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IMPACT OF SPATIAL GROWTH OVER NATURAL ECOSYSTEM: A CASE STUDY OF CHANDAKA WILDLIFE

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Abstract: World is developing at a rapid pace and increased rate of urbanization is one of the key indicators of it. By 2050, 55-75% of global population is going to be living in this urban places. To accommodate this increase in the population, cities or the urban areas will tend to extend their boundaries leading to urban expansion. This rapid growth will result in the increase in proximity between urban and protected areas. Sometimes this urban growth is even unplanned and haphazard in nature and result in habitat fragmentation and loss in flora and fauna. This paper discusses the case of Chandaka Wildlife Sanctuary of Odisha, that lies partly within Khurda and partly in Cuttack Districts of the state and in close proximity of the state capital, Bhubaneswar. The urban conglomerate of Bhubaneswar- Cuttack- Khurda is increasing rapidly. Bhubaneswar has engulfed Bharatpur Range Forest within the municipal limits. Through the Landsat satellite imagery, the spatial changes over the last two decades are identified using the Normalized Difference Vegetation Index and Normalized Difference Built-up Index Values for the Sanctuary and its 5 km Buffer as delineated in the Chandaka Wildlife Management Action Plan 2011. Places that have undergone rapid spatial changes in this period has been identified using grids and further studied for the anthropogenic causes that has led to these changes. Study also considered the Elephant-Human conflict that has taken place in the nearby areas of the sanctuary due to the loss of habitats in the process of development. Finally, this study suggests broad recommendations and proposals that could be undertaken to prevent and manage the degradation of protected areas due to rapid development by introducing or remodifying the existing zoning regulation and guidelines in and around the limits of a protected area so that both nature and mankind can coexist together.

IndexTerms **– Spatial Growth, Urban expansion, Urban Sprawl, Impact on natural ecosystem, Urbanisation, Fragmentation, NDVI, NDBI, Human-elephant conflict**

I. INTRODUCTION

Rapid urban expansion has affected biodiversity through habitat conversion, degradation, fragmentation, and species extinction. The world's population is projected to reach 8.5–9.9 billion by 2050, with 55–78% living in urban areas. This global explosion of urban population will undoubtedly cause an increasing demand for urban land. Indeed, urban land has already expanded much faster than urban population (Li et al., 2022). Although urban land covers only 0.2–2.4% of the global terrestrial surface, urban expansion has been a major driver of global land use change, which leads to habitat conversion and degradation, habitat fragmentation, and consequent biodiversity loss (Li et al., 2022). India is the second most populous country and is observed that the amount of land that is being used for urban development is expected to increase more than three times up to 2030. Increase in population is inversely related to green cover in urban India.

II. DELINEATION OF STUDY AREA

According to Forest Survey of India (FSI) 2019, 22% of India's geographical area is covered with forest. Madhya Pradesh, Arunachal Pradesh, Chhattisgarh and Odisha are the four states with highest forest cover. The wildlife composition of these four states reveals that the highest number of wildlife species (the population the vulnerable and endangered species is considered i.e.; Tiger, Asiatic Lion, Leopard and Elephant) is found in Madhya Pradesh i.e., 32% with the prime animal being Leopard then followed by Odisha with 31%; further followed by Arunachal Pradesh and Chhattishgarh with 22% and 15% respectively among these four states. In case of Odisha where the wildlife population is 31% and the Elephant has the highest population of state with 1/3rd of its geographical area covered with forest. Out of the 19 wildlife sanctuaries in Odisha, Chandaka- Dampara Wildlife Sanctuary (CDWS) experiences severe biotic interference out of the growth and development of Bhubaneswar City, Chandaka Wildlife Sanctuary is identified under threat from spatial growth due to urbanization and associated anthropogenic activities. Hence Chandaka Wildlife Sanctuary is taken as the study area to understand the impact of spatial changes on the natural ecosystem.

III. Introduction to the Study Area

CDWS is spread over 193.39 sq.km of rolling table land and small sprawling hillocks of Khordha and Cuttack sections, it's a wildlife sanctuary since August 1982 (Welcome to Chandaka - Dampara Wildlife Sanctuary, n.d.). The sanctuary exists in two different parts; the major part contains an area of 172.12 km² while the other part, Bharatpur-Jagannathprasad sector is 19.27 km². The area was rich in tiger species until sixties. The establishment of state capital at Bhubaneswar in 1957 redounded in enormous pressure for wood, centring material and constructional and lead to the destruction of natural habitat in the region.

IV. Aim and Objectives

Aim:

- To study the effect of rapid urban growth near the sanctuary and provide possible solution to protect the Chandaka Ecosystem.

Objectives:

- To study the existing condition of Chandaka ecosystem.
- To identify the settlements built-up and the possible reasons disrupting wildlife activities and their movements.
- To analyze the extent of the threat of urbanization and spatial growth on the Chandaka Wildlife Sanctuary.
- To manage the threat by efficient planning strategies (creating awareness, implementing zonal regulations, limiting humanitarian activities etc.)

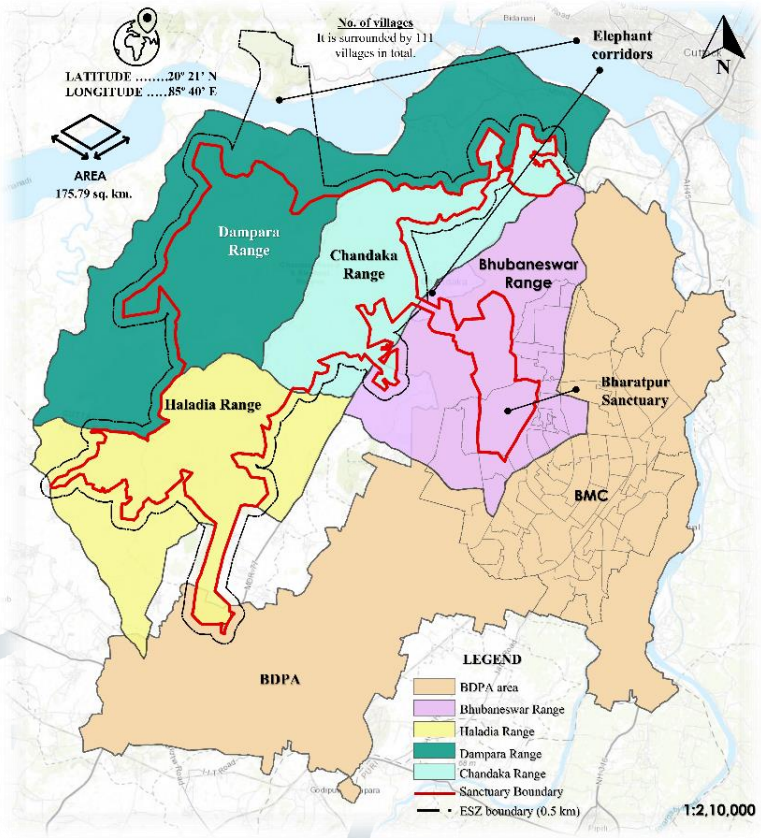

Figure 1: Administrative Regions of CDWS (Source: Primary)

V. Methodology

After understanding the research domain, the research topic and study area has been finalized in the initial stage along with the formulation of the research aim and objectives. Further the study area and its buffer zone of 5 KM radius (as specified in Chandaka Management Plan) is divided into grids for an easy study and the Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built-up Index (NDBI) mapping is done for the area to identify the grids that has been affected over the last 2 decades. Further the study has also considered the impact of this change of spatial growth with respect to the keystone animal of the sanctuary that is Elephants. Two grids are selected for detailed study of anthropogenic causes.

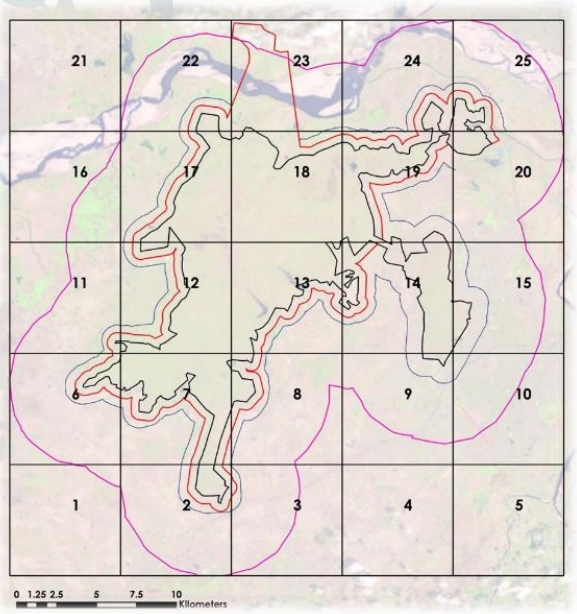

Figure 2: Grid Division of CDWS (Source: Primary)

VI. Normalized Difference Vegetation Index and Normalized Difference Built-up Index

Formula for Calculating NDVI

NDVI = (NIR – Red) / (NIR + Red) *[NIR – Near Infra-Red]*

For Landsat 7 data, NDVI = (Band 4 –Band 3) / (Band 4 + Band 3)

For Landsat 8 data, NDVI = (Band 5 –Band 4) / (Band 5 + Band 4)

Using this formula, satellite imagery and GIS analysis tool, the NDVI map is prepared. From the Maps prepared for 2001, 2011 and 2022 using NDVI analysis (given below) it is observed that, in Chandaka the value of NDVI has gradually decreased from 0.3 to 0.75 From the year 2001 to 2022, i.e., Dense vegetation has decreased from 55% to 26%. Bharatpur Sanctuary which is a part of the city, has drastically decreased its vegetation, which is also an elephant corridor. Shrubs, bushes and other green landscape has decreased.

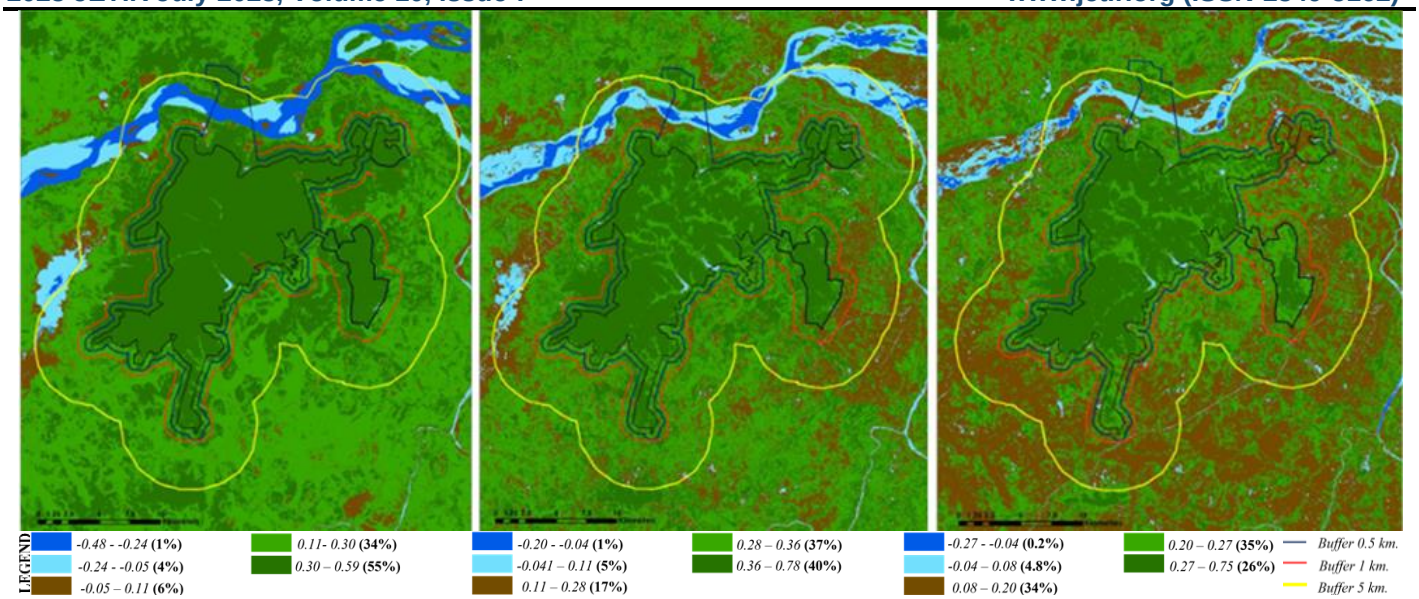

Figure 3: NDVI Maps of CDWS and its buffer for the year 2001, 2011 and 2022 respectively.
(Source: Primary)

Formula for Calculating NDBI

NDBI = NDBI = (SWIR – NIR) / (SWIR + NIR)

For Landsat 7 data, NDBI = (Band 5 –Band 4) / (Band 5 + Band 4)

For Landsat 8 data, NDBI = (Band 6 –Band 5) / (Band 6 + Band 5)

Using this formula, satellite imagery and GIS analysis tool, the NDBI map is prepared. The Negative value of NDBI represent water bodies whereas higher value represents build-up areas. NDBI value for vegetation is low. From the Maps prepared for 2001, 2011 and 2022 using NDBI analysis (given below) it is observed that, in surrounding areas of Chandaka area Built-up area has gradually increased, from the year 2001 to 2022 the positive value has increased near the periphery of the sanctuary, simultaneously the value is increasing in the core sanctuary area. Urban built-up area has increased from 4% to 11% in last two decades.

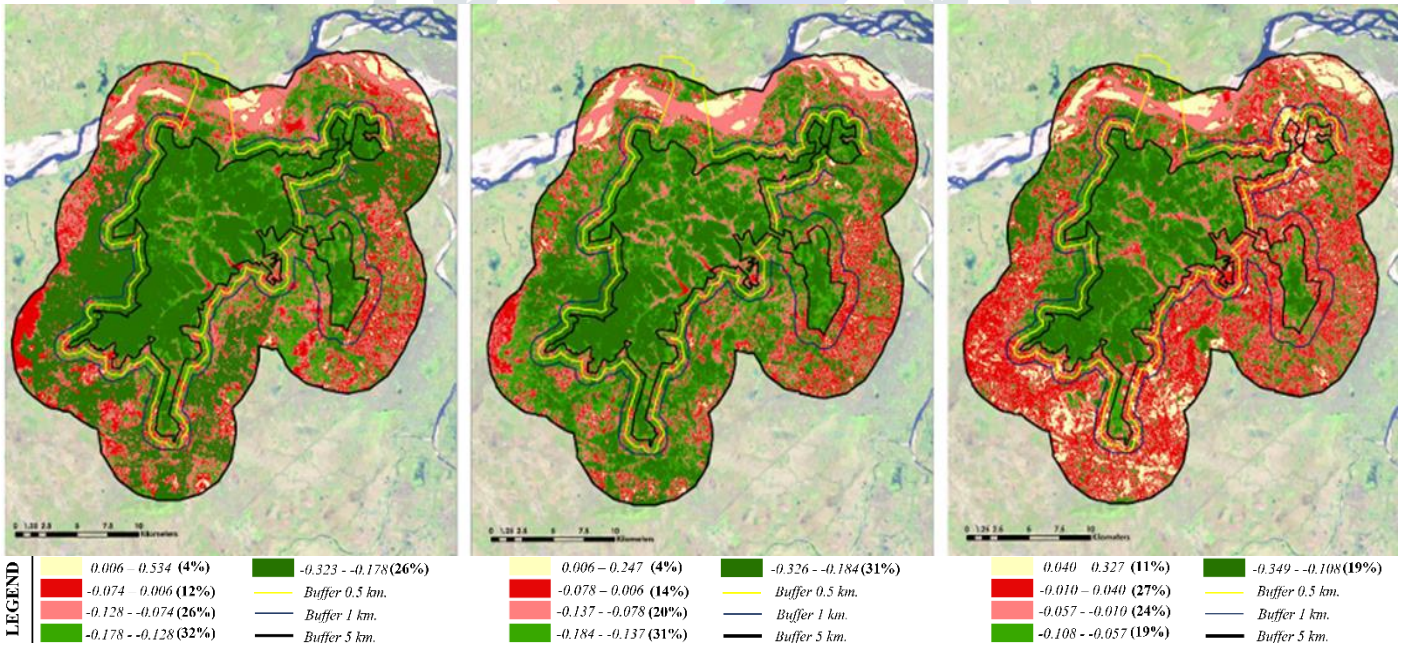

Figure 4: NDBI Maps of CDWS and its buffer for the year 2001, 2011 and 2022 respectively
(Source: Primary)

VII. Elephant Depredation

Elephant depredation is the damage caused by elephants to crops, property, or human lives due to habitat loss and fragmentation. Some of the causes of elephant depredation are habitat loss, fragmentation, and degradation due to human activities, reduced availability of elephant food species in the forests, competition with livestock, and poaching. In Chandaka, mostly Elephants cause depredation in a herd of less than 5 number or in a herd consisting of more than 25 elephants. The Elephant depredation is mostly observed in winter season as in this season, the crops attract the elephants. In the map, the elephant depredation status has been demonstrated in context of the 5kms surrounding areas of CDWS. The Colour code shows the season in which most cases have been seen in that area and through the size of the points total number of elephant attacks can be depicted. From this analysis we came to know that Grid 14 and Grid 8 have most elephant depredation cases in different seasons. It is observed that most cases are seen in winter season due to change of cropping pattern.

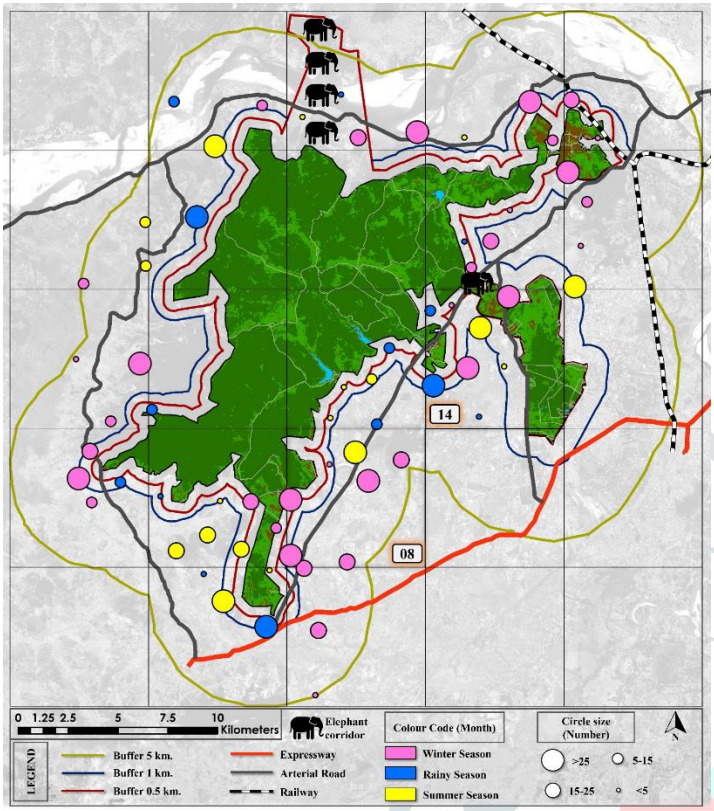

Figure 5: Elephant depredation status of CDWS with respect to season & size of herd.
(Source: Primary)

A. Elephant Depredation in Grid 14

In Grid-14, the village Gangapatna, Daspur, Jagannath & Sundarpur Prasad has been affected by depredation more than 25 numbers of elephants in a year. While Andharua, Malipada & Dalua has been affected by the lesser number of elephants, i.e., <5. Where, in Bhola village elephant depredation is usually seen in Rainy seasons and the numbers of elephants are 5-15. Grid-14 faces nearly 125 cases in a year.

B. Elephant Depredation in Grid 8

In Grid-8, the village Haripur, Mendhasal & Binjhagiri, Paniora village faces depredation by more than 25 numbers of elephants in a year, while Deulipatna, Garamadhia & Palaspur has been affected by 15-25 numbers of elephant attacks. Jamujhari is the only village present in Grid-B which is affected by <5 elephants per year. Grid-8 faces nearly 165 cases per year.

Causes for Elephant Depredation in CDWS

Violation of Zoning Regulations: Conversion of land within the sanctuary and its ESZ boundary into residential (or any other built-up use zone).

Human Interference: Collection of Non-Timber Forest Products give raise to illegal activities like poaching, deforestation within the sanctuary.

Crop Pattern: In some areas the crops, vegetables that are cultivated attracts elephants and hence result in crop raiding.

Surveillance: Lack of monitoring & surveillance towards issues like forest fire, poaching, deforestation by the management authority.

VIII. Grid Analysis and Results

Grid 8 & 14 are selected for further detailed study.

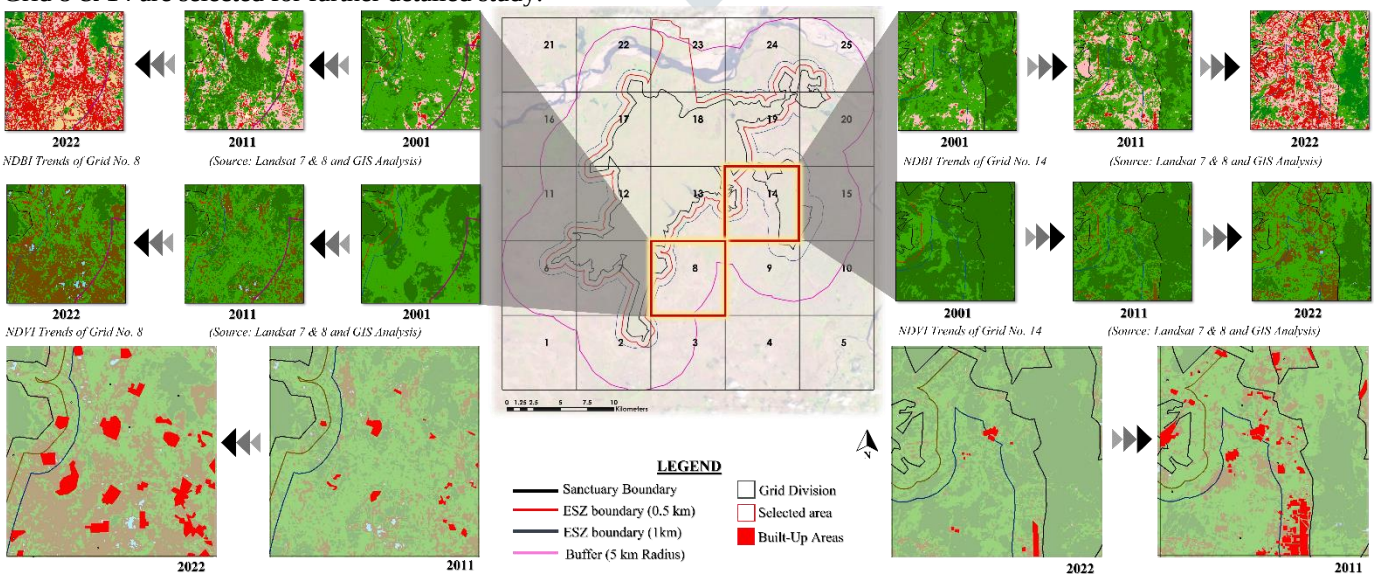

Figure 6: Spatial Analysis of selected Grid 14 and Grid 8
(Source: Primary)

Grid 8 comprises mostly about the buffer area whereas Grid 14 comprises of Bharatpur Sanctuary, also one of the major elephant corridors. In 2001, in both Grid 8 & 14 the built up was very less which kept on increasing slowly for next 10 years. In Grid 8 the change/ decrease in vegetation was due to the increase of the rural settlements leading to increase of agricultural practices over that area. Built-up percentage increased by 6.5% in the next 10 years. Most depredation cases are observed in winter as it is the harvesting season and many vegetables. Whereas in case of Grid No 14 the vegetation decreased mainly due urbanization in that area which increased by 4.2% during the period of 10 years.

Table 1: Comparison of Grid 14 and Grid 8 with respect to various variables and their indicators.

Variables	Indicators	Grid 14	Grid 8
Habitat	Loss of habitat	Natural habitat loss has increased in Grid 14 due to increase of urban built-up.	Habitat loss has increased in Grid 14 due to growth of rural settlements and extensive agriculture
Environment	Increase in environmental pollutions level and deterioration of soft-scape	Pollution has level has been increased due to increase of residentials areas.	Pollution has level has been increased due to increase in agricultural practices and tourism.
Vegetation	Decrease in vegetation density level	Normalised Difference Vegetation Index has decreased over the years.	Normalised Difference Vegetation index has decreased over the years.
Agricultural	Cultivated lands volume	Cultivation lands has not significantly increased with the decrease in vegetation.	Cultivation lands has increased in this area.
Temperature	Forest Fires	Mostly Arson has been observed in this part (for poaching).	Sporadically Forest Fires has been observed in this part.
Constructions	Growth of illegal build up	Growth of illegal built up has increased also inside the ESZ.	Mostly rural settlements are seen and outside the ESZ.

IX. Recommendations and Conclusion

Based on the results of the NDVI, NDBI and Grid Analysis, it can be concluded that the development around CDWS has led to spatial changes with the Sanctuary and its surrounding areas. Anthropogenic causes like cultivation, formation of rural settlements, poaching, pollution and urban development has led to the habitat loss and fragmentation in CDWS. Elephant depredation has increased due to all this factor giving rise to human -elephant conflict in the nearby areas.

Some of the recommendation to protect and preserve the Chandaka Wildlife Sanctuary includes:

- **Early Warning System Regarding Elephant Movement:** Using Global Positioning System or GPS collar on the matriarch of the herd; the total herd could be tracked in real time, though when it is said real time there is a one or two-hour delay (*Elephant Early Warning System – Helping Communities Live Near Wild Elephants - Wildlife SOS*, n.d.). Authorities would know the general location of the herd at all times.
- **Regular Habitat Analysis and Evaluation:** The sanctuary authorities need to conduct regular surveys to know the deficiency in the sanctuary in terms of landcover, food, water.
- **Voluntary Elephant Watch:** There are about 100 villages, which are more or less affected by crop depredation. Village youth will be encouraged to constitute voluntary elephant watch by September- October. Each elephant watch will have a contact person whose name, address, telephone number etc. will be registered in the range office. The members of the elephant watch will be assembled in a workshop in September and various methods employed to drive elephants will be discussed. The emphasis will be laid how to avoid accidents and human deaths rather than crop loss. The contact person will be expected to intimate the presence of elephants close to the village to the concerned Range officeClick or tap here to enter text.. Each village elephant watch will be provided with spot lights, required number of batteries and specially made fireworks (rocket type) and incentive money for contingent expenditure. It will be the duty of the elephant watch to prevent entrapment of an elephant family group in a patch of vegetation outside the sanctuary. For this purpose, crowd will be controlled and elephants will be given a safe passage back to the sanctuary. The watch will particularly see that there is no firing of pellets, or throwing of stones or other hard objects to the retreating elephants
- **Monitoring of Physical Environment:**
  - Silt wash and siltation rates: Silt may come from sheet erosion or bank erosion which may pose serious threat to aquatic life by reduction of photic zone and reduction of reservoir life. Measurement of siltation rates in important nalas is hence required Therefore, nalas to be brought under the scanner by the authorities.
  - Water retention & water quality: The percentage of rain water retained as ground water and surface water and loss due to run off can be analyzed at the specialized institutes. Water quality will also be analyzed in terms of dissolved salts, suspended sediment, organic matter and Bacteria load.
- **Proper Implementation of Zoning Regulation:** Grid 19 and 20 are taken as a model grid for the implementation of Zoning Regulation within the sanctuary and its ESZ boundary to control the human influenced changes in landuse. The recommendations include: Anthropogenic activities need to be monitored within the ESZ boundary along with the sanctuary and its periphery area; Land conversion from forest to residential (or any other landuse) should not be allowed; If any building or construction is taking place it should be according to building rules and zoning regulations and should not be within the ESZ Boundary; Zonal Plan needs to be prepared for proper management of activities within the sanctuary.

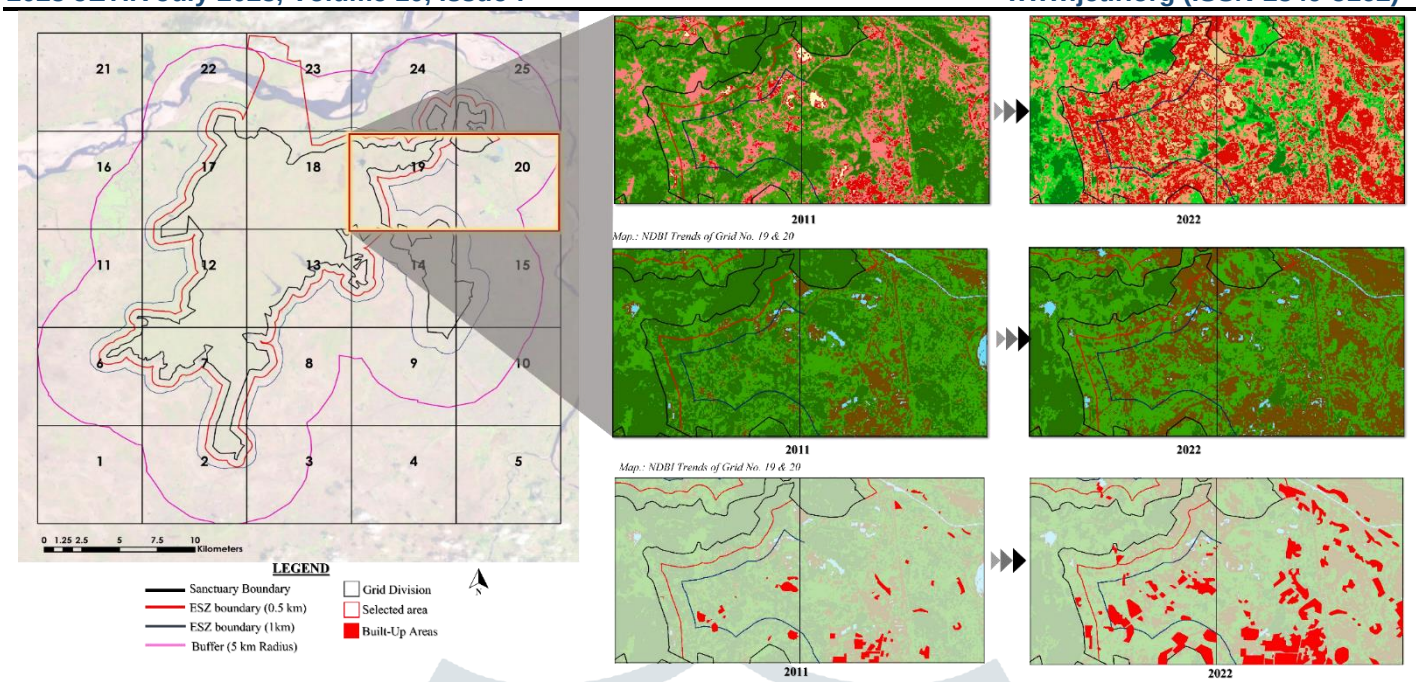

Figure 7: Model Grid for the implementation of Zonal Regulation
(Source: Primary)

- **Control of Grazing:** Grazing will not be permitted inside the sanctuary. Village people around should be motivated to utilize the forest land around the sanctuary to use as pasture for cattle grazing. For this, they can use different hybrid grass and have a controlled grazing mechanism.
- **Community Awareness**: Campaign needs to be conducted regarding the values and importance of forest and wildlife for a proper management.(*IMPACT OF SPATIAL GROWTH OVER NATURAL ECOSYSTEM: A CASE STUDY OF CHANDAKA WILDLIFE by Urmikant - Issuu*, n.d.)

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