic, concentration of NO₂ has been fluctuating over the years. According to National Ambient Air Quality Standards, the permissible value of NO₂ is set to a standard of 40µg/m³. The graph depicts that the concentration of NO₂ from 2011 to 2020 has remained within the permissible limit. The maximum concentration was observed at the monitoring station located at Industrial area Phase-1, due to excessive vehicular emissions (Figure 25).



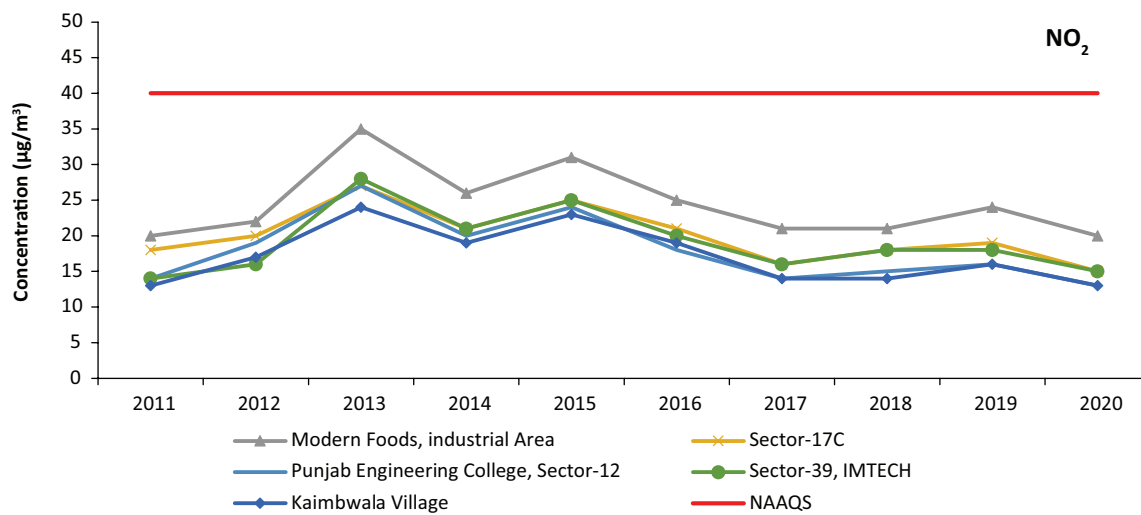


Figure 25: Trend in annual average NO₂ levels in Chandigarh during 2011-20

Source: CPCC

PM₁₀ and PM_{2.5} concentration trends: Particulate matter is the sum of all solid and liquid particles suspended in air many of which are hazardous. This complex mixture includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets. These particles vary greatly in size, composition, and origin. Particles in air are either directly emitted, for instance when fuel is burnt and when dust is carried by wind, or indirectly formed, when gaseous pollutants previously emitted to air turn into particulate matter. Based on size, particulate matter is often divided into two main groups –The coarse fraction contains the larger particles with a size ranging from 2.5 to 10 µm (PM₁₀ - PM_{2.5}). The fine fraction contains the smaller ones with a size up to 2.5 µm (PM_{2.5}). The particles in the fine fraction which are smaller than 0.1 µm are called ultrafine particles. They have a tendency to get embedded deep into the lungs and cause a broad range of respiratory illness. The annual limit for PM₁₀ is 60µg/m³ and for PM_{2.5} is 40µg/m³. Figure 26 and 27 shows the changing trend of PM₁₀ and PM_{2.5} levels in the city over the years. Observations reveal that the levels of PM₁₀ and PM_{2.5} have been constantly exceeding the permissible limits since 2011.

Highest annual average PM₁₀ and PM_{2.5} concentrations were observed at Modern Foods, Industrial Area of Chandigarh, whereas, the lowest concentrations were observed at Punjab Engineering College, Sec-11, Chandigarh. However, irrespective of monitoring locations, the annual average PM₁₀ and PM_{2.5} concentration showed a declining trend from 2017 onwards (Figure 26 and Figure 27).



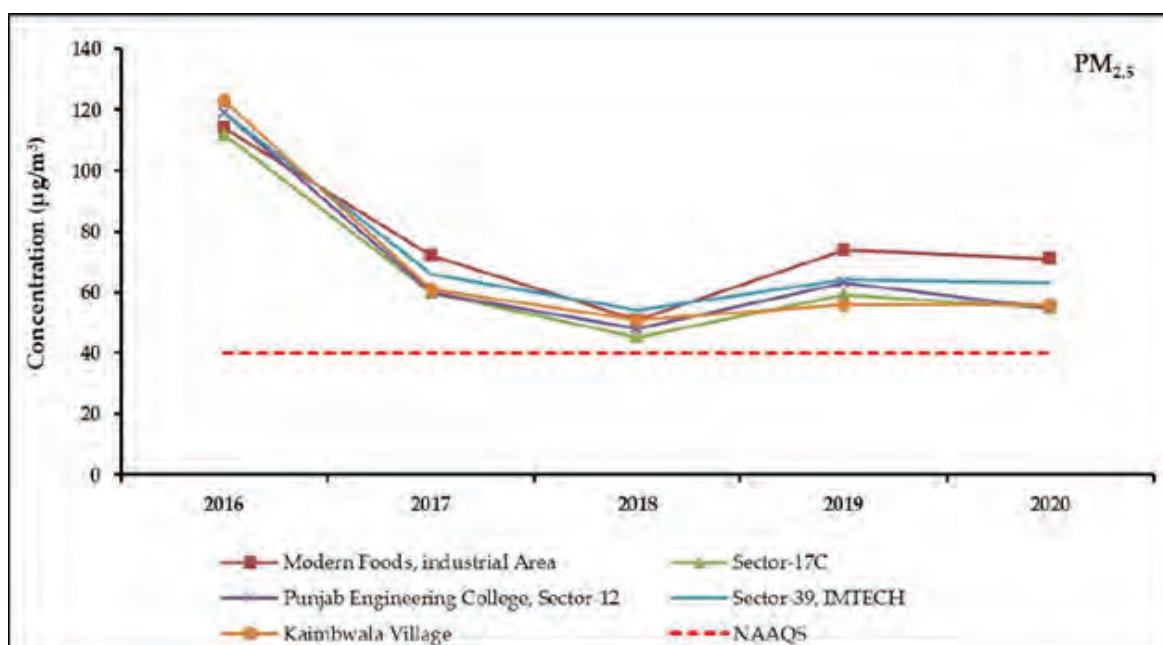


Figure 26: Trend in annual average PM_{2.5} levels in Chandigarh during 2016-20

Source: CPCC

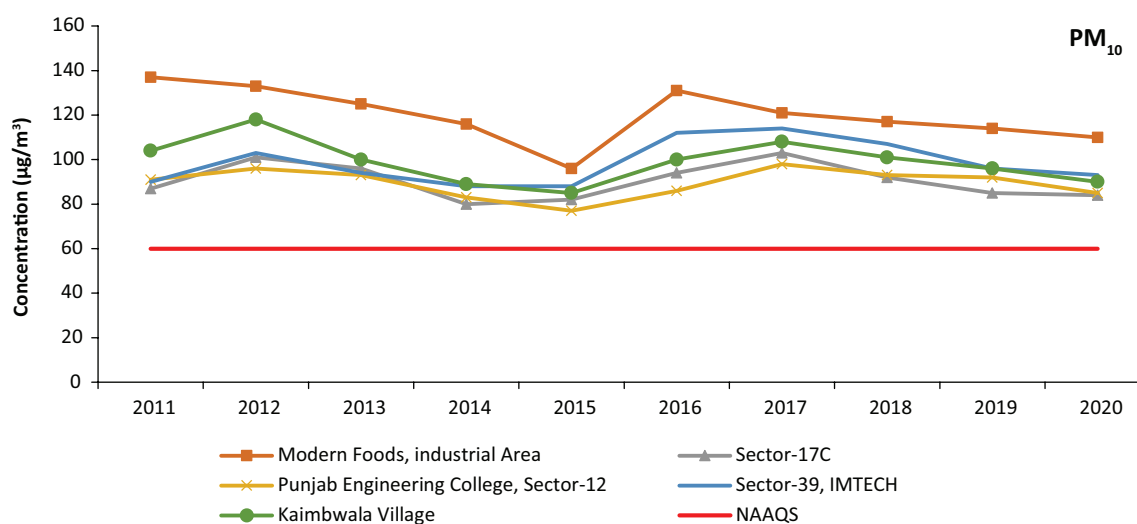


Figure 27: Trend in annual average PM_{2.5} and PM₁₀ levels in Chandigarh during 2016-20

Source: CPCC

Being surrounded by the agricultural hubs (Haryana, Punjab), the city is recipient to PM₁₀ in bulk from various activities like stubble burning and wheat harvesting. The PM₁₀ levels peak were observed in the months from April to June (stubble burning in outskirts) and from October to November (winters catalyse the PM concentration owing to its low temperature) (Figure 28). It is evident that PM₁₀ concentrations are much higher during winters due to meteorological adversity-low wind speeds and shallow mixing heights when compared to the summer season. Such meteorological conditions are unfavourable to the dispersion of air pollutants especially vertically, resulting in high concentrations of pollutants near the



surface in winter months. Additionally, natural processes like pollen dispersal and propagation of seeds by air accounts for major proportion of PM levels for any city.

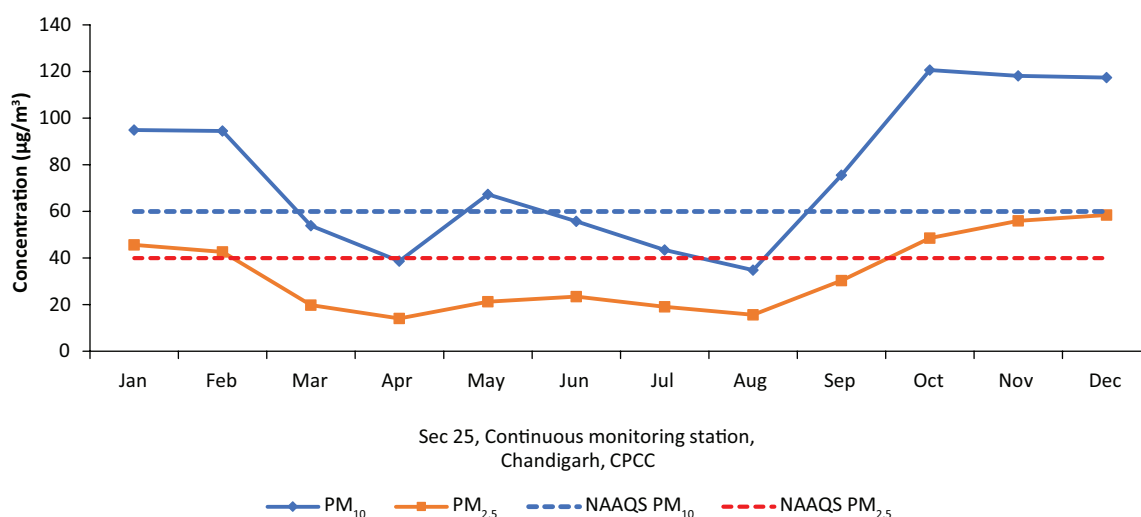


Figure 28: Month wise variation in RSPM Concentrations over Chandigarh during 2020

Source: CPCPC

Dotted red line represents annual average PM₁₀ standard and dotted blue line represents annual PM_{2.5}

Air quality of Chandigarh During Diwali: The status of air quality during Diwali period is determined by multiple factors viz., additional local emissions from fire crackers, transport of stubble burning emissions (for Chandigarh), local weather as well as large scale circulations, etc. Air quality is expected to deteriorate on the following days of Diwali due to emissions from fire crackers the previous night. Concentration of particulate matter (PM_{2.5} and PM₁₀) depends on the magnitude of emissions on the night of Diwali and the static stability of the boundary layer, mixing layer height and surface wind speed on the following day. Weather plays an important role in controlling air quality through wet scavenging (rainfall) or dispersion (due to high winds) or convection (due to high solar radiation) causing year to year variability during the Diwali period. Figure 29, 30, and 31 illustrate the variation of PM₁₀, PM_{2.5}, and NO_x in Chandigarh during the Diwali period (5 days before and 5 days after Diwali) for the years 2019, 2020, and 2021. The PM₁₀ and PM_{2.5} concentration in Chandigarh during the Diwali period of 2021 was lower as compared to the years 2019 and 2020 due to aggressive campaigning by the administration for Green Diwali in the city. In the year 2020 Chandigarh witnessed rainfall during the Diwali period and hence the concentration levels remained low (Figure 29 and 30). The concentration in the year 2019 was observed higher than the year 2020 and 2021. However, the PM₁₀ and PM_{2.5} concentrations in all the years i.e. 2019, 2020 and 2021 were above the NAAQS five days pre and post Diwali day. As opposed to the previous years the PM concentration did not peak this year. The hourly concentration of PM however was observed to increase from 10 pm in the night of the Diwali day and it peaked at 12 am (110 µg/m³) and then further decreased. The air quality index (AQI) on Diwali day and post Diwali day remained in the moderate category. This observed decreasing trend of pollutant concentrations (PM₁₀, PM_{2.5} and NO_x) on Diwali over the years can be attributed to aggressive campaigning by the administration for Green Diwali, increasing awareness is done amongst people through FM radio, newspaper advertisements, newsletters by eco-clubs and schools organized by Environment Department, Chandigarh.



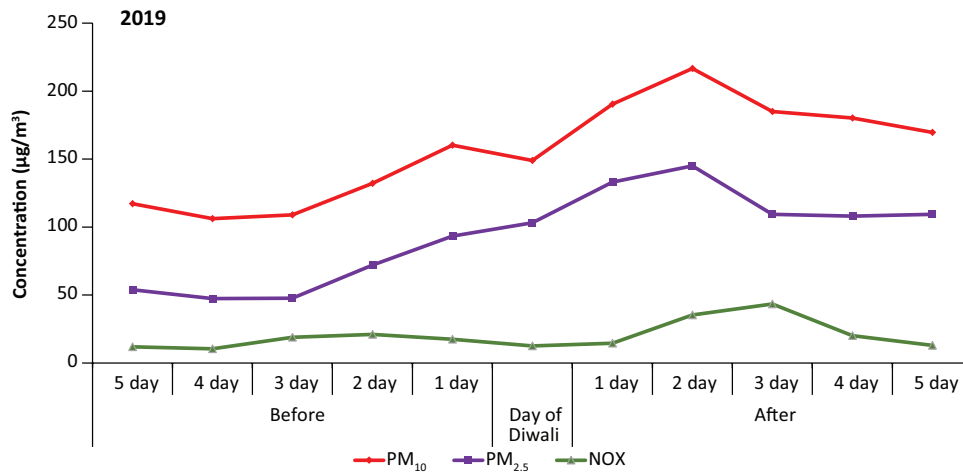


Figure 29: Levels of PM₁₀, PM_{2.5} and NO_x on Diwali during 2019

Source: CPCC

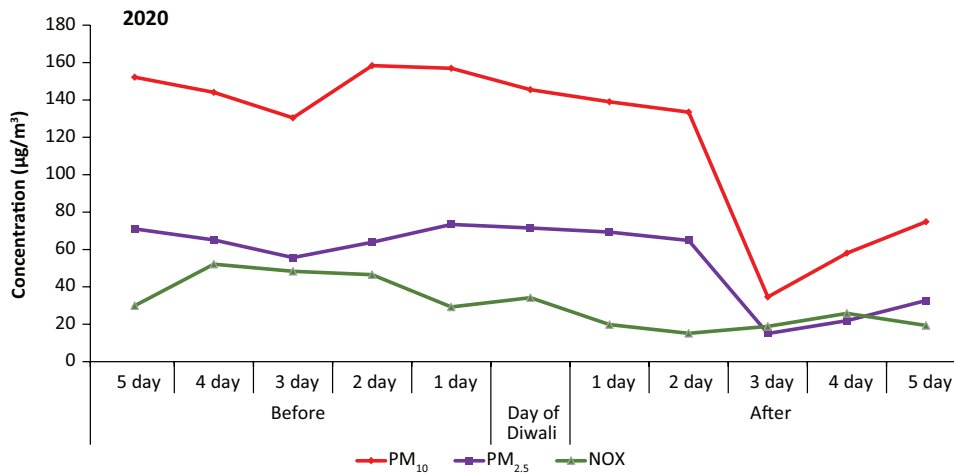


Figure 30: Levels of PM₁₀, PM_{2.5} and NO_x on Diwali during 2020

Source: CPCC

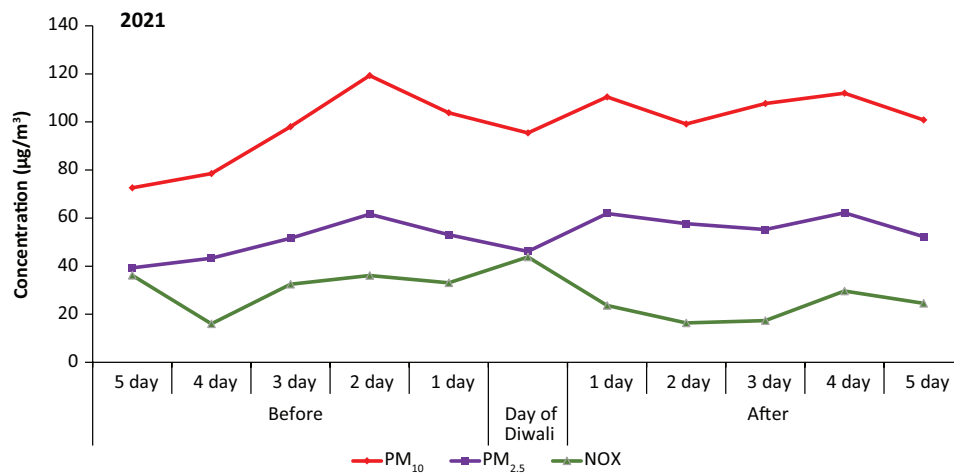


Figure 31: Levels of PM₁₀, PM_{2.5} and NO_x on Diwali during 2021

Source: CPCC



- Air Quality Index (AQI):** NAMP was started to safeguard public health through increased understanding of changing patterns of air quality status in specific geographical locations. The data is often used by researchers to establish sources of air pollution through modeling exercises. This process starting from data generation to useful interpretations help researchers to communicate to the policy makers about the possible measures to be undertaken to curb air pollution at source. However, it was also realized that the data should be disseminated in a format that can easily be understood by the public. In this way people can protect themselves from any immediate impacts which elevated levels of any air pollutant may have on their health. Accordingly, CPCB and MoEF launched 'The National Air Quality Index' (NAQI) web portal which disseminates information on local air quality in the form of a single number which is result of amalgamation of a group of pollutants which is then assigned to a descriptive category.

As stated by Central Pollution Control Board (CPCB 2015), the AQI (i) assists administrators in allocating funds and determining priorities to manage air quality in cost effective manner; (ii) enable comparison of air quality conditions at different locations, which helps in pointing out areas and frequencies of potential hazards; (iii) assists in identifying faulty standards and inadequate monitoring programs; (iv) is useful for performing trend analysis to compare the air quality in the historical, current, and futuristic senses and (v) helps in translating the complex scientific and medical information into simple but reliable knowledge, which is easily understood by the general public. The overall calculation of NAQI on the basis of concentration of eight pollutants is shown in Table 19 and out of these eight pollutants one of PM₁₀ or PM_{2.5} parameter is mandatory. An AQI is calculated only for locations where continuous monitoring is carried out in the country, as the frequency of monitoring in manual stations is only twice a week, and moreover they mostly monitor only three pollutants i.e. SO₂, NO₂ and PM₁₀.

Table 19: Breakpoints for AQI Scale 0-500 (units: $\mu\text{g m}^{-3}$ unless mentioned)

AQI Category (Range)	PM ₁₀ 24-Hr	PM _{2.5} 24-Hr	NO ₂ 24-Hr	O ₃ 24-Hr	CO ₂ 4-Hr (mg m ⁻³)	SO ₂ 24-Hr	NH ₃ 24-Hr	Pb 24-Hr
Good(0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6-1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1-10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very Poor (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	430+	250+	400+	748+*	34+	1600+	1800+	3.5+

*Hourly monitoring, Source: CPCB, 2015



- Status of AQI, Chandigarh:** As per CPCB bulletin on status of category-wise numbers of AQI in Chandigarh during 2020 and 2021, out of 365 AQI numbers reported in 2020, 121 were in Good category, 149 were in Satisfactory category, 92 were in Moderate category and remaining 3 were in Poor category (Table 20). In 2021, out of 365 AQI numbers reported in 2021, 81 were in Good category, 128 were in satisfactory category, 151 were in Moderate category and remaining 5 were in Poor category. The analysis of AQI values in Chandigarh during both the years indicates that 24% (average for both years) AQI value are falling in Good category, 39% are in Satisfactory category, 35% are in Moderate category and 1% are in Poor category indicating minor breathing discomfort to sensitive people.

Table 20: Status of AQI, Chandigarh

AQI Category (Range)	2020	2021
Good (0-50)	121	81
Satisfactory (51-100)	149	128
Moderate (101-200)	92	151
Poor (201-300)	3	5
Very Poor (301-400)	0	0
Severe (401-500)	0	0
Total no. of Days	365	365

Source: CPCB, 2021, Prominent parameter- $PM_{2.5}$

- Number of monitoring locations:** Population plays an important role in the air quality of any region. Increase in the population will have a direct impact on increased air pollution as the emissions of the region will be increased. Conversely, high population density in a bad air quality region implies exposure of higher number of people to air pollution. Thus, the appropriate number of air quality monitoring stations in any region must be a function of population. Table 21 shows the prescribed number of air quality monitoring locations according to population for various pollutants. The population of Chandigarh is approximately 12, 02, 000 in 2020. Thus, by using the guidelines as prescribed by Bureau Indian Standards (BIS), there must be at least eight (8) air quality monitoring stations all across the UT.



Table 21: Prescribed number of air quality monitoring stations according to population of the region

Pollutant	Population of Evaluation Area	Minimum no. of AAQ Monitoring Stations
SPM	<1, 00, 000	4
	1, 00, 000–10, 00, 000	4+0.6 per 1, 00, 000 population
	10, 00, 000–50, 00, 000	7.5 + 0.25 per 1, 00, 000 population
	>50, 00, 000	12 + 0.16 per 1, 00, 000 population
SO ₂	<1, 00, 000	3
	1, 00, 000–10, 00, 000	2.5+0.5 per 1, 00, 000 population
	10, 00, 000–1, 00, 00, 000	6+0.15 per 1, 00, 000 population
	>1, 00, 00, 000	20
NO ₂	<1, 00, 000	4
	1, 00, 000–10, 00, 000	4+0.6 per 1, 00, 000 population
	>10, 00, 000	10
CO	<1, 00, 000	1
	1, 00, 000–50, 00, 000	1+0.15 per 1, 00, 000 population
	>50, 00, 000	6+0.05 per 1, 00, 000 population

Source: Bureau Indian Standards 2000

4. Impact

Release of air pollutants into the atmosphere can have negative impacts both for the local and global environment; human health; buildings; and agricultural production. Exposure to pollutants, such as PM, NO_x, and SO₂ is known for their long-lasting effect on human health. Particulate matter has contributed significantly to the decline in health, mainly in the elderly and children. Major constituents of particulate matter i.e., elemental carbon (EC) and organic carbon (OC) are primarily responsible for harmful health effects (Hamilton & Mansfield, 1991). According to Dey et al. (2012), rapid increase in high aerosol loading over the last decade is a grave concern considering its impending impacts on health. The HEI (2019) assessed the impact of PM_{2.5} concentrations in India and concluded that around 1.1 million deaths in 2015 were a result of being exposed to air pollution. Certain toxicological studies reveal that NO₂ exposures can potentially lead to pulmonary inflammation and decreased respiratory defence mechanism. NO₂ can also be co-related with reduced lung function and worsening symptoms among asthma patients (Han, Ji, Li, & Sang, 2017)

Black carbon, a fine particulate matter, is usually emitted from combustion activities, such as biomass burning, vehicular emissions, and so on. As a short-lived climate pollutant, black carbon can absorb infrared radiation and contribute to global warming although its life is much shorter in comparison to other greenhouse gases, such as methane and carbon dioxide. Effects of presence aerosols in the environment are also linked with change in the monsoon patterns over the Indian subcontinent.



The ill-effects of air pollutant emissions could impact the biological diversity. Though it is evident that air pollution contributes to ground-level emissions, limited studies have been conducted to address the effects on our biodiversity. Acid rain, which is a result of air pollution, is caused by the oxidation and wet deposition of SO_2 and NO_x emissions in the atmosphere (Rao, Rajasekhar, & Rao, 2016). Therefore, acid rain can have harmful effects on our biodiversity. Ozone is another pollutant which is toxic to both plants and animals.

Ozone results in reduced photosynthesis and slower growth in plants. In animals and humans, ozone can affect the lung tissues causing respiratory conditions, such as asthma (Stevens, et al., 2020). The effect of ground-level ozone on the crop yield was studied by (Sharma, et al., 2019), where the researchers evaluated the pan India losses in crop yield and financial problems incurred during 2014–15 due to the ozone.

SO_x and NO_x emissions can harm the flora, fauna, material surfaces, and even damage buildings and structures. The negative effects may be in the form of health impacts discolouration, loss of material, structural failing, and soiling. This can reduce the service life of buildings and can severely damage historical monuments and structures. Some of the major sources and health impacts associated with various air pollutants are presented in Table 22.

Table 22: Sources and health impacts of various air pollutants

Pollutants	Sources	Effects
Nitrogen dioxide (NO_x)	Combustion processes (heating, power generation, and vehicles)	Bronchitis in asthmatic children. Reduced lung function growth
Particulate Matter ($\text{PM}_{2.5}$, PM_{10})	Major sources are vehicles, industrial sources, domestic fuel burning, road dust re-suspension, construction activities	Cardiovascular And respiratory diseases, lung cancer, acute lower respiratory infections, chronic obstructive pulmonary disease.
Carbon monoxide (CO)	Incomplete fuel combustion (as in motor vehicles)	Reduces the oxygen carrying capacity of blood, causes headaches, nausea, and dizziness. Can lead to death at high levels
Sulphur dioxide (SO_2)	Burning of sulfur-containing fossil fuels for domestic heating, power generation and motor vehicles.	Affects respiratory system and lung functioning. Coughing, mucus secretion, aggravation of asthma and chronic bronchitis. SO_2 with water forms sulfuric acid and causes acid rain.

Source: TERI, 2015.

About 20-30% of the population suffers from allergic rhinitis/hay fever in India, and approximately 15% develop asthma (Ministry of Science and Technology, 2021). Pollens are considered as major outdoor airborne allergens responsible for allergic rhinitis, asthma, and atopic dermatitis in humans. Increase in green spaces in Chandigarh lead to a rise in airborne pollen, consequently increasing pollen-related allergic ailments.

5. Response

Air pollution has now become a global concern, and considering this; several initiatives have been taken by the central government, also applicable in Chandigarh, which have a major effect on reduction of air



pollution in India. It must be noted that pollution in the city is not necessarily on account of emissions within its geographical boundaries. Transportation of air pollutants is a fairly common phenomenon. For instance, nearly 68% of PM_{2.5} pollution in Delhi can be attributed to activities outside the physical boundaries of the city (Sharma, Ojha, Pozzer, & Gunthe, 2019). Although no such study has been conducted for Chandigarh but reduction of air pollution in the surrounding areas is bound to have a positive impact on air quality of the city.

5.1 Major initiatives for emission control in India

In India, the central and state governments have taken several steps to control air pollution and improve the ambient air quality. Various initiatives, such as the use of compressed natural gas (CNG) as an alternative fuel, the odd-even measures implemented in Delhi, the introduction of Bharat Stage VI vehicle and fuel standards, the Pradhan Mantri Ujjwala Yojana (PMUY), and the National Clean Air Programme (NCAP) are some examples in this endeavour. The CPCB ensures the monitoring and regulation of the NAAQS in the cities, towns, and industrial areas with the cooperation of the respective state pollution control boards (SPCBs). Under these plans, various sector-wise measures have been implemented in the urban cities of India. For the transport sector, for instance, some of these measures include the use of electric vehicles (EVs) as a mode of public transportation, development of cycling infrastructure, use of bioethanol as fuel, and the construction of multi-level car parking facilities and peripherals to tackle congestion. Within the industrial sector, some of the measures undertaken comprise the implementation of zig-zag technology for the stack emissions from brick kilns, online monitoring of discharges through the Online Continuous Emission Monitoring Systems (OCEMS), and the installation of web cameras in highly polluting industries. To tackle the problem of open burning of garbage and household wastes, door-to-door collection of segregated wastes has been introduced and several compost pits have been established in urban cities. In the residential sector, the government has set a target of achieving 100% usage of LPG for cooking purposes. Further, to control the concentrations of particulate matter (PM) and dust particles, various steps, such as the green buffer around cities, maintenance of 33% green cover around urban areas, installation of water fountains across the cities have been taken over the years (Ramanathan, et al.).

5.2 Initiatives at the state or local level in Chandigarh

The entire Chandigarh was declared as an 'air pollution control area' under the Air (Prevention and Control of Pollution) Act, 1981, from 1 February 1988. After that Central Pollution Control Board (CPCB) has started monitoring the air quality in Chandigarh from the year 1989, and then in the year 1991, the Chandigarh Pollution Control Committee was set up. Currently, the ambient air quality monitoring is being operational at eight locations in Chandigarh (5 Manual + 3 Continuous monitoring stations). The degree of impact of policy implementation can be measured in terms of change in air pollution trends. Over the last 3 decades, various steps has been taken by the Chandigarh administration to improve air quality, such as a change in vehicular technology to reduce exhaust emissions, improvement in fuel quality, strict air quality standards, etc. The lead-free petrol was introduced in April 2000 in Chandigarh and India, which are equivalent to (Euro I) norms. Further, under the Motor Vehicles Act, 2000, Compulsory 'Pollution Under Control' (PUC) Certificates was made a mandatory and public offense. The various Bharat stage norms were implemented after that as notified by the Central Government of India. The LPG and CNG vehicles were introduced in the city during 2009 and 2016, respectively (AIP, 2015). Other steps to improve air quality included a ban on diesel autos, ban on smoking at a public place, ban on burning of leaves, and solid waste. A significant step to reduce air pollution includes diversion of buses to the outskirts of



cities, i.e., shifting of the interstate bus terminal and motor market. Further general awareness about air pollution was created among residents, schools, and colleges by eco clubs, seminars, workshops, etc. This also helped to promote bicycle routes, the use of E-rickshaw, and other eco-friendly options.

Moreover, the UT government comes up with an action plan which is to be implemented in near future for control of air pollution in the city. Among the short-term plans, to tackle vehicular pollution, the action plan talks of checking fuel adulteration and random monitoring of fuel quality data. The UT government launched various public awareness campaign for air pollution control, vehicle maintenance, minimal use of personal vehicles, lane discipline etc. Among long-term plans, Chandigarh government is working on the widening of roads and improvement of infrastructure for decongestion of roads. More than 200 kms of bicycle tracks and footpaths have been constructed (Figure 32) to segregate the non-motorised vehicles from the main traffic flow. The UT government is working on publicizing the use of E-Vehicle (Figure 32), 617 E-biking docking stations have been constructed & others are in pipeline (Figure 33). In addition, 80 electric buses are currently running as a public transportation in Chandigarh.



Figure 32: Promotion of E-vehicles in Chandigarh

Source: CPCC



Figure 33: Cycle rally to create public awareness on benefits of riding bicycle in the city

Source: CPCC



A significant step to reduce air pollution includes diversion of buses to the outskirts of cities, i.e., shifting of the interstate bus terminal and motor market. This also helped to promote bicycle routes, the use of E-rickshaw, and other eco-friendly options. Chandigarh Government is also working on procurement of mechanical street sweepers (Figure 34) and water sprinklers on both roads and roadside trees (Figure 35). Footpaths, market areas and road berms are also cleaned and washed with tertiary treated water at fixed intervals. CPCC has released 1.5 crores to Municipal Corporation Chandigarh (MCC) under National Clean Air Programme (NCAP) for the greening and paving activities in U.T. of Chandigarh. MCC has planted small shrubs/ plants along the road in many sectors with an aim to reduce air emissions generated out of vehicles pollution by acting as a barrier along the roads (Figure 36).



Figure 34: Mechanical Street sweeping on the roads in Chandigarh

Source: CPCC



Figure 35: Water sprinklers on both roads and roadside trees in Chandigarh

Source: CPCC



Chandigarh having processing facility of 160 MT of C&D wastes per day. Municipal Corporation Chandigarh has started C&D Waste Processing Facility in Industrial Area, Chandigarh (Figure 36). The plant produces material which can be utilized for cement concrete roads such as washed sand, crushed aggregate of 10 mm, 20 mm and 40 mm. In addition, the plant also manufactures road material i.e., PCC kerbs, PCC Channel, PCC Tiles, Paver Block etc (Figure 36). The plant reduces the in house cost of construction by approximately up to 10% and has the tipping charges and processing cost at relatively lower costs than other cities in India.



Figure 36: C&D Waste Processing Facility in Chandigarh

Source: CPCC

Further the government is working on general awareness about air pollution among residents, schools, and colleges by dissemination of AQI to general public, eco clubs, seminars, workshops, etc. (Figure 37).



Figure 37: General awareness among residents, schools, and colleges by dissemination of AQI to public, eco clubs, seminars, workshops in Chandigarh

Source: CPCC



Chandigarh Pollution Control Committee has installed one air purification tower at transport chowk, sector 26, Chandigarh (Figure 38). which is one of the busiest chowk to trap the air pollutants which may otherwise contribute to the high AQI in the city. Chandigarh government has already banned the 15 years old commercial vehicles in Chandigarh. To take control over biomass and garbage burning, the air action plan of Chandigarh also talks about having a special task force for regular checking and control of burning of municipal solid waste in the city. Additionally, Municipal Corporation of Chandigarh (MCC) sets up three (3) Material Recovery Facility (MRF) in the UT. Since November, December and January experiences the worst air quality because, the falling temperature makes the air denser and increase its pollutants holding capacity, the air quality action plan aims to reduce pollution by implementing emergency measures like halting construction activities, closing pollution causing industries. The action plan also talks about conducting awareness-building campaigns for the citizens of Chandigarh especially focussing on the vehicle owners, industries, and students.



Figure 38: Air purification tower in Chandigarh

Source: CPCC

