

# Assessment of Wildlife Connectivity inside a Protected Area Using Circuit Theory Approach

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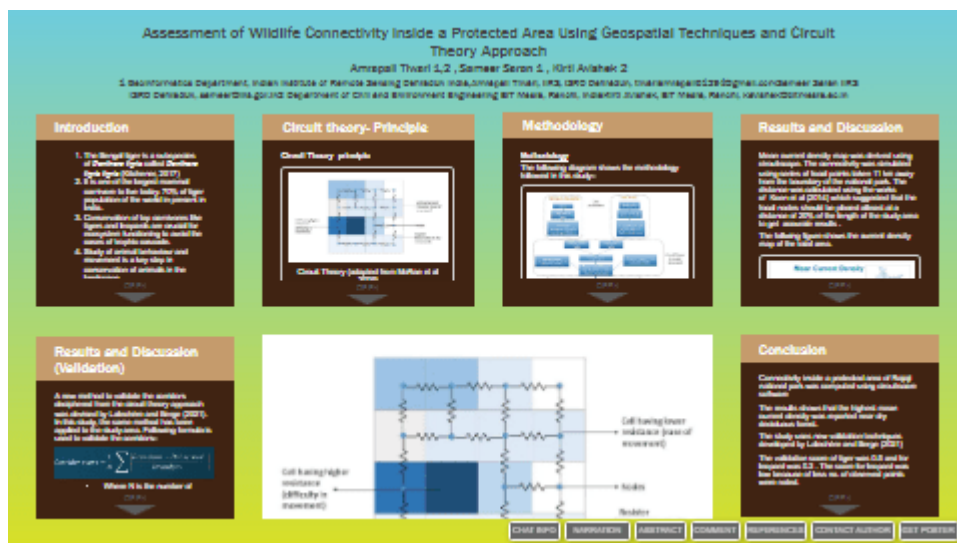
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Animal behaviour such as dispersal and migration ensure their survival in the landscape. It has been established in the past few decades that wildlife conservation and study of their movement in the wilderness is vital for sustainable ecosystem. Thus, identification of regions having high movement permeability for planning and maintenance of functional wildlife corridors has turn out to be a fundamental requirement for habitat management. This study emphases on movement of big cats- Bengal Tiger (*Panthera tigris tigris*) and Leopard (*Panthera pardus fusca*) in the protected area of Rajaji National Park situated in Uttarakhand State of India. The National park is a designated tiger reserve with large amount of tigers and leopards at its disposal. Here, Circuitscape was used to generate connectivity map of the study area. The results were validated using occurrence points downloaded from GBIF. The habitat suitability and resistance of the landscape was estimated based on literature review and expert opinion survey. Since, both the species have comparable ecological niche, similar habitat parameters were used for generation of resistance map of the species. Occurrence points for the species were downloaded from GBIF. 60% of the points were used as nodes or focal points where species presence is recorded whereas 40% of the points were used in validation of the connectivity paths. Results depicts the current density map of the study area highlighting areas with high connectivity for the species.

# Assessment of Wildlife Connectivity inside a Protected Area Using Geospatial Techniques and Circuit Theory Approach



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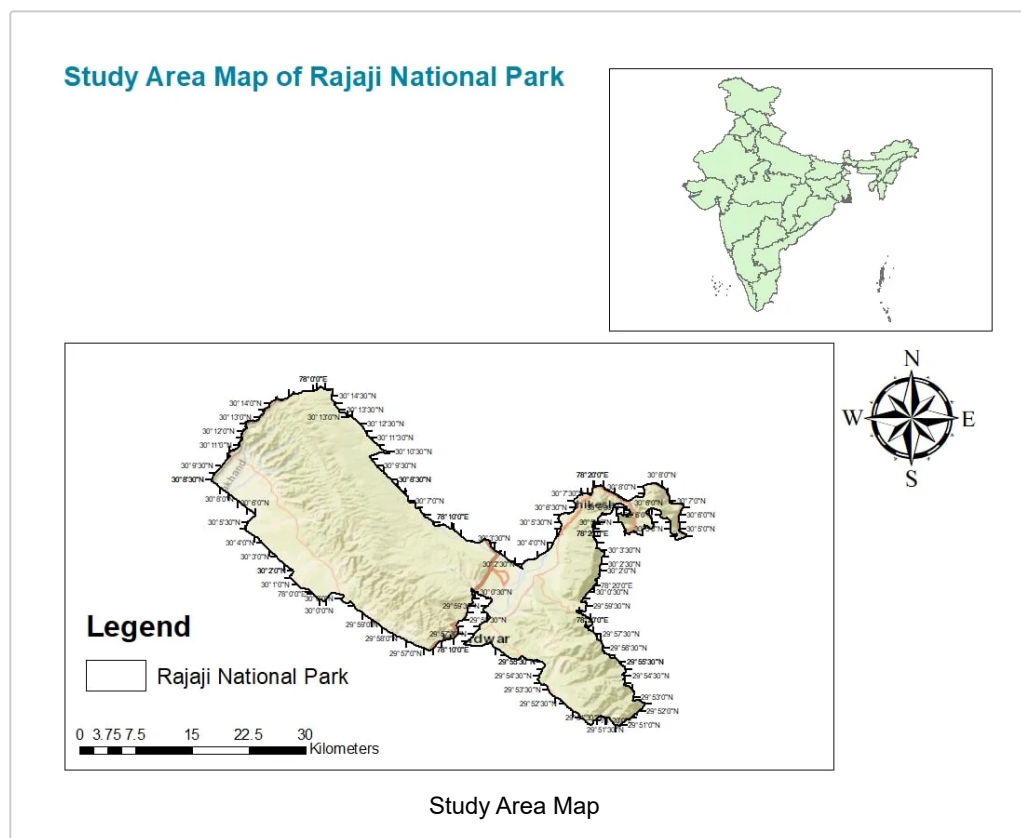


## INTRODUCTION

1. The Bengal tiger is a subspecies of *Panthera tigris* called *Panthera tigris tigris* (Kitchener, 2017)
2. It is one of the largest mammal carnivore to live today. 70% of tiger population of the world is present in India.
3. Conservation of top carnivores like tigers and leopards are crucial for ecosystem functioning to avoid the cases of trophic cascade.
4. Study of animal behaviour and movement is a key step in conservation of animals in the landscape.

In this study, movement of top carnivores like tigers and leopard are studied. CircuitScape is used to model the connectivity of tigers in Rajaji National Park of Uttarakhand state of India.

### Study Area

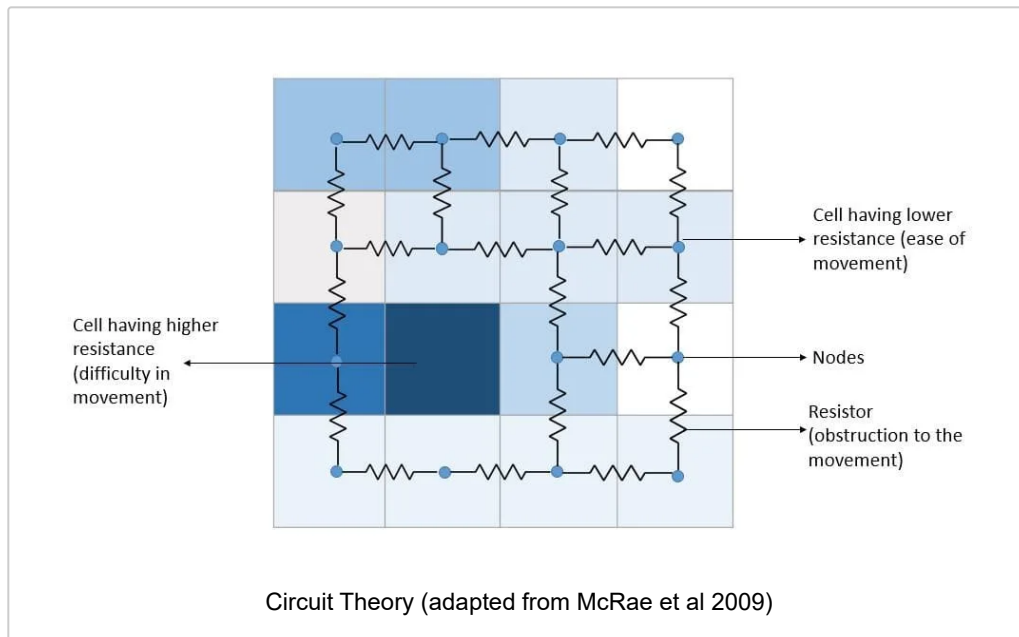


### Rajaji National park

Rajaji national park is spread in the area of 390 km<sup>2</sup> in shivalik foothills. It is spread across Haridwar, Dehradun and Pauri districts of Uttarakhand. Vegetation in the area is usually tropical moist deciduous forest with vegetation like *Terminalia bellirica* (Bahera), *Shorea robusta* (Sal), *Mallotus philippinensis* (Rohini), *Acacia catechu* (Khair), *Ficus bengalensis* (Bar) and *Dalbergia sissoo* (Shisham), *Adina cordifolia* (Haldu). It is a natural habitat of Asian elephants (*Elephas maximus*). Other animals found in the national park are *Axis axis* (Spotted deer), *Cervus unicolor* (Sambhar), *Sus scrofa* (Wild boar), *Ophiophagus hannah* (King cobra), *Muntiacus muntjak* (Barking deer), *Panthera tigris* (tiger), *Panthera pardus* (leopard) and *Hyaena hyaena* (Hyaena) (R. Joshi, 2009)

## CIRCUIT THEORY- PRINCIPLE

### Circuit Theory- principle

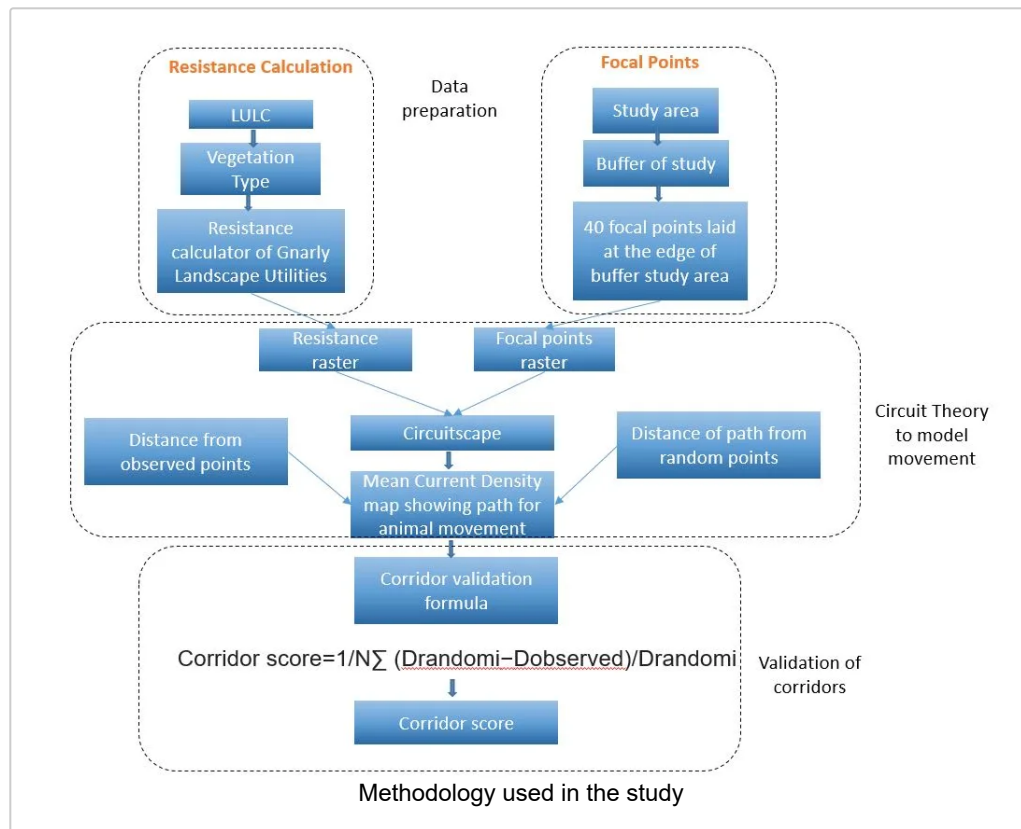


In circuit theory, an analogy is made between flows of current in the electrical circuits with the movement of organisms in ecological landscapes. Electrical concepts of current, voltage, charge, resistance applies here. Laws governing the flow of current is used to develop an understanding of animal movement in the landscape (Carroll et al., 2012). According to McRae et al. resistance in the electrical circuit is interpreted as obstructions present in the path of animals and conductance of electrical circuit as habitat permeability. Current flowing through the circuit can be used to compute the expected probabilities of movement of random walkers. Voltage or potential difference is used to predict the probability that random walkers would leave any point in the landscape and reach the destination before another.

# METHODOLOGY

## Methodology

The following diagram shows the methodology followed in this study:-



In this study, circuit theory is used to compute the connectivity inside the Rajaji National park.

### *Resistance*

Land use and vegetation type are considered primary parameters that are used to optimize the resistance surface for the study area. The gnarly Landscape utility toolbox is used to execute the process. The resistance surface indicates the amount of resistance incurred by the animal while moving across the landscape.

### *Focal Points*

Focal points are the regions between which connectivity is to be modeled. For this study, firstly a buffer of 20% of the length of the rectangular study area was taken around the study area. Focal points were taken at the boundary of the buffer region. This step was particularly important to reduce the biases caused by placing the focal points at the boundary of the study area (Koen et al., 2014).

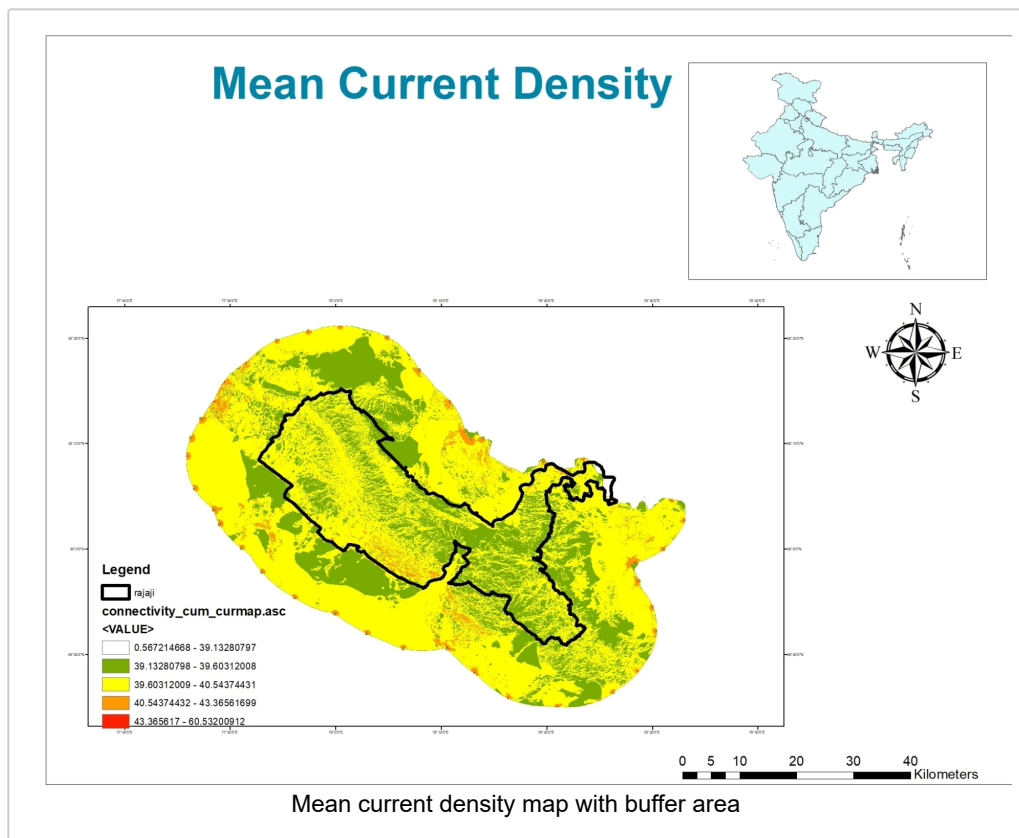
### *Circuitscape*

Circuitscape uses the circuit theory approach to model connectivity in the landscape. It uses resistance surface and focal points as input and gives mean current density as output. For this study, circuitscape was run in pairwise mode.

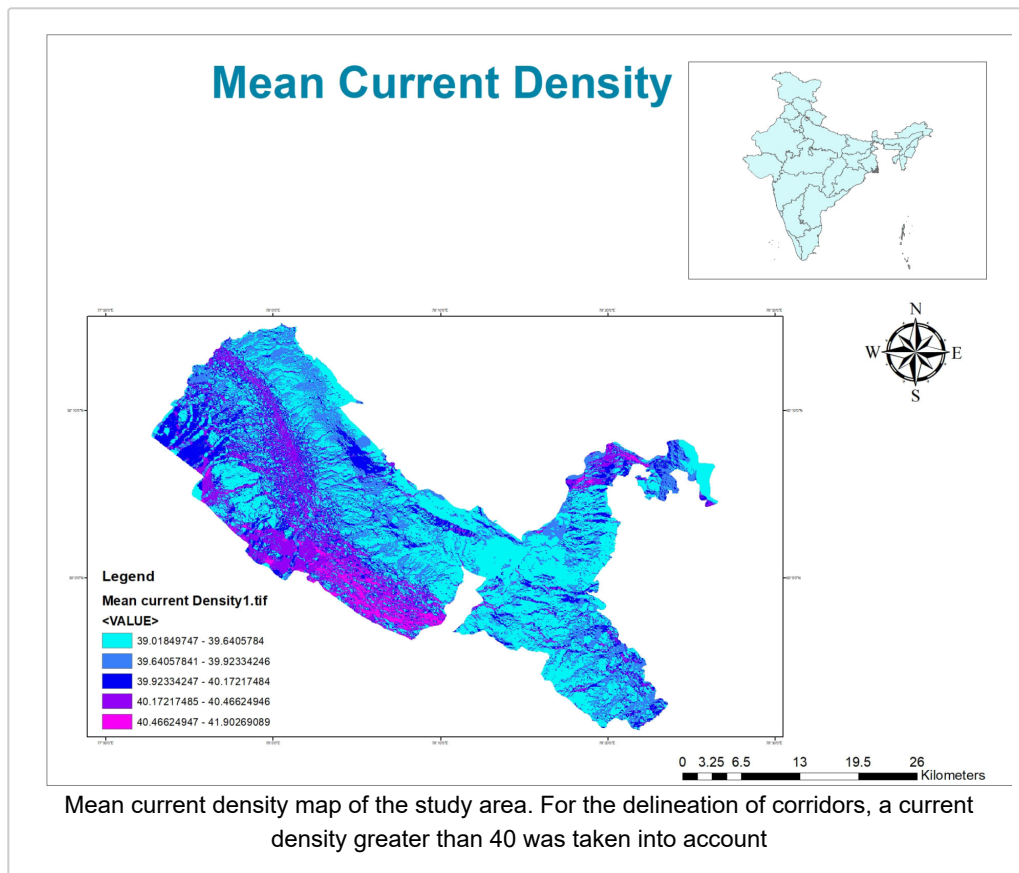
## RESULTS AND DISCUSSION

Mean current density map was derived using circuitscape. The connectivity was simulated using series of focal points taken 11 km away from the boundary of the national park. The distance was calculated using the works of Koen et al (2014) which suggested that the focal nodes should be placed atleast at a distance of 20% of the length of the study area to get accurate results .

The following figure shows the current density map of the total area.



The black boundary shows the boundary of the national park.



High current density is observed at the dry deciduous forest. The high current density areas also shows the 'pinch points areas' with respect to conservation of species. These are the areas where change in habitat loss or fragmentation could lead to complete loss of connectivity in the area.

## RESULTS AND DISCUSSION (VALIDATION)

A new method to validate the corridors deciphered from the circuit theory approach was devised by Lalechère and Berge (2021). In this study, the same method has been applied to the study area. Following formula is used to validate the corridors:-

$$\text{Corridor score} = \frac{1}{N} \sum \left[ \frac{D_{\text{random } i} - D_{\text{observed}}}{D_{\text{random } i}} \right]$$

- Where N is the number of random draws i,
- $D_{\text{random } i}$  is the average cost distance (or Euclidean distance) to the corridors from randomly selected points in the landscape for draw i,
- $D_{\text{observed}}$  is the average cost distance (or Euclidean distance) to the corridors from the validation points

validation of the pathways for two carnivores:-

### For Tigers:-

Observed points:100

Random points:100

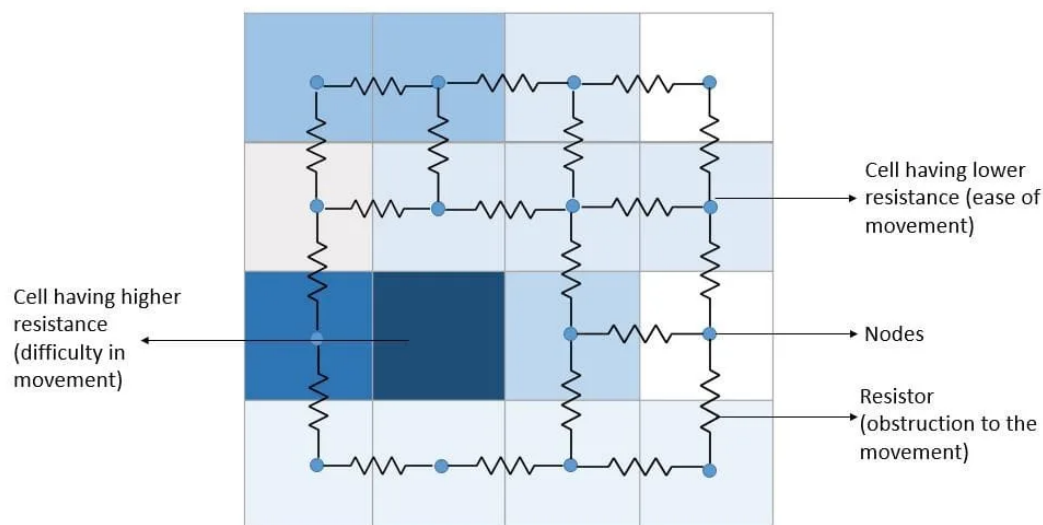
corridor score calculated for Tiger: 0.5

### For Leopards:-

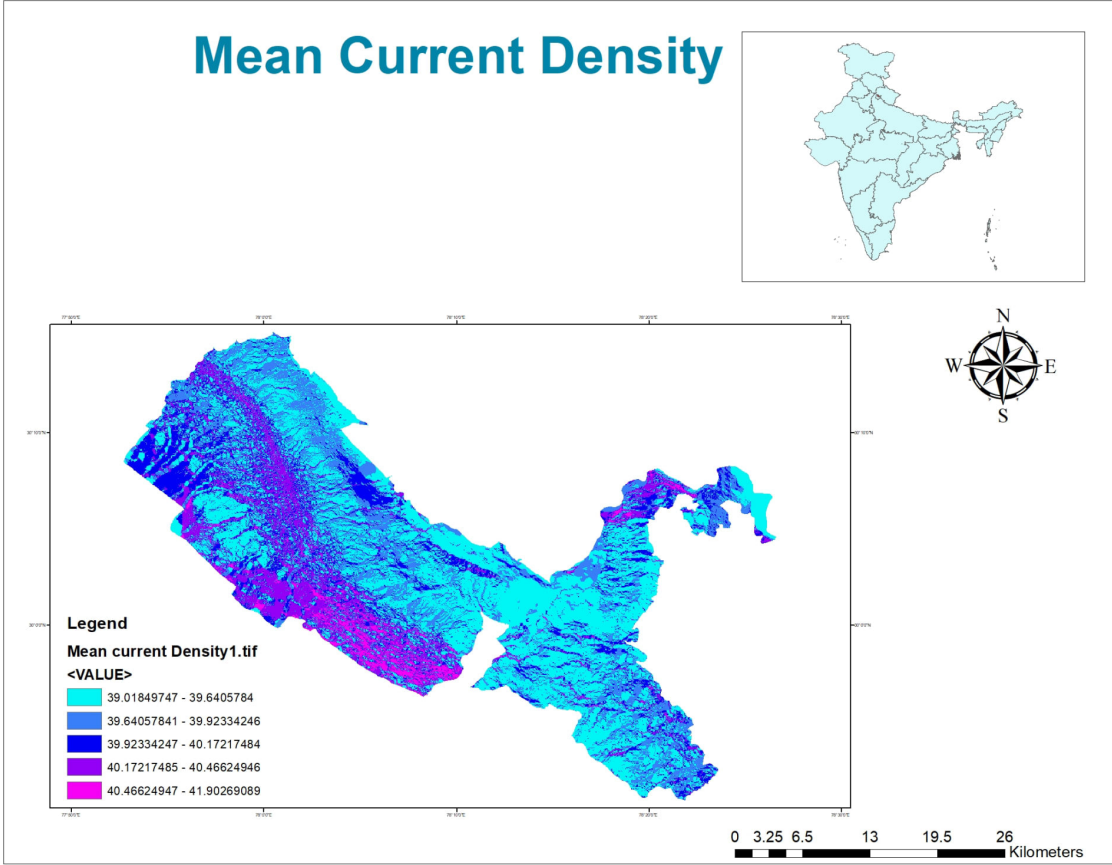
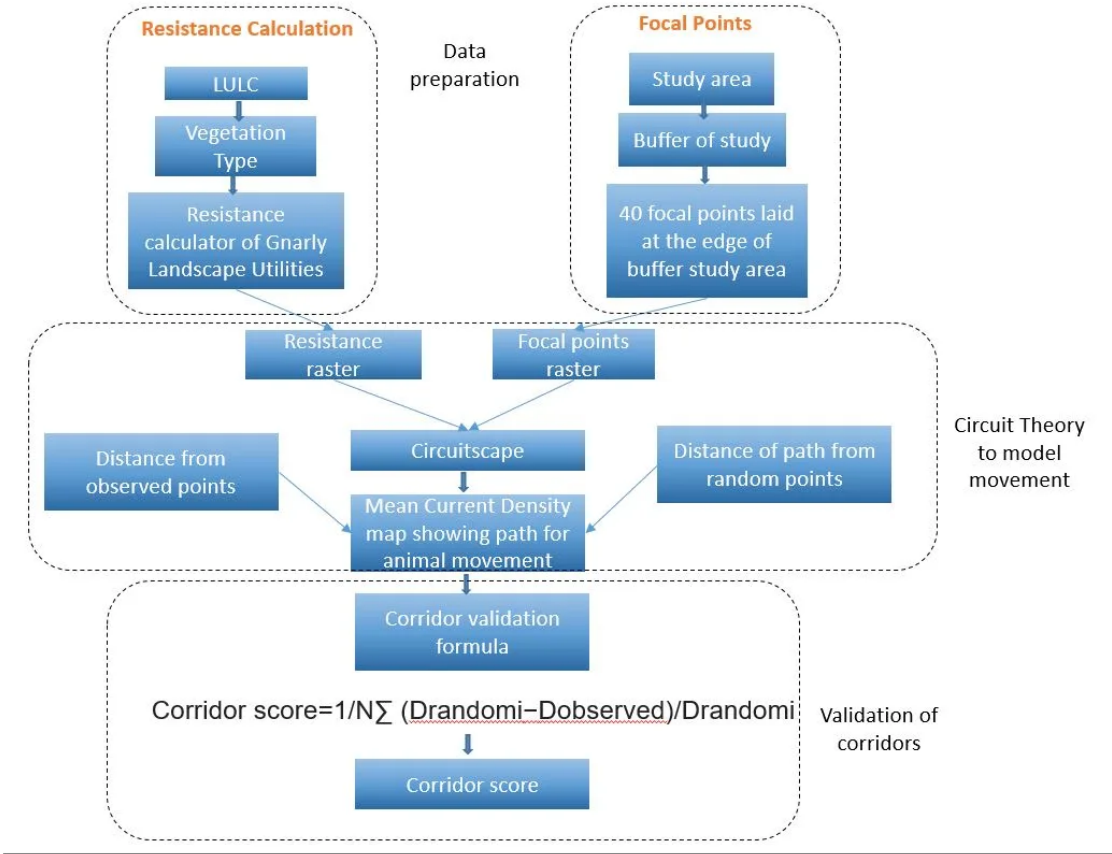
Observed points:20

Random points:20

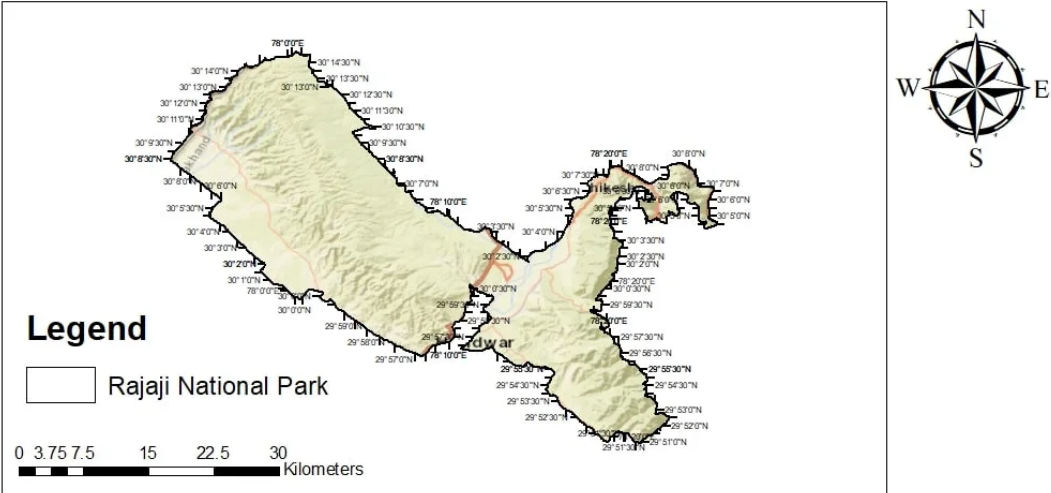
Corridor score calculated for Leopard: 0.3







Study Area Map of Rajaji National Park



## CONCLUSION

Connectivity inside a protected area of Rajaji national park was computed using circuitscare software

The results shows that the highest mean current density was reported near dry deciduous forest.

The study uses new validation techniques developed by Lalechère and Berge (2021)

The validation score of tiger was 0.5 and for leopard was 0.3 . The score for leopard was low because of less no. of observed points were noted.

Such studies are important in case of conservation biology because it helps in understanding connectivity inside the protected area and also between protected areas. Such studies are of paramount importance in addressing the cases of human animal conflicts.

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## ABSTRACT

Animal behaviors such as dispersal and migration ensure their survival in the landscape. It has been established in the past few decades that wildlife conservation and the study of their movement in the wilderness is vital for a sustainable ecosystem. Thus, the identification of regions having high movement permeability for planning and maintenance of functional wildlife corridors has to be a fundamental requirement for habitat management. This study emphasizes the movement of big cats- Bengal Tigers (*Panthera tigris tigris*) and Leopards (*Panthera pardus fusca*) in the protected area of Rajaji National Park situated in the Uttarakhand State of India owing to their influence on human-animal conflict in the region. The National Park is a designated tiger reserve with a large number of tigers and leopards at its disposal. In this study, Circuitscape was used to generate a connectivity map of the study area. The results were validated by calculating the corridor score using occurrence points downloaded from GBIF. The habitat suitability and resistance of the landscape were estimated using literature review/expert opinion survey and land use land cover maps generated from remote sensing satellite data of the study area. Since both the species have a comparable ecological niche, similar habitat parameters were used for the generation of a resistance map of the species. Occurrence points for the species were downloaded from GBIF including data from camera traps of the Wildlife Institute of India. 60% of the points were used as nodes or focal points where species presence is recorded whereas 40% of the points were used in the calculation of corridor score for validation of the connectivity paths. Results depict the current density map of the study area highlighting areas with high connectivity for the species allowing policymakers to make informed decisions for conservation and planning.

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