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Impact of Land Use and Land Cover Changes on the Remnant Patches of Kondapalli Reserve Forest

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ABSTRACT: ***Despite its reserve status as forest, the Kondapalli Reserve Forest (KRF) of the Eastern Ghats, India has been severely interfered. The present research is aimed at evaluating changes in land use and coverage in and around KRF using time satellite data. The present analysis indicates that from 1990 to 2015 the forest cover has declined considerably; data indicate that tremendous urban extensions and improvements across KRF were observed from 2017. This rise is related to the population development and thus uses property for the essential needs of the people. The land use rate and the soil absorption ratio were determined to determine the pace of human growth in the area. Around 1990 and 2017, the findings of this study revealed a steady increase of the built-up land and a decline of the forest class from 1990 to 2015. In addition, the study forecast that the new capital city of Amaravati will have a negative impact on the KRF and proposed that the conservation measures for its current deforestation and degradation trends should be adequate.***

KEYWORDS: ***Kondapalli forest, Eastern Ghats, Land consumption rate, Forest degradation, Vijayawada.***

INTRODUCTION

The task of the powers around the world was historically to defend the sovereignty of the territorial boundaries of the government from foreign interference and to guarantee internal security, anti-insurgency or anti-terrorist operations. Two new aspects have been introduced since World War II: regional peacekeeping and disaster relief. A wealth of empirical cases show that the military has diverged from its traditional defense of the state from external enemies to non-traditional missions within the state. In the case of South Asia, for example, the army was sometimes involved in disaster relief activities as well as in natural disaster recovery and reconstruction. The query of Timothy Edmunds was: "Who are the military? “Since the Cold War ended in 1991 he said, the perception of the military's role has changed profoundly. Because internal conflicts and civil wars came to the fore after the collapse of the bipolar system and US – Soviet rivalry. This non-traditional position of the military is particularly aimed at examining and illustrating its function in the protection of the ecosystem in the Indian context[1].

The military often began to perform these less conventional positions in India. One example is the conservation process that started in the 1980s involving the military. Since then, six

bataillons have been released in five nations, namely Rajasthan, Assam, Delhi, Jammu and Kashmir and Uttarakhand, by the Ecologic Task Force (ETF). So far not a lot of work has been done on this quite unique entity, which is often made up of demobilized Indian army soldiers who have either retired or otherwise been released, along with active military personnel. The D'souza predicted that the Indian military might play a significant position and be a pioneer in India's climate change policy and strategy on domestic and foreign fronts. Growing indicators of the effects of climate change, together with India's increasing effect on global climate control[2].

Using the cases of the ETF, that contribution shall be made by applying it to a violent frost area such as the Bodolland Territorial Autonomous Districts in Assam, India to broaden existing conceptual and theoretical views in the CRL. The area was the site of a brutal dispute between the Bodogroups, lands of the land, Adivasis and ethnic Muslims, brought to work on tea, train and settled agriculture by the British colonial administration in the country. In a further section, the contour and the nature of the conflict are discussed in detail. This effort aims to put the environmental call together[3].

Conservation on 'combat roots' and the real deployment of military forces in politically troubled countries where counter-insurgency work is carried out Such history not only records the role of the ETF in East India, but also reveals how modern structural structures of day-to-day conflict are introduced into the political system. This conflict creates the space of 'military preservation,' i.e. use of military and paramilitary personnel, education, technologies and partnerships in conflict, mainly on land and on resources among various national groups and on State and military operations against forest rebels. Start attempts to preserve. This was also seen as an attempt to inoculate local political contingencies in the global benefits of forest restoration.From February to May 2016 and focused on observational data gathered over six months of fieldwork consisting of interviews and participatory findings with ETF officials and workers, the forest department and local people residing in these protected forest areas

From July to September 2017, the contribution illustrates how the context of the "climate militarization" literature, which expresses conservation as a tool for aggression and how natural protection regimes create "nuclear wars," can be used to complement and increase the background here. It is achieved by taking into account the militarized methods of conservation, using military techniques and order, will still take on lighter or milder modes of implementation based on the principle of war based conservation. That type of green militarization does not necessarily lead to high forms of immediate physical violence, although local people who rely on reserved forest areas for their livelihoods may expose them to special and various forms of direct, indirect and symbolic violence. These violence arrangements are often facilitated and maintained by factors outside the immediate practice of conservation. It further ties the ideology behind the ETF to green militarized systems in which "political strategies and principles are gradually incorporated into environmental activities." Here is an important explanation as to who and what comprises the local population. The reserve forest consists primarily of the people of

Bodo and Adivasi, who are named by the state as 'incroachers.' They rely on subsistence farming and/or working in the vicinity as a daily wage laborer[4].

City. Living in a reserved forest means schools, amenities such as roads and electricity, and other fa- cities for health and sanitation are not accessible. These populations have historically faced multiple displacements due to violent conflict where their houses are burnt down, or eviction by forest department, or destruction of property in human-animal conflict. They are also harassed repeatedly by the Army and para-military due to alleged linkages with local militants. Over the years there has been a deepening of informal arrangements related to forestland and access to resources. Therefore, the contribution retains its attention on how state (ETF, forest department and armed forces) and non-state actors (local communities and rebel / insurgent groups) work and engage with each other in a war environment, particularly those specifically embedded in the mechanism of war. As Verweijen and Marinjen point out, while the broader work on green militarization makes significant contributions to the understanding of the interplay between violence, conservation and conflict, including through state (para) military actors' policies and activities, it does not analyze in detail how green militarization. In fact, this case resonates in certain respects with what Verweijen and Marinjen identify in the case of the Virunga National Park in Congo where 'strong' counterinsurgency strategies, such as aggressive law enforcement operations carried out by combined units of armed park guards and the Congolese armed forces, blend with 'soft' counterinsurgency (militarized) security approaches, resulting in a conservative strategy[5].

Actually, these 'softer' and 'symbolic' policies are intended to establish a 'inclusionary control' practice that, in Dunlap's and Fairhead's words, is designed to maintain 'conflict in its most manageable phase – 'peace.' Moreover, as the Green Militarization literature further insinuates, both conservation and counterinsurgency practices use violence, whether as an intentionally and directly inflicted bodily harm in its narrow conceptualization, or as more broadly interpreted in the sense of 'structural' or 'symbolic' violence. In addition, this essay aims to add meaning to this growing body of research addressing militarized modes of conservation by drawing on India’s conceptions of 'violent' ecological aggression, as much of the study has so far concentrated on other regional contexts. The Historical and recent study of military activity in conservation (here in northeastern India), also known as military-environmentalist debate, is hardly an over-investigated subject. This essay is aimed at recognizing the more conventional interinstitutional and multilayered solutions to soft militarization embedded within this intersection of conservation-counterinsurgency in daily modes of systemic and symbolic violence. Finally addition on another level of ecological militarization – its aggressive consequences[6].

Conflict and everyday relations between the different state and non-state actors operating in an area of violent conflict where conservation fuses with counterinsurgency. This further layers the study of the connections between (counter) insurgency and conservation, and illustrates how more money is bequeathed to counterinsurgency over conservation activities in this particular

case. Few questions which arises in this paper are 1) what are the changes in water bodies of Kondapalli forest?

Rationale behind the current study

The Kondapalli Reserve Forest (KRF)[7] is one of the only remaining virgin forests in Andhra Pradesh (AP) state's Krishna district and forms part in Eastern Ghats – EG 's western flange. It is the only forest patch that acts as green lungs for Krishna district's Vijayawada region. While the forest has been designated a woodland reserve, it is vulnerable to human interference, affecting the biodiversity thereof. In due course of time the reserve forest has seen remarkable urban growth, development activities and many other anthropogenic interactions in its vicinity. In the most part, growth of settlement and farming areas at the detriment of the protected environment is one of the main problems found in KRF. In addition, the plan to condemn a portion of KRF for the development of the newly created AP state capital-Amaravati would also benefit the KRF and its flora and fauna. At this juncture, the spatial condition of these forests must be evaluated in the light of evolving LULC and measures recommended for restoration to avoid further destruction of the land. Against this context, the present research focuses on examining the significant changes in spatiotemporal LULC that have arisen in KRF and its surroundings over a 27 year period. The study also aims to identify LULC's key drivers of change and how those changes have affected the KRF and its biodiversity[8].

Study Area

The latitudes of the EG lie between 11 ° 310 and 22 ° N and 76 ° lengths 500 and 86 ° 300 E covering an area of 75,000 km2 and are one of India 's nine floristic regions. The EG range may be found over three states viz. Orissa, Andhra Pradesh and Tamil Nadu forming two distinct areas as Northern-EG and Southern EG. KRF is a part of the 121 km2 EG belt and is split into five forest beats viz. Kondapalli, Duggiralapadu, Jujjru, Kanchikacherla and Mullapadu. The present area of study (KRF) is a meeting place between the Northern and Southern EG. KRF is typically a tropical dry evergreen forest-7 / CI, according to Champion and Seth, though it now exists as a typical dry deciduous scrub. KRF's wildlife is composed of leopards, wild dogs, jackals, wild boars, wolves, deer, etc.

MATERIAL AND METHOD

Satellite data classification and LULC change mapping

The study used five-period multi-temporal data derived from the viz., Landsat, IRS 1C/1D LISS III, and Sentinel (Table 1). Datasets from 1990, 2000, 2009 and 2015 were used for the study of developments, while data from 2017 are used to verify the conclusions derived from previous data and to reflect existing LULC with a particular emphasis on the growth of built-up areas. Each sensor data has a different spatial resolution, as shown in Table 1. However, data sets were not resampled to a common resolution, as emphasis was placed on working with statistics

obtained by pixel comparison after mapping rather than pixel. Green, red, and infra-red bands were used to generate standard false color composite (FCC) depending on the type of sensor data.

The study selected an area of 3 km as a buffer zone to identify changes in spatio-temporal LULC in KRF's vicinity. The KRF boundary was digitized from toposheets of the Survey of India (SOI), and a buffer zone of 3 km was created to clip the study area from each LULC mapping satellite data. The KRF (Fig. 1) and a small patch of the Konduru Reserve forest (box in Fig.1) covered the 3 km buffer area along with other classes of LULC. However, while calculating forest statistics (though shown in the final map) the Konduru forest was ignored. Initially 2015 picture was labeled on the ground using unsupervised method to produce spectral clusters that represent different types of LULCs. To identify various features on the ground, a hard copy of the cluster map was used for field survey reconnaissance. During field survey the ground control points (GCP) were marked on the cluster map using GPS device for the predominant LULC classes. Also, the existing literature survey and interaction with the forest department and local institutions was done to gather knowledge base on currency rent. Following the field survey, training sets were prepared for different LULC classes to classify satellite data using maximum classification of probability.

Bi-spectral plots were used to verify the separability of training sets to get homogeneous signatures for each class. A similar method was adopted for classifying data on each satellite (Landsat, LISS III, and Sentinel) based on field knowledge and spectral knowledge of different classes. Finally, the classified thematic map was evaluated for its accuracy using an error matrix (Fitzgerald and Lees, 1994), using GCP collected field and random sample points generated by the system. The thematic maps derived from 1990 to 2017 have been assessed for change in the LULC classes. The 2017 LULC map was considered for changes focusing mostly on built-up land. Forest area has not been compared, as satellite data from 2017 is from a dry period. An exact and accurate reason for the loss of the forest (due to degradation or phonological changes) is also not possible with data from 2017. The research used multi-temporal data of five cycles derived from the viz. Landsat, IRS 1C/1D LISS III, and Sentinel (Table 1), from separate satellites[9].

Datasets from 1990, 2000, 2009 and 2015 were used for review of improvements, while data from 2017 are used to verify the conclusions derived from previous data and to reflect existing LULC with a particular emphasis on extension of the built-up region. Each sensor data has a different spatial resolution, as observed in Table 1. Nevertheless, data sets were not resampled to a specific resolution because focus was placed on dealing with statistics collected through pixel comparison rather than mapping.

Land consumption and land absorption

Considering the rapid urbanization and impact of newly established AP state capital on land use near KRF, soil consumption rate (LCR) and soil absorption coefficients (LAC) have been calculated. The calculations were based on the assumptions that: land consumption is increasing with an increasing population, resulting in an amplified urban expansion; and this will have a severe impact on the forest periphery leading to encroachments and disturbances (Laxmikant et al., 2012). The rate of land consumption and coefficients of absorption are determined using formula given by Yeates and Garner (1976), as;

LCR A = P 1⁄4

Whereas

LCR = A compactness measure (for the progressive spatial expansion of a town)

-- A = town size in hectares; P = population

LAC 1⁄4 A2-P2 — P1

Whereas

LAC = A measure of change in the consumption of new urban land by increasing the urban population by each unit.

A1 and A2 are the early and later years (in hectares), P1 and P2 are population numbers.

In each sample year the closest population available (Table 2) was used to produce both the LCR and the LAC.

RESULT

The thematic outputs of 1990, 2000, 2009 and 2015 showed 8 classes' viz., forest, degraded forest, water bodies, agricultural land with crops, and without crops, ash pond, other land, and built-up land (Table 1, Fig. 1). The degraded forest areas are clearly seen in 2017 data owing to its 10 m spatial resolution. It is observed from Table 1 that the built-up land has vastly increased from 1990 to 2017. A shift in ash pond along with its size, and shape was also seen with respect to time. The water body class increased from 1990 to 2000 but later they were also dried and further converted into other lands. There is much variation found in the schools, agricultural land with and without crops.

The overall classification accuracy of the map obtained for the respective years from 1990 to 2017 was 84.39, 88.32, 94.42, 85.11 and 89.44 have their kappa values accordingly as 0.81, 0.86, 0.91, 0.78 and 0.94. The precision shown by the kappa values of 0.78 and > 85 per cent respectively are considered to be very good and excellent, finally showing better accuracy and agreement with derived thematic maps. Focusing mainly on the trees, the user's accuracy improved from 89.29% to 96.94%, although the precision of the manufacturer declined from

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100% to 85.19%. As per Paul a classification accuracy of 85 percent is acceptable with digital image classification along with the inclusion of error matrices for the best interpretation of derived thematic maps.

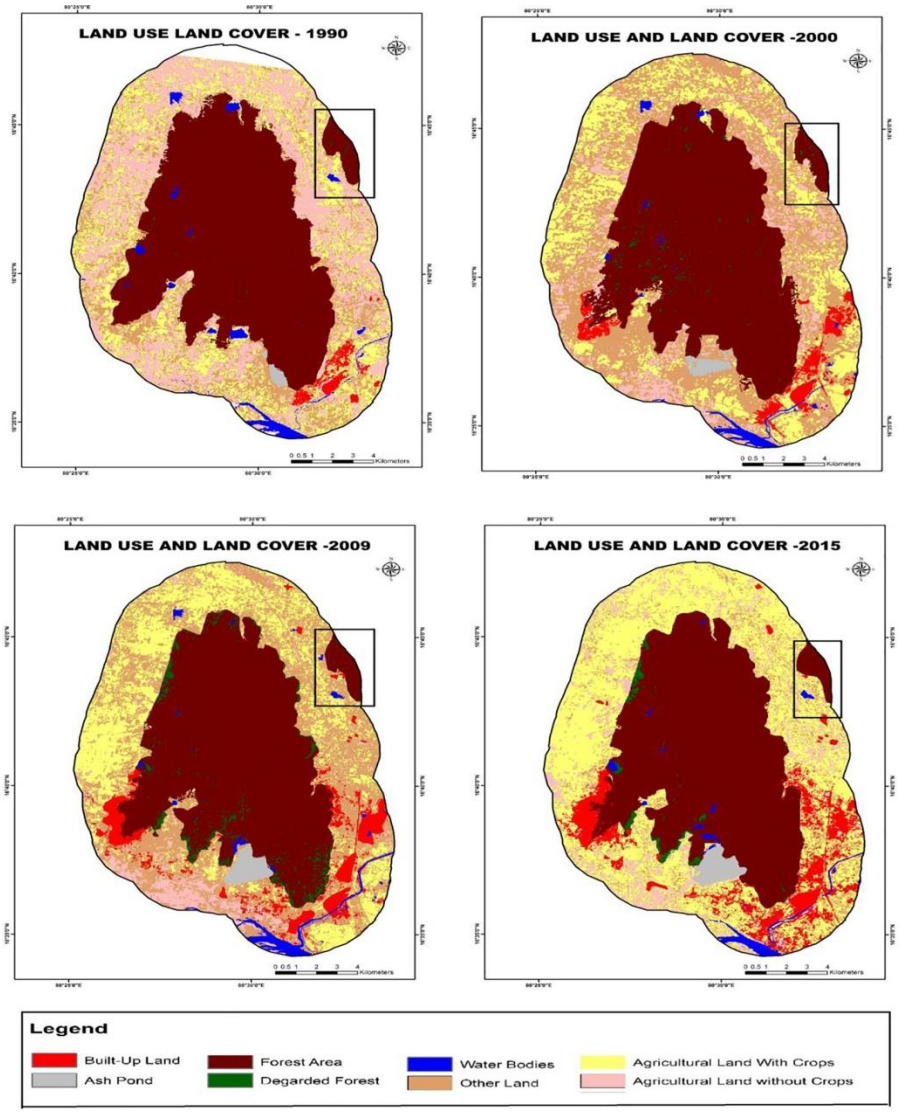

Fig. 1: Spatiotemporal LULC Map of the Study Area.

Table 1: Demonstrate LULC distribution in study area.

Year	1990		2000		2009		2015		2017	
Class Name	Area (km^2)	Area(%)	Area (km^2)	Area(%)	Area (km^2)	Area(%)	Area (km^2)	Area(%)	Area (km^2)	Area(%)

Forest	120.80	42.73	113.90	40.10	110.30	38.90	110	37.53	77.97*	27.64
Degraded forest	0.19	0.10	1.50	0.59	5.40	1.90	2.50	0.85	33.30*	11.81
Ash pond	0.90	0.29	2.00	0.70	3.30	1.20	3.80	1.32	3.38	1.20
Built – up land	3.09	1.18	8.18	3.00	14.70	5.28	22.50	7.96	47.50	16.84
Water bodies	4.20	2.50	3.19	1.20	4.45	1.60	3.40	1.19	2.32	0.82
Other land	43.49	15.30	88.10	30.90	77.69	28.60	29.15	10.30	17.45	6.19
Agricultural land with crops	50.20	17.10	47.00	16.70	55.00	19.4	97.60	34.56	37.87	13.43
Agricultural land without crop	63.99	24.04	19.99	7.30	12.00	4.30	17.79	6.28	62.26	22.07
Total	280	100	289	100	289	100	282	100	282	100

DATA COLLECTION AND ANALYSIS

Validation of the study

Compared to 1990 (where the forest area reported was 115,74 km2) the 2017 data shows an area of 77,97 km2 with an rise in the built-up areas (Table 1). The forest loss (in 2017) can be due to both mechanisms of deforestation and phenological changes. The 2017 Sentinel satellite data used in LULC mapping is from February-a warm month in which forests are warm in nature, trees lose their leaves. The forest area appears to be diminishing as a result. Whether forest shift is due to deforestation or phenological trends with this evidence, however, it is not possible to discern. The purpose of using data from 2017 is primarily to map classes other than forest. Sentinel data with a 10 m spatial resolution helped to more distinctly quantify changes in LULC. The urban sprawl Data clearly show the settlements and other built-up classes with perfect transport access. The eastern, western and southernmost part of the study area was observed with a major expansion. Such anthropogenic interference strongly affects the forest and its wildlife. It is clear that the construction and urbanization pat- terns are on the rise, even along the forest outskirts. Changes have also been observed in the forest within.

It may be a phase of decay or other seasonal phonological changes, to some degree. The previous data sets were not able to distinguish micro-changes in the research region due to their low resolution. Yet the new data from 2017 revealed changes better because of its high resolution. Therefore, this comparison of previous LULC modifications with data from 2017 was very helpful in understanding the degree to which the built up class rises.

Table 2: Population Figures Of Kondapalli Village in 1990, 2009 And 2017.

Year	Census	Source	Population Figure
1990	1981 Census	The Statesman's Year-Book 1990–91	10,999
2009	2009 Census	The Imperial Gazetteer of India, Volume 9	20,199
2017	2011 Census	censusindia.gov.in	34,390

Land consumption and land absorption

The results of this analysis show that the LCR, which evaluates the compactness and crowd of cities, shows the city's gradual spatial expansion from 1990 to 2009, which increased further in 2017. Moreover, between 1990 and 2009, the land absorption coefficient that compares use from certain types of LULC to new urban areas from increasing population growth unit was high. Ever since there is no significant variation in their coefficient value, they are still considered to be the least absorbed areas of land

. There is an increase between 2009 and 2017 which indicates that the rate at which lands are used for development is high. This may also be the pattern in the future due to the expansion of the city of Amravati (new state capital of the AP) as there appears to be concentration of development in the middle of the city at present and could further extend to the outskirts (sub- and peri-urban areas) that are intruding into the vicinity of the KRF.

DISCUSSION

The original forest area is 115 km2 according to the SOI toposheet and as per AP forest department as well as published literature the area is 121 km2. The area recorded in 1990 relating to the KRF is 115,74 km2. A forest area comparison from 1990 to 2015 (115–106 km2) showed a decline in trend and forest conversion from T1 to T2 to other classes. Between 1990 and 2000 a major change was observed in forest area. Although this change seems minimal, as observed from other satellite data, it has a significant impact in initiating further degradation of the KRF. The total climate transition from 1990 to 2015 has been reported to be about 9.74 km2 on the negative side and it would be higher if the reduction of land in 2017 were also considered. The findings of the current analysis suit the research on decrease in Krishna district forest. The study, based on the 2010 to 2011 satellite data observations, reported a loss of 1,158 km2 (115,8 ha) of forest land throughout the entire district. The decline was due to encroachments and the

forest department's clearance of trees in order to increase plantations. The study explicitly addresses Kondapalli forest status as not long: A view of the quickly depleting Kondapalli forest near Vijayawada.

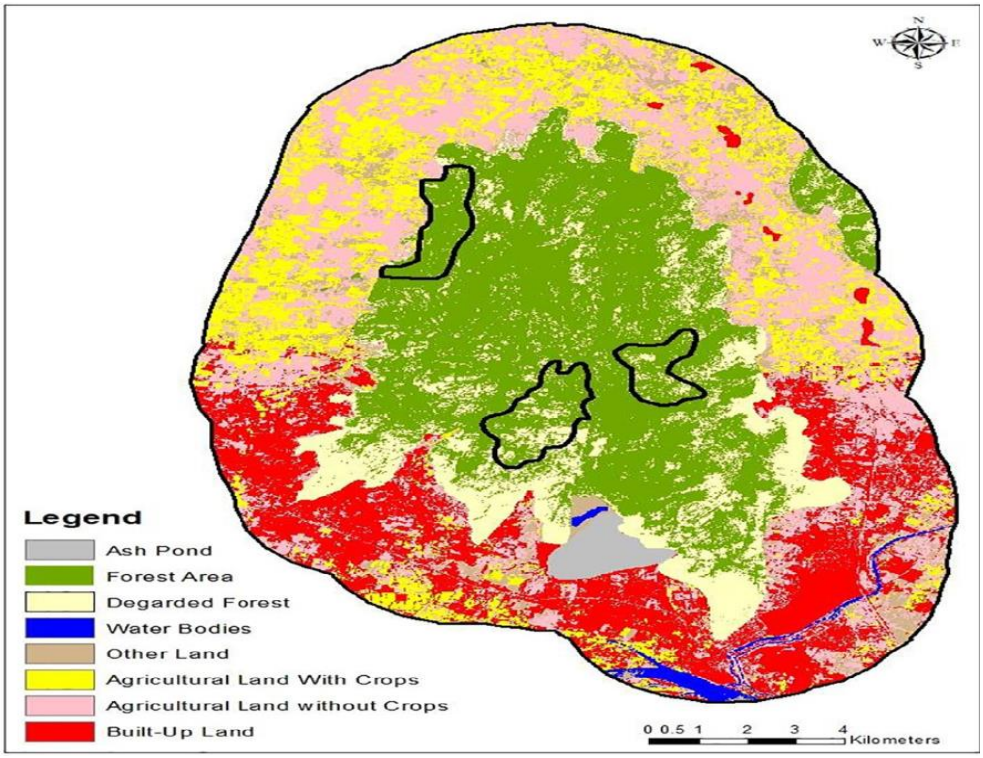

Fig. 2: LULC map of 2017. (Black polygons in the map represent proposed denotified forest area diverted for infrastructure development by AP Capital Region Development Authority, Vijayawada. Redrawn from the).

Likewise, the current analysis recorded a depletion of 9.74 km2 of forest land amounting to 0.4 km2 per year over a period of 25 years (1990–2015). The research found a great deal of forest destruction and depletion along the forest edge, rather than in inland sections. However, a clearing of the forest by forest department under the scheme "CAMPA" for plantation operations was observed during field survey at a few places.

Also few water bodies present within the forest were lost along with the forest loss. When seen in 2015, the water source at the tip of the KRF, which was easily visible in 1990, was gradually drained and finally turned to farm land. Also degraded were the two water bodies at the bottom towards the south side-one totally lost and another now act as an outlet for ash pond. There was also a significant change regarding the displacement, as well as an increase in the ash pond size. The ash pond was moved in the year 2000, where it was originally a desolate field in 1990. Later in 2000 the place where there was an ash pond (abandoned) was used for agriculture.

Furthermore, the area was converted into built-up land and was completely transformed into an urban area in 2015.

The Fig. 3 offer evidence of transformative LULC divisions in which water sources, class LC, were converted into agriculture and later into ash ponds; and a desolate class of land converted into agriculture and eventually into built-up areas. The noted LULC changes are analogous to the naturally occurring succession cycle, where forest is the climax level, and where built-up or urban areas in artificial system constitute the climax state of the landscape, sequentially replacing forest and agriculture.

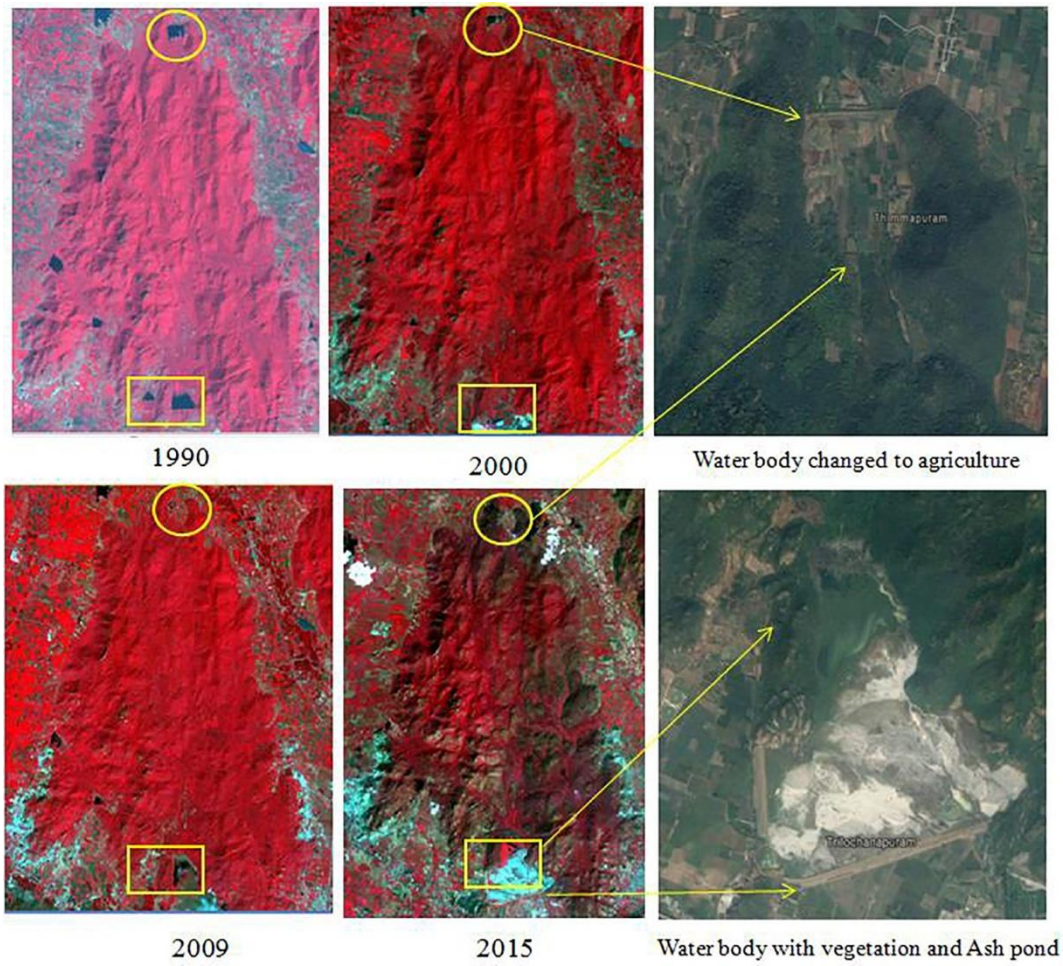

Fig. 3: Spatiotemporal changes in water bodies of Kondapalli forest. (Courtesy: Google earth images as supportive evidence).

Forest change – Drivers

Since 1990, the developed up areas have been dramatically changing. Notable changes in and around KRF have been observed resulting in the degradation and shrinking of the forest area

along the boundaries. The primary reason behind this change is attributed to mining and industrial activities along with settlement expansion which affected the forest environment. Big impact on the environment was attributed to mining operations. The KRF is mined for Chromite, Granites and Charnokonites and mainly woodland beats at Kondapalli and Kanchikacherla. No evidence of mining activity was reported in 1990, as observed from satellite records, but later in 2000, the forest 's southern left side showed tremendous mining activity, which continues to this day. Mining activities around the forest pose threats to vegetation and wildlife as well as pollution. It is forecasted that the KRF and its surrounding hills and hills will be heavily quarried to meet the needs of the construction activities of the new capital-Amaravati. In addition, KRF was also depleted by the development of industries.

Many factories, such as Andhra Pradesh Heavy Machinery and Engineering Ltd., Godrej Agrovet Ltd., Lanco Power Ltd., Vijayawada Thermal Power Station, Indian Oil Corporation Ltd, Bharat Petroleum Corporation Ltd., Hindustan Petroleum Corporation Ltd., Gas Authority of India Ltd etc., are formed around KRF within a buffer of 500 m. At the one hand, factories have their own impact at forests and on the other, rapid industrialization has favored the development of settlement areas leading to encroachments and disruptions throughout the KRF climate.

Logging/grazing, forest fires, tourism & recreation

All of the drivers discussed above have externally affected the forest, but the forest is also internally subject to various anthropocentric activities, leading to its degradation and loss. The forest's easy accessibility and dry nature along with the absence of high-order wildlife (especially cat family) favored entry into and subsequent exploitation of the forest. Illegal wood logging is a common global practice and the KRF is also logged for firewood as well as commercial wood. Few trees were logged at an old age, while few were chopped at a younger age, resulting in a decline in the population of juveniles.

Since most of Kondapalli village population is dependent on toy making, trees such as Givotiamoluccana (L.) Sreem. And GyrocarpusamericanusJacq is extensively logged in for fabrication of toys. The population of these species drastically reduced due to indiscriminate logging, questioning the livelihoods of artisans and craftsmen.

Cattle feeding was a common phenomenon observed during field surveys, as well as logging. Logging activities affect younger wood populations while cattle feeding leads to saplings damage, hampering regeneration processes.The forest has often sometimes been subject to forest fires either lawfully by the forest service as part of underground shrub clearing or unlawfully by the local population to remove wild animals from their hunting grounds. The forest is vulnerable to fire often naturally, since it is dry in nature. Forest fires are found mainly in the beats of Mullapadu and Kondapalli. While tourism and leisure practices do not result in forest destruction, they have serious effects on forest climate. The KRF embeds the popular fort of

Kondapalli and is one of the most important tourist attractions for visitors. Furthermore, the renovation and restoration work undertaken by the Archeological Department attracts tourists to visit this spot. Further AP state government aims to upgrade this site for improved tourism, which could pose a danger to KRF, in addition to the current existing conditions. As part of leisure, more than 1000 people visit local temples in Mullapadu and Kondapalli beats located within the KRF each year. It has been noted that infiltration of this sort of local population disturbs the vegetation around the temple and pollutes the atmosphere.

Impact OfAPCRDA

In addition to the factors mentioned above, the survey conducted by AP Capital Region Developmental Authority (APCRDA, 2017), Vijayawada reported the diversion of KRF's 8.9 km2 forest area towards the establishment of the proposed sports and physical training center and agritourist projects. Three forest sites (Forest Bit-1: 16 ° 39014.6800 N – 80 ° 29047.9600 E; Bit-2: 16 ° 40044.1000 N 80 ° 30045.4000 E; Bit-3: 16 ° 43022.5800 N 80 ° 27038.9900 E) were chosen on the basis of their easy access from national highways (Black polygons illustrated in Fig. 2, APCRDA, 2017).

Alternate sites were also identified by the APCRDA, but were rejected due to mining operations near those sites and eventually opted for KRF sites. The plan also involves the construction of public and semi-public leisure facilities in the vicinity of KRF, along with the creation of another industrial zone. This not only leads to loss of forest area and its biodiversity, but also increases the level of disturbances and subsequent pollution and degradation, threatening forest ecosystem dynamics. On the one hand, the forest department (part of state government) adopts conservation strategies but on the other hand, for development activities, the same government invades forests. Eventually, illegal human activities (possibly the climate effect should be weighed as well) along with government policies, would challenge KRF’s viability in future.

CONCLUSION

The present research was undertaken to determine the effect of improvements to LULC on KRF and its biodiversity. From the study it is evident that there is a considerable decrease in the forest cover from 1990 to 2015; as seen from 2017 data, huge urban expansion and development activities around KRF were observed. Significant changes were noted along the periphery of the KRF in terms of for-mation of agriculture and built-up areas. These changes are related to the population development, thereby consuming land, available for their basic needs. As observed from 1990 to 2017 (27 years) satellite results, the intensity of human activity in and around KRF is growing and has a significant effect on the environment.

Along with the extension of the villages, numerous KRF construction operations faced threats not only to the environment but also to its wildlife. KRF serves as the green lungs for the city of Vijayawada and any change in the destruction and degradation of this forest has serious implications for the city's population and micro-climatic conditions. It is predicted that the newly

established capital city has tremendous impact on the KRF by encroaching a portion of forest area for development activities. There's a question around biodiversity security and sustainable growth in the present scenario. Though both are important, it is a challenge to choose the one between the two.

In the light of capital city development, its conservation and protection should be given preference, rather than economic development, with reference to KRF. In the name of development activities and policies, the general public is grabbing forest land from the periphery, while government is invading the inner forest. At this juncture, given its biodiversity and ecological goods and services, it is necessary to rethink the Government's proposal to identify the forest area. Serious and rigorous conservation measures are needed to save these residual patches, regardless of government policy. Similar emphasis should be put on reclaiming missing water sources to boost the Vijayawada city's climate conditions.

REFERENCES

[1] T. J. Baker and S. N. Miller, "Using the Soil and Water Assessment Tool (SWAT) to assess land use impact on water resources in an East African watershed," *J. Hydrol.*, 2013, doi: 10.1016/j.jhydrol.2013.01.041.

[2] N. Sajikumar and R. S. Remya, "Impact of land cover and land use change on runoff characteristics," *J. Environ. Manage.*, 2015, doi: 10.1016/j.jenvman.2014.12.041.

[3] N. Rodríguez Eraso, D. Armenteras-Pascual, and J. R. Alumbreros, "Land use and land cover change in the Colombian Andes: Dynamics and future scenarios," *J. Land Use Sci.*, 2013, doi: 10.1080/1747423X.2011.650228.

[4] S. Arunyawat and R. P. Shrestha, "Assessing land use change and its impact on ecosystem services in northern Thailand," *Sustain.*, 2016, doi: 10.3390/su8080768.

[5] M. S. Pervez and G. M. Henebry, "Assessing the impacts of climate and land use and land cover change on the freshwater availability in the Brahmaputra River basin," *J. Hydrol. Reg. Stud.*, 2015, doi: 10.1016/j.ejrh.2014.09.003.

[6] P. Panagos, P. Borrelli, K. Meusburger, C. Alewell, E. Lugato, and L. Montanarella, "Estimating the soil erosion cover-management factor at the European scale," *Land use policy*, 2015, doi: 10.1016/j.landusepol.2015.05.021.

[7] P. Nugroho, D. Marsono, P. Sudira, and H. Suryatmojo, "Impact of Land-use Changes on Water Balance," *Procedia Environ. Sci.*, 2013, doi: 10.1016/j.proenv.2013.02.036.

[8] S. Bajocco, A. De Angelis, L. Perini, A. Ferrara, and L. Salvati, "The impact of Land Use/Land Cover Changes on land degradation dynamics: A Mediterranean case study," *Environ. Manage.*, 2012, doi: 10.1007/s00267-012-9831-8.

[9] K. L. Findell *et al.*, "The impact of anthropogenic land use and land cover change on regional climate extremes," *Nat. Commun.*, 2017, doi: 10.1038/s41467-017-01038-w.