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# Design of hydro landscape for improving tiger habitat and tourism at Tadoba National Park

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**Abstract**
Due to favourable conditions for tiger habitat and ample prey availability, the number of tigers at Tadoba national park has jumped to 115 within the year 2019. The growing number of tigers and the ecologically rich environment of Tadoba National park is the reason to attract many tourists from within and outside the country. As a result, there is a growing number of resorts within the vicinity of the forest boundaries. The presence of the water bodies is the must criteria for tiger survival and growth. Tadoba national park has only two sources of perennial water bodies which are mostly occupied by the tigers during the peak summer season. Consequently, other animals do not prefer to go near these water sources to avoid the risk of their life which makes them sick and they die because of thirst. So, the forest faces a shortage of prey for tigers. On top of that, the upcoming resorts in the proximity of these forests and tourism activities may lead to further exploitation of forest resources especially water. It may also change the microclimatic conditions of the forest and hence can disturb the conducive environment required for the growth of the tiger. Since we cannot stop the development but we can plan it judiciously so that the forest resources and wildlife habitat are not compromised. This paper discusses the strategies that can be adapted to overcome these adverse effects of resort development and how the tourism activities of the area can be modified to prevent future exploitation of the national park. Tadoba national park receives 1175mm of annual rainfall which gives it a water recharge potential of around 6000 litre per hour. The same water can be utilised to develop hydro landscape solutions. By developing approximately 50 numbers of water bodies in the depression areas, we can create a conducive environment required for tiger growth. Moreover, with the proper development of the rainwater harvesting master plan for these resorts, the water required for irrigation and landscape beautification can be retrieved. The rainwater can further be used for the development of lakes in the resort campus and the excess of this water can be diverted to the proposed water bodies in the forest areas.

**Keywords:** tiger habitat, microclimatic conditions for tigers, eco-tourism, urbanization, conducive environment for tiger growth

## Introduction

The tiger or *Panthera tigris* is one of the magnificent animals in the world. Belonging to the Felidae family and Mammalia class, this creature is admired for its beauty, feared and respected for its strength and brutality. Due to its uniqueness and importance in the forest ecosystem, it is considered a species worth conserving. India has approximately 70% of the total world's tiger. The tiger reserve forests are interconnected through ecological corridors and the habitat suitability for the survival of the tiger is idle here. However, due to rapid urbanization and boom in the tourism industry, development has started occupying forest areas. Resulting in fragmentation of green corridors, shrinking of forests, and thus degradation of tiger habitat. Tiger is one of the red-listed species as per IUCN. Therefore, proper planning of development and creating awareness to save these species from extinction is the need of the situation.

According to the reports, the number of tigers in Tadoba National Park has reached 115 in 2019 from 85 in 2018. The presence of 120hc Tadoba Lake, ample prey availability, and dense forest cover make it an ideal place for tigers to grow and survive. The area has a remarkable recreational value due to the presence of various species like sambar, wild boar, chital, crocodile, and even peacock. These species are frequently visible and are found in abundance here. Consequently, tourists from various parts of the country and other parts of the world, are attracted to witness the diverse forest ecosystems.

To fulfil these tourism demands, many resort campuses have started emerging in the vicinity of the forest boundaries. The insensitive urbanization and tourism approach can lead to soil, water contaminations, and natural habitat loss which will increase pressure on endangered species like a tiger. The urbanization near the forest boundaries will increase the cases of human-tiger conflicts. During summer seasons, water becomes a scarce commodity, as the evaporation rate is very high. To fulfil water needs, the tigress along with its cubs are often seen coming out of the buffer zone in search of water. Ultimately these settlements will have to depend on the forest resources for their operation which will lead to the exploitation of these resources, especially water.

However, tourism plays a key role in creating awareness and sensitivity towards the social, economic, and cultural values of the forest. It is also a source of income for many communities living near this area. Revenue generated through tourism can be used for the conservation and management of the forest. Hence

proper planning strategies for the resorts and a sensitive tourism approach are the need of the situation.

The presence of water bodies and a wetland environment is favourable for tiger growth. Hence hydro-landscape solutions can be provided to improve the microclimate for tiger habitat which will consequently contribute to their growth.

**Scope and Objectives of the Study**

Hydro landscape solutions are tiger-friendly as they are innovative solutions to create water bodies. The growth of the tiger is directly dependent on surface water resources and hence with this paper, the attempt is to resolve the water scarcity issues by creating the optimum number of water bodies.

**Objectives**

1. To delineate the location and aerial extent of the tiger national reserve forest and the urban growth.
2. To understand the general and reproductive behaviour of tigers.
3. To analyse, the conducive environment required for the tiger growth and strategies to improve the same.
4. To assess the impact of growing resorts on the proper growth of the tiger with special reference to macro and microclimatic conditions.
5. To develop tiger-friendly tourism strategies.
6. To design conducive environment for the tigers and tourists using hydro landscape solutions.

**Methods and Materials**

After the scope of the study, we shall be able to adopt the following methodology

**1. Demarcation of the Tadoba National Park**

a. To delineate the location and extent of the tiger reserve forest, we shall use satellite data of the forest area and demarcation of the national park as per MOEF and WII report.
b. Understand the urban growth pattern by observing satellite data of the area. Different tools like GIS and google earth will be used for the analysis purpose.
c. Aerial extend will also be confirmed using toposheet number F44T3 and F44T7 from survey of India.

**1. Remote sensing technology and literature survey through published reports, books, MOEF reports and any other information pertaining to the subject matter**

a. Climatic data, geological, hydrogeological, soil conditions, vegetation cover, vegetation type, dispersion of different wildlife in the area will be used from MOEF and WII report, zoological research institute reports, Maharashtra forest reports, and published papers to understand the forest ecology and environment.
b. Data on tiger habitat preference, its characteristics, and reproductive behaviour will be collected from various reports and research papers.
c. Remote sensing through various satellite data on platforms like ArcGIS and google earth will be done to understand existing forest density, forest cover, topography, and locations of water bodies.
d. The analysis of tiger prey like Sambar, Nilgai, and Chital in the area will be done and their possible density will be marked according to their habitat preference.
e. The different layers thus obtained through remote sensing will be overlapped to determine the most suitable habitat conditions for the tiger and possible locations to develop water bodies in Tadoba national park.

1. To evaluate environmental impact, the principal guidelines from EIA for the proper growth of the tiger vis a vis urban development with the experience through published research papers by the various scientist, ecologist planners, architects, and tourism people along with the administrator.
2. The tourism pattern of the Tadoba national park will be studied and the collective measure to attract the tourist for this purpose will be adopted with modern state of art.

In order to achieve the main objective of the paper title Design of Hydro landscape for improving tiger habitat and tourism at Tadoba tiger reserves, the published reports about hydrological impact of the urban areas by designing a rainwater harvesting master plan, waste water processing and treatment master plan, micro climatic details using eco inventory analysis of the area, along with the special reference to urban impact on tiger reserve forest to promote the tourism in this domain will be worked out with the help of above mentioned baseline information.

**Analysis and Discussion**

**Context and Geographical Extent of Tadoba National Park**

Tadoba national park falls between longitude 79°14'32"E and 79°23' 34" E and latitude 20°15' 07"N and 20°24'28"N. The entire area lies under Chandrapur district of Maharashtra state and includes Chandrapur, Bhadrawati, Chimur, Warore, and Sindewani Tehsils. As per the MOEF and WII demarcation, the extent of the area is 116.55 sqkm. Tadoba national park sharing its edges with Andhari wildlife sanctuary (509sqkm), together known as Tadoba Andhari tiger reserves.

Tadoba national park is surrounded by forests having tigers. It is located in the central part of the country and has a connection to Indravati tiger reserve, Chhattisgarh towards the south via forests of Chandrapur and Gadchiroli district. It is connected to Kanha national park through Navegoan – Nazira protected area of the state to its North-Eastern side. The conditions for tiger growth are favorable in this area. As per the joint report from the Maharashtra forest department, NNRMS, and Wildlife Institute of India in 2018, the estimated tiger population of tigers in core and buffer areas has reached 115 in 2019 from 81 in 2018.


**Fig 1:** Map showing geographical extent of Tadoba national park (Source: author generated using google imagery and demarcation by MOEF, NNRMS and WII)

**Characteristics of Tiger and Conducive environment required for tiger growth and survival**

The tiger prefers a large undistributed forested landscape with sufficient prey to raise young and maintain its long-term genetic and demographic viability. Tigers do not prefer scorching sunlight environments and hence use aspects of slopes or dense shade to rest. They like to lie down in pools or undisturbed rivers to cool down their body temperature. Camera recordings and observations confirmed that the tigers at Tadoba are usually spotted sitting in a shallow water body and are most active during the cooler parts of the day. Moreover, they use thick vegetation as cover to hide and hunt their prey. The tiger prefers bigger preys like sambar *(Cervus unicolor),* Chital *(Axis axis),* and nilgai *(Boselaphus tragocamelus*), over smaller prey like languor *(Presbytis entellus),* wild boar *(Sus scrofa*), etc. to ensure ample food for many days. (Kumar, Sivakumar, & Ramesh., 2015)

To create a conducive environment for increasing tiger density in Tadoba national park, it is very important to understand the reproductive physiology and behaviors of the tiger.

Mating of the tiger is does not depend on the seasonal variation. The oestrus period is approximately 5 days. The tigress during oestrus period becomes restless and starts marking the trees and plants with their scent by spraying urine.

Gestation period of a tigress is approximately 104 days. During this period the tigress looks for an environment where it can take rest, away from any kind of disturbances and harsh climatic conditions like excessive heat. The tigress before parturition likes to rest in an enclosed space like a den. Since the cubs when they are born are blind and cannot hunt and feed themselves, enclosed environment is needed by the tigress to ensure their safety. Just before the birth time, tigress shows changes in behaviour like restlessness, aggression. Tigress may not eat for the first few days after parturition, however fresh water should be available all the time. The tiger kills the cubs, especially the male cubs to make sure that the tigress is available to him for mating. Hence it is important that the tigress has not to go distant places for hunting and water. Artificial dens can be created in the forest areas to provide isolated and safe environment for the cubs and is close to the water bodies and prey availability.

Hence the habitat preference of tigers depends on climatic conditions, presence of water bodies, topography, prey availability, vegetation type, forest cover, soil temperature, and distance from human settlements.

**Habitat Suitability Analysis at Tadoba National Park**

The surroundings of the forest are mostly open farmlands along with the presence of dotted human settlements. Some of these settlements lie within 1km from the forest boundaries. According to the reports, there are approximately 40 upcoming resort projects too.

Tadoba national park comprises tropical dry deciduous systems of Central India. The area has teak forest, dominated mixed bamboo forest which forms medium dense tree canopy, mixed forest, riparian forest, grasslands, and scrub. The height of the trees varies between 3m to 15m.The fringe areas next to farmlands are mostly bushes and grasses with forest cover density less than 10% whereas the area adjacent to Andhari wildlife sanctuary and southern areas of the national park has thick forest cover over 20% (as shown in fig2).

Consequently, the prey population like Nilgai and Chital will be more near grass and scrub vegetated due to their habitat preference. Whereas, Sambar population is more likely to live at dense vegetated parts (Fig. 4)

A centrally located scenic lake which is 120hc in the area and is a perennial water source. The main river Andhari originates from Pandharpauni from Tadoba national park and joins river

Wainganga in the south. This river is perennial in the South of Dewad-Kolsa and retains water in small pockets. As per reports, there are 10 large water tanks in the protected areas for permanent water sources and 7 water tanks on the periphery of the forests which are recharged artificially. Moreover, water from rain gets collected in small pockets and lasts till January. Despite all this, water is scarce in this area.

The area is mostly plain except for the northern part which is a little undulating and hilly. The average elevation of the area is 284.07m above M.S.L. with 360m highest and 230m being the lowest elevation points. These hilly portions in the area give rise to many streams. (Editor: Director. 2006. Fauna ofTadoba - Andhari Tiger Reserve (Maharashtra), Conservation, 2006)

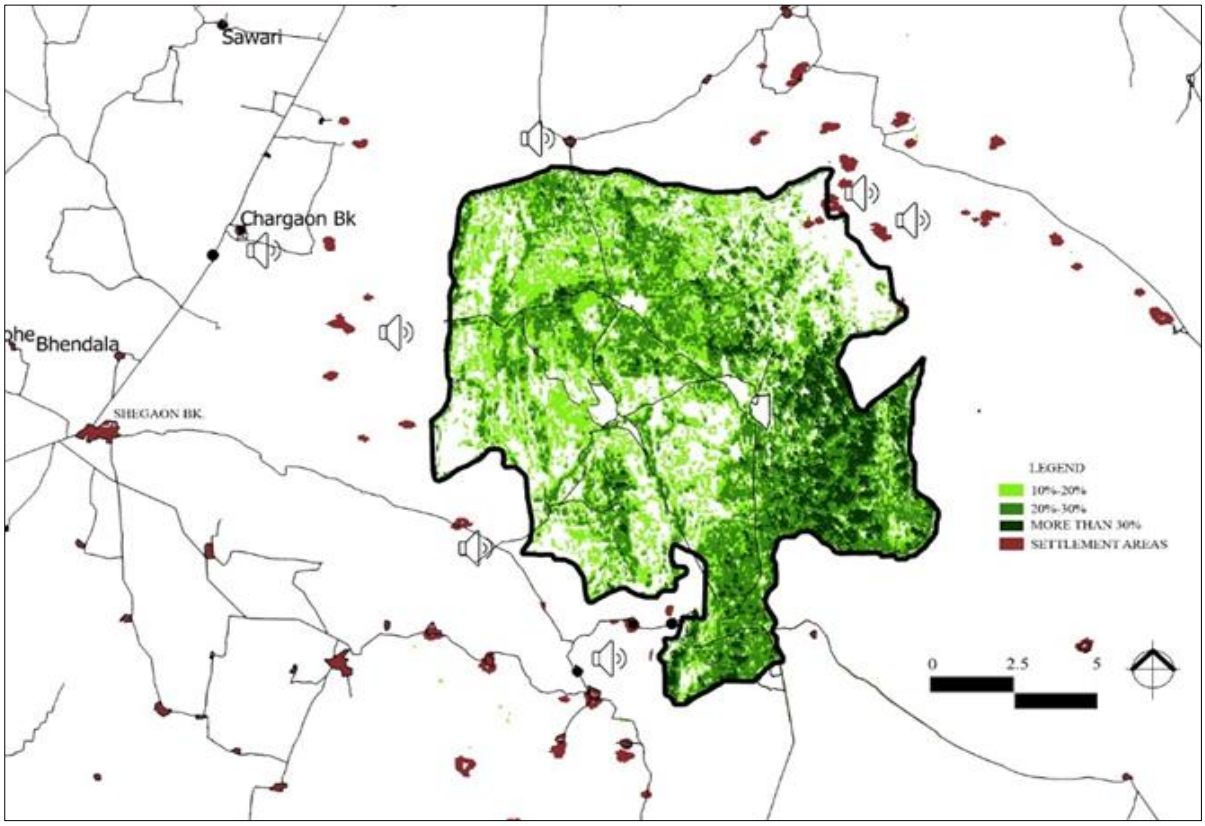


**Fig 2:** Map showing forest cover density and human settlement areas

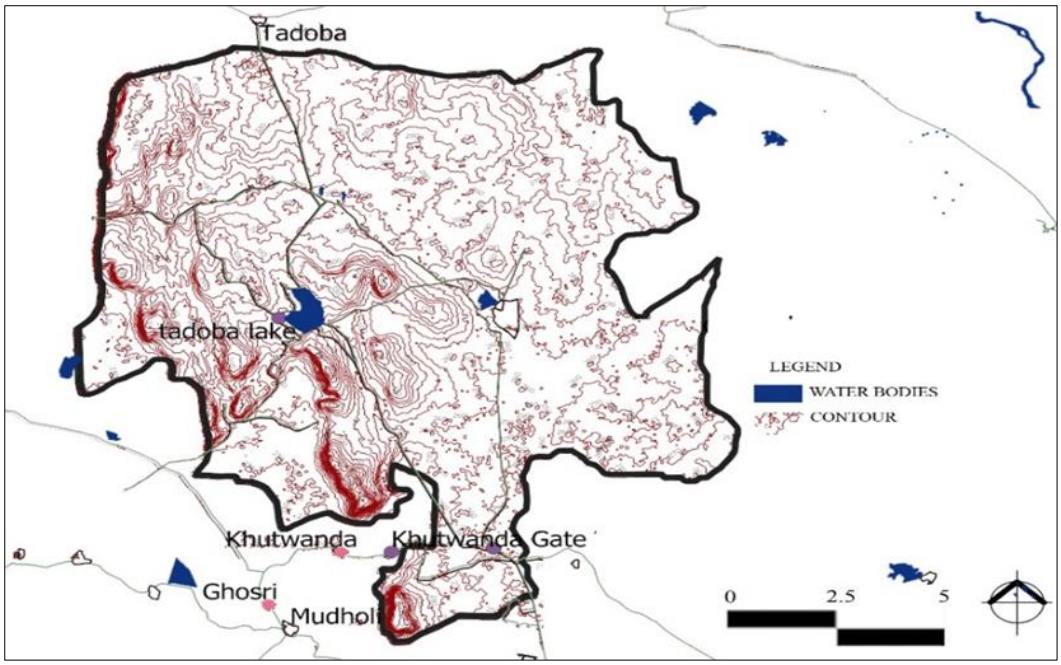


**Fig 3:** Map showing topography and existing water bodies of the area

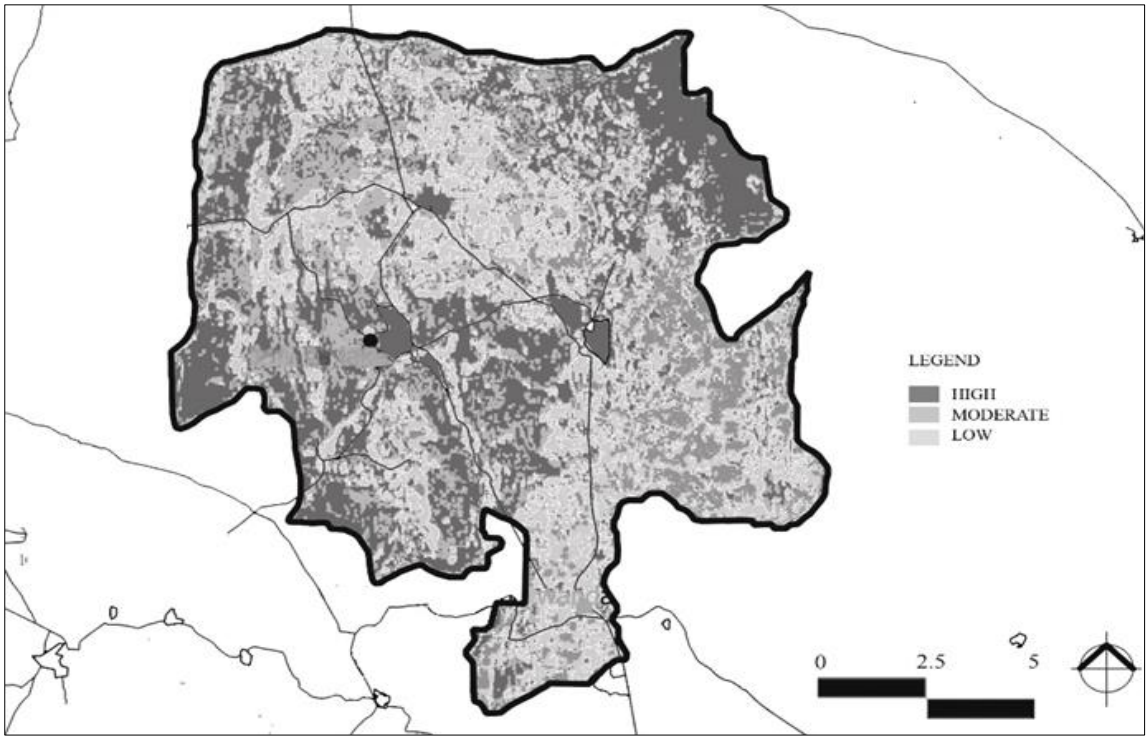


**Fig 4:** map showing high prey availability for tiger (Chital, Sambar and Nilgai)

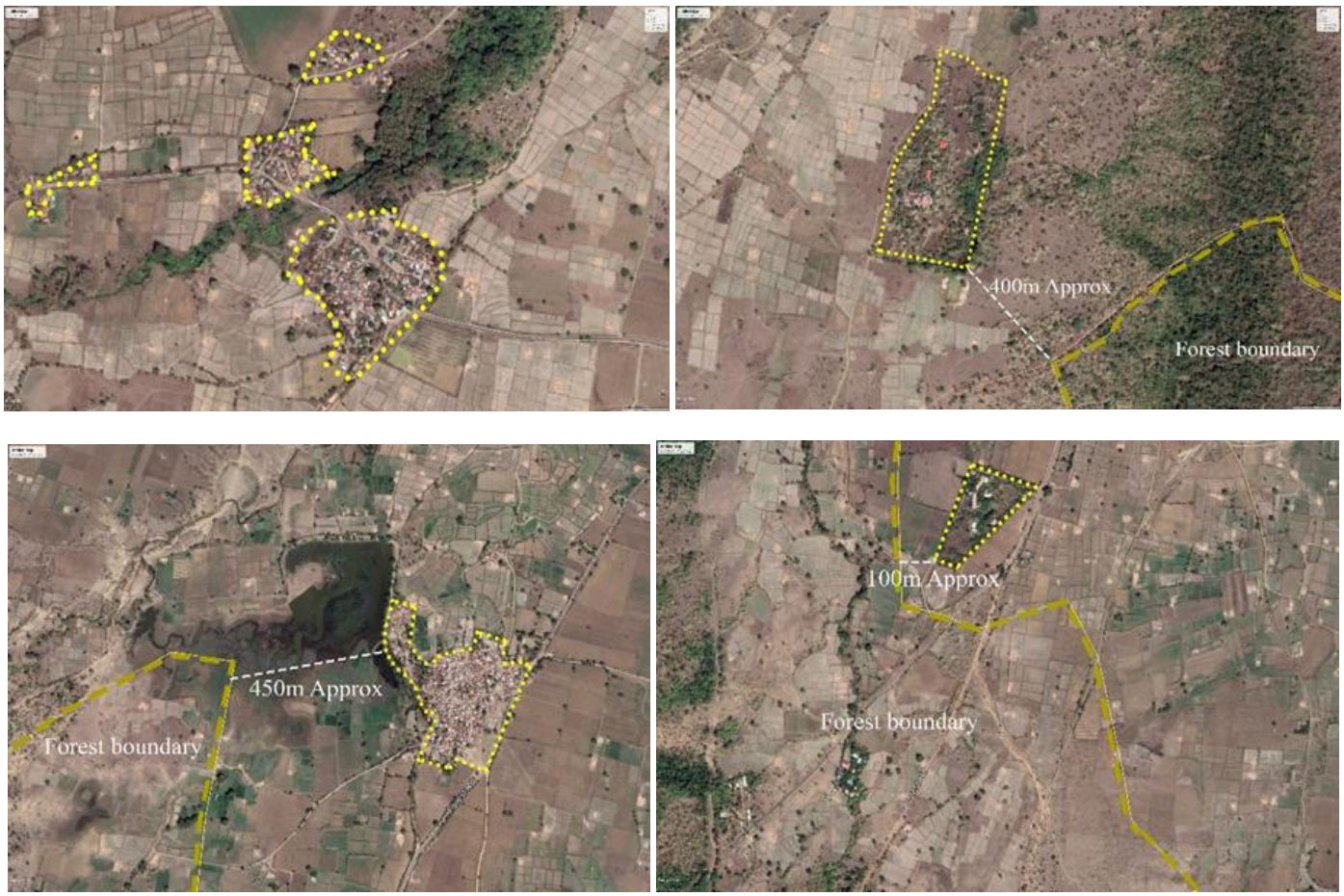


**Fig 5:** Google imagery showing urbanization pattern near Tadoba national park

**Urbanization Impact Assessment with Reference to Macro and Micro Climatic Conditions**

The urbanization growth in this area is at the starting phase and taking place without proper planning. Hence, it is important to set up guidelines for better-integrated development. An environment management plan would be a better approach towards improving the components that can impact the microclimate of the tiger habitat.

**Land Environment**

To avoid fragmentation of the tiger habitat and reduction in forest cover, the construction activities should start leaving 5km buffer margins from the forest boundaries.

The construction of resort campuses should be such that it looks like a part of the forest. Resorts can be surrounded by thick vegetation all around with recreational activities for tourists like golf, playfields, seating spaces, etc inside the campus.

The roads to reach these resorts should also be planned at the beginning phase itself. Construction of roads from inside the forest may cause accidents to the animals and hence wildlife corridors should be planned. The honking of the vehicles and high-altitude lights should also be banned as it may disturb the tiger habitat.

**Water Environment**

Although the area receives rainfall throughout the year, the water is still a scarce commodity especially in summers. The tourist occupancy rate is less during summer and monsoon seasons, so the water dependency in resorts will be comparatively less. Water requirements for the resorts can be planned using rainwater harvesting techniques in the starting phase itself. Recycling of greywater for irrigation, collection of runoff water by making artificial lakes can be done. The excess of this water can be diverted to the forest areas to improve microclimatic conditions for wildlife growth. Any provisions like a septic tank or sewage disposal should be avoided near a water body or water source as it may ill the animals after consumption.

**Vegetation**

The tigress during oestrus period starts marking trees by spraying urine on the trees. If the trees are having smooth bark, the scent will wash away and the tiger will be unable to know the requirement. Consequently, the tiger breeding will be limited. The trees with rough bark like *Lagerstroemia parviflora, Terminalia crenulate, Aegle marmelos, Diospyros melanoxylon* etc. are preferred.

Planting inside the resort campuses should be done with native plants, as it will be supported by the local climate and will require less water and maintenance for their sustainability.

**Air Environment**

The temperature near water bodies and dense vegetation areas remains less as compared to urban settlements and farmlands. The growing number of resorts will increase the heat island effect and may alter the microclimatic conditions for the forest as well. Hence, the resorts can be planned at a distance of 1km from each other to reduce the same.

The humidity level is high in the forest because of the frequent shower occurring in all months. To provide a conducive environment for the tiger, artificial lakes and resting ground can be made.

The tigers are very sensitive to smell. The smoke from DG set generator and smell from cooking may disturb the tiger. Hence, the location of these resort campuses should be opposite to the wind direction to prevent any kind of smell or pollution from entering the forest. Additionally, the noise and vibrations from the resorts in form of loud music, heavy machines, vehicles, and DG generators should be under control. The use of solar panels should be promoted as Tadoba receives great intensity of sunlight most of the days in the year.

**Aesthetic**

The tigers avoid going to the source of bright light. As they are highly active during the evening and nighttime of the day, the bright and high beam lights coming from the resorts may disturb their activities. The lighting arrangement in the resorts should be considering functional requirements only. Use of high beam lights, bright colorful lights, and up lights should be strictly prohibited. The use of bright colors for resorts should be avoided as it will lead to high albedo formations.

**Socio- Economic Aspects**

A rise in tourism and resort facilities will also attract people to find jobs for their living that will lead to the need for more settlements, small shops, and social infrastructure. Proper planning for controlled and phase-wise development should be done.

**Building Materials**

The building materials used should be of low maintenance and sustainable. Use of recycled materials such as fly-ash bricks, autoclaved aerated concrete (AAC) bricks, etc. should be encouraged.

Waste collection, treatment, and disposal is a very important aspect. Untreated waste is disposed of in the open ground may lead to the pollution of the food chain of the tiger. On top of that, the waste along with the rain may enter the water bodies and can make it unfit for consumption. Hence proper treatment of the waste should be done within the campus and the waste disposal system should be properly planned by the governing bodies in advance.

**Energy Conservation**

To prevent pollution and energy consumption for power requirements, sources of supply, backup, etc, passive solar architecture techniques should be promoted. By incorporating sustainable practices in resort design we can minimize the impacts that will create microclimatic discomforts.

**Tourism Pattern of Tadoba National Park and Strategies for Tourism Growth**

According to the reports from the Maharashtra tourism survey, the area receives the largest footfall in the month of December, January, and February. The climatic conditions are pleasant in these months and the visibility rate of the tiger is high as the temperature is pleasant for them to come out. The number of visitors is less during the summer and monsoon seasons. The tourism activities in pristine areas such as Tadoba National park

will create a sense of awareness and appreciation towards the forest and its species. Apart from that, tourism can provide economic support and livelihood to the local communities. However, the prime objective of preserving the forest and its species should not be compromised at any cost. Therefore, tourism strategies should be developed to ensure the proper growth of the forest and wildlife.

**Planning**

Proper planning of tourism activities which will include

a. Tourism activities permitted in the forest area
b. Limiting number of visitors at a time

**Demarcation of the Tourist Areas**

a. To prevent disturbances to the tiger breeding activities, tourist activities should be prohibited inside the core parts of the tiger habitat.

Planning of roads for visitors should not be done in the core zone

**Monitoring Arrangements**

a. The movement and availability of the tiger should be monitored with the help of the camera and the visitors can be allowed in specific areas and time accordingly.
b. The resorts can be digitally modified by making provisions for the live visuals from the forest areas along with the binocular arrangements to observe tiger activities without actually disturbing them.

**Avoiding Vehicular Pollution**

The oil spills by the vehicles used in safaris may enter water bodies along with the stormwater and can contaminate it for tiger consumption. The use of battery-operated cars can solve the issue.

**Design of Hydro Landscape for Improving Tiger Habitat and Tourism at Tadoba Tiger Reserves**

To support the tiger's growth and improve microclimatic conditions in its habitat, we need to develop water bodies and resting grounds in the core areas of Tadoba national park. For this purpose, we need to prepare a water harvesting master plan for the upcoming resorts. As per reports, the area gets 90%of its rainfall in the months of July, August, and September and the rest 10% in other months. The average rainfall is about 1227mm per year with humidity varying from 17% to 89%. Temperature varies from 4°C to 44°C and the evaporation rate is about 1.1m which is very high

.

**Relationship between Soil, Vegetation and Water**

The observation from google imagery shows that the water after rain gets collected in areas with depression and can be seen till October. This observation indicates the presence of black cotton soil which prevents the water to seep away into the ground. Additionally, the vegetation pattern in these catchment zones is sparse.

By developing these catchment areas, we can make approximately 50 numbers of water bodies and resting grounds for tigers. To improve microclimatic conditions in the resort premises as well as in the forest, the rainwater collected from resorts can be used to develop a lake inside the resort, and then the excess of this water can be diverted to the forest to feed proposed water bodies. The availability of water quantity from these resort campuses can be calculated using the empirical formula.

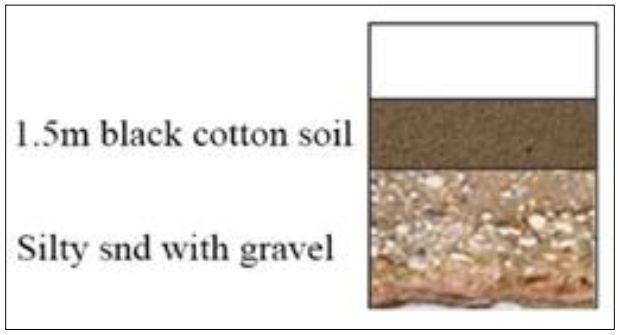


**Fig 6:** Present soil condition

The water bodies may get dry quickly because of the high evaporation rate and seepage losses. To make these water bodies sustainable, we will have to do suitable surface treatment for them. The area has black cotton soil on the top layer up to 1.5m, followed by silty sand mixed with highly permeable gravel. In the lake digging process, the retaining material i.e., black cotton soil will be removed. Hence, to retain the water, we will have to design a geomembrane base for the lake. There are three ways of retention-

a. Rubber – It will be a costly solution and can get penetrations due to uneven surface.
b. Plastic geomembrane – considering the heat and temperature at Tadoba national park, this is also not going to work
c. The third solution is providing a geomembrane made up of clay and bentonite.

We will have to dig the entire area where the lake has to be built. The depth of the lake may vary from 2.2m to 3m as evaporation loss is also there. The base can be filled with 20cm of clay mixed with 5% of hydraulic cement and ESS material like bentonite.

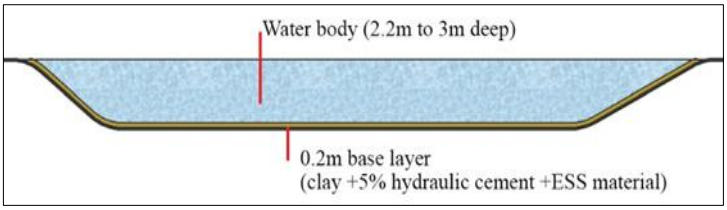


**Fig 7:** Proposed base treatment for water bodies

In this way we can design, various scattered water bodies and lake in the core areas. This kind of solution will help in tiger growth.

**Conclusion and Recommendations**

Tadoba national park has great potential to support tiger growth. Consequently, tourism activities and urbanization will take a great leap that can highly disturb the microclimate of the forest. Additionally, issues like water scarcity, pollution, and reduction of forest cover may impact the tiger habitat and growth. However, with the help of proper planning and strategies, as discussed in the paper, we can look forward to integrated development.

The following specific conclusion has been made for the study area:

a. The Tadoba national park was delineated using satellite imagery, GIS, and the boundary extent provided by MOEF, NNRMS, and WII which gives the idea about the extent and surroundings of the national park. The data thus obtained is very useful for analysis and to understand the possible intervention zones for the betterment of future tiger growth along with careful tourism planning. The delineation is also important to provide guidelines regarding the minimum distance that is required between wildlife boundaries and urban growth.
b. Since the reproductive behavior of the tiger has got the specific areas. Therefore, they should be demarcated and protected properly from tourism and other human activities to ensure the privacy and isolation of the tiger. The same areas have been demarcated on the map.
c. The conducive environment for tiger growth is the water bodies surrounded by the bushes to protect the tiger from excessive heat. The tiger after hunting and eating raw meat of its prey develops high cholesterol levels, therefore, it is natural that the tiger will feel very hot especially in hot seasons. Since the area has got the basaltic rock and due to ferromagnesium mineral, the area becomes very hot. Therefore, the heat component should be compensated by providing water bodies and wetlands. In other words, the suitable hydro landscape by conducting the eco-inventory in relationship with soil, water, and vegetation should be developed properly.
d. There is a demarcated boundary based on the climatic and microclimatic conditions along with the nature of the habitats of different wildlife especially the tiger. However, tourist development is also required. To deal with this critical issue, the hydro landscape parameters such as control of temperature, radiation, humidity, albedo formation, wind flow direction, etc. should be deal firmly with the help of the hydro landscape i.e., the detailing of the water bodies surrounded by the bushes and the wind tunnel along with the soil and rock configuration of the base should be done properly.
e. Ecology plays a very important here and the national park like Tadoba cannot afford the biodiversity loss. However, the development of tourism is a critical area where safaris and other tourist vehicles are encroaching upon the specific habitats of the tiger especially in its reproductive zones or the mating ground. Additionally, the growth of the tiger also depends upon its hunting ability which is only possible when all other wild animals grow properly. To control the proper growth, the conducive environment of the suitable hydro landscape for these animals should be provided which is only possible by Eco inventory analysis of the forest.

The above-mentioned parameters are clearly indicating that the proper growth of hydro landscape for the study area is required. Proper growth of soil water and vegetation is possible by suitable analysis of eco inventory to control the microclimate and to make area suitable for the wild animals especially tigers and tourism.

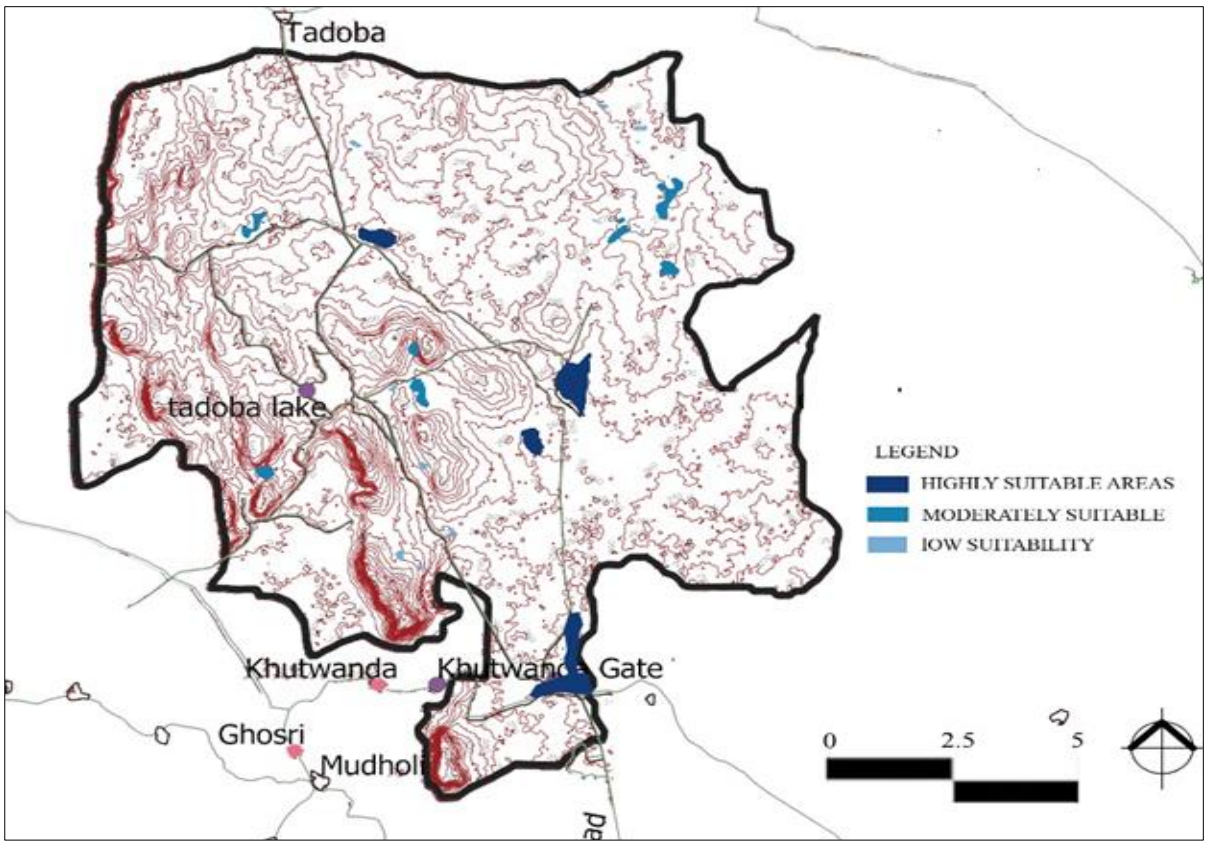


**Fig 8:** Area suitability map for proposed water bodies

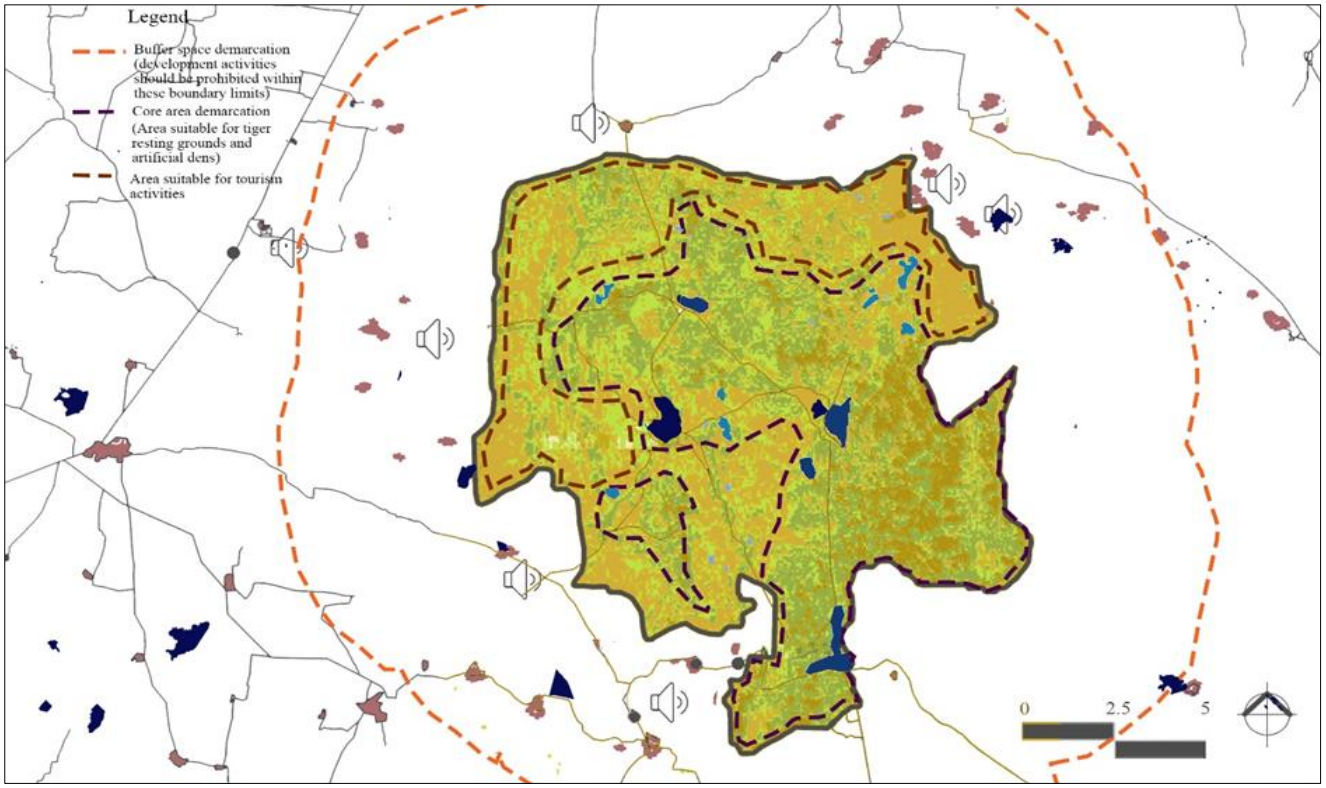


**Fig 9:** Map showing area demarcation for different recommended activities at Tadoba national park (map obtained by overlapping forest cover, prey availability and water bodies)

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