

# **FOREST FRAGMENTS**

in Eastern Vidarbha Landscape

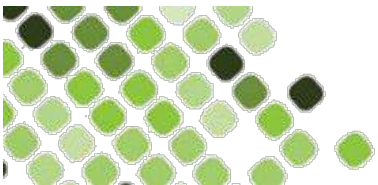
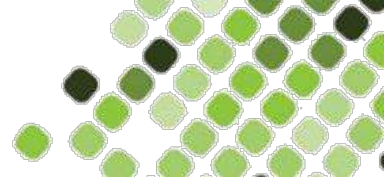
# **MAHARASHTRA**

## **THE TIG - SAW PUZZLE**



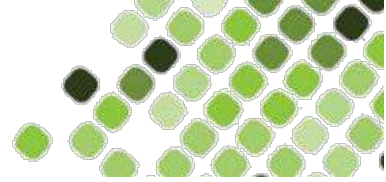
## THE TIG - SAW PUZZLE

Forest Fragments in Eastern Vidarbha  
Landscape, Maharashtra



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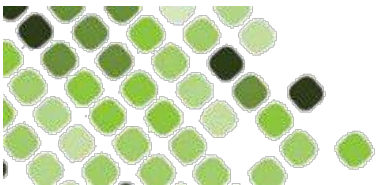


# FOREST FRAGMENTS in Eastern Vidarbha Landscape MAHARASHTRA

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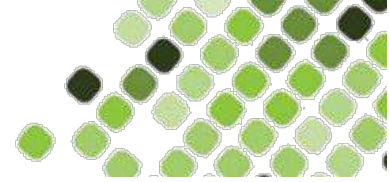


भारतीय वन्यजीव संस्थान  
Wildlife Institute of India



## THE TIG - SAW PUZZLE

Forest Fragments in Eastern Vidarbha  
Landscape, Maharashtra



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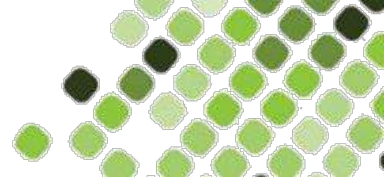
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**Forest Cover Data:** Forest cover data for the year 2014 at a spatial resolution of 23.5 m from Survey of India.

**Citation:** Habib, B., Nigam, P., Mondol, I., Ghaskadbi, P and Hussain, Z. (2018): Forest Fragments in Eastern Vidarbha Landscape, Maharashtra. The Tig – Saw Puzzle. Wildlife Institute of India and Maharashtra Forest Department – TR No. 2018/17 Pp 37.



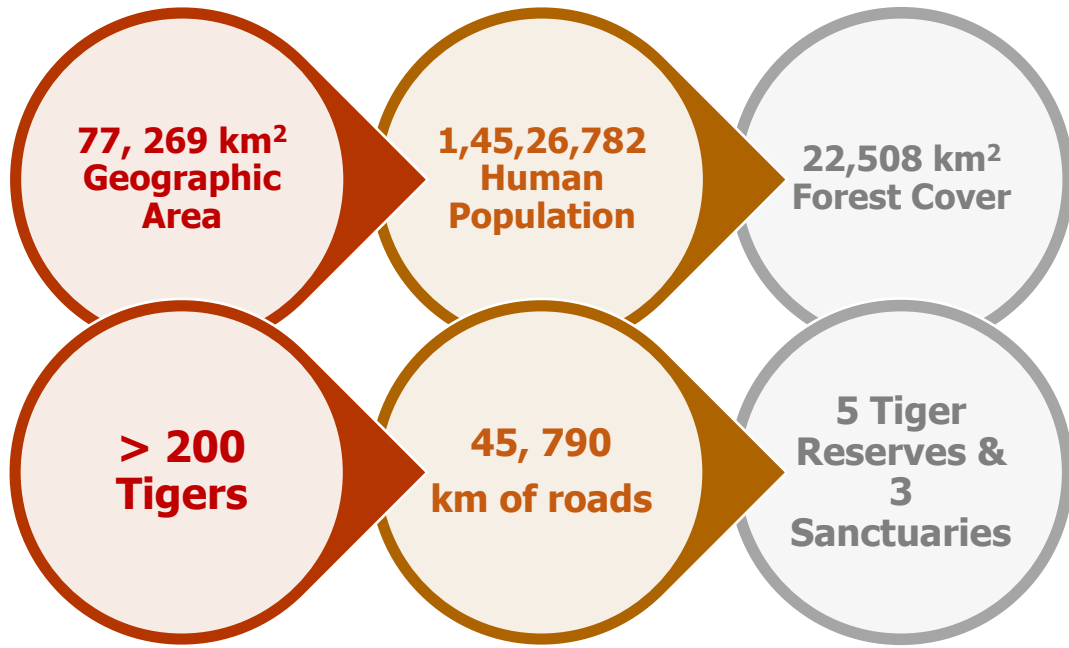
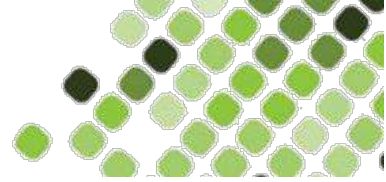


This report is an outcome of discussion with Shri. A. K. Mishra, Principal Chief Conservator of Forests (Wildlife), Chief Wildlife Warden, Govt. of Maharashtra. The main objective of the report is to understand the issues of human – wildlife conflict with respect to size and location of the forest fragments in the State of Maharashtra.

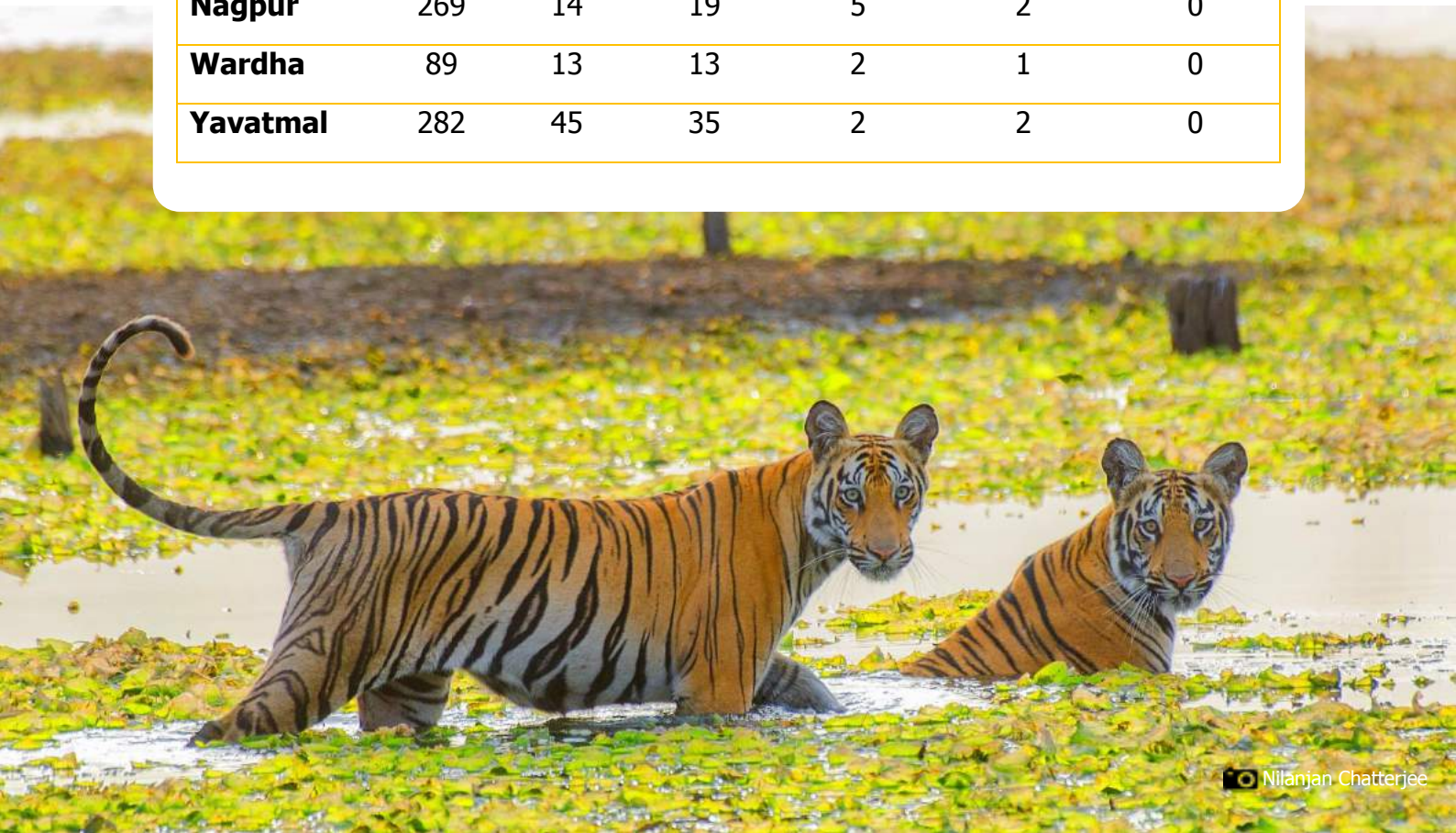


## THE TIG - SAW PUZZLE

Forest Fragments in Eastern Vidarbha  
Landscape, Maharashtra



District	Fragment Size (Sq. km)					
	1 to 5	5 to 10	10 to 50	50 to 100	100 to 500	Above 500
Bhandara	98	10	8	4	1	0
Chandrapur	412	58	42	4	3	1
Gadchiroli	812	82	66	6	4	4
Gondiya	196	125	18	1	3	1
Nagpur	269	14	19	5	2	0
Wardha	89	13	13	2	1	0
Yavatmal	282	45	35	2	2	0



## Introduction

The tiger is included among the list of the most threatened carnivores in the world. They have seen rapid decline in their numbers across their range which in itself has seen a 93% reduction (Wikramanayake et al., 1998). With increase in human population, loss of habitat, poaching and prey decline the future for tigers in the world seems bleak (Dinerstein & Wikramanayake, 1993; Nowell & Jackson, 1996). Unfortunately, several protected areas harbouring tigers are relatively small in size and isolated (Dinerstein & Wikramanayake, 1993), and under such scenarios the long term survival of tigers has a slim chance (Seidensticker, 1987; Rabinowitz, 1993). Therefore it is imperative that these habitats are connected to allow for dispersal of tigers. To add insult to injury, existing corridor habitats are highly fragmented and facing high levels of anthropogenic pressure, and a detailed assessment is required to understand on-ground scenarios.

In the Indian subcontinent bioregion, which also includes Nepal and Bangladesh, Wikramanayake et al., (1998) identified 59 Tiger Conservation Units (TCUs) which cover an area of 325,575 km<sup>2</sup>, of which only 54,945 km<sup>2</sup> (16.87%) are protected. The Central Indian landscape (CIL) contains 107,440 km<sup>2</sup> of TCUs of which 59,465 km<sup>2</sup> are Level I and Level II TCUs (Wikramanayake et al., 1998). The CIL and Eastern Ghats supports about 18% of the global tiger population and had been identified as a global priority landscape for tiger conservation (Sanderson et al., 2010). The Central Indian tiger population, although functionally connected, suffers from the presence of highly fragmented corridors and loss of habitat to agriculture. Although a lot of research have been carried out to study the genetic connectivity of the landscape, none have attempted to study the patch characteristics of the fragmented remnants of forests in the corridors.

This study aims to analyse the patch characteristics of forests outside PAs and in corridors, to inform the forest management of the magnitude of fragmentation in the landscape which will enable them to draw better informed policies to aid long term tiger conservation in the landscape.

## Study Area

This study has been carried out in six districts (Bhandara, Chandrapur, Gadchiroli, Gondia, Nagpur and Wardha) of the Nagpur division and one district (Yavatmal) of the Amravati division in the state of Maharashtra, India (Figure 1). The study area lies between 18° 40' 32.45" N to 21° 41' 48.10" N and 77° 15' 39.93" E to 80° 54' 26.11" E. It houses a human population of 1, 45, 26, 782 people (Source: Census of India, 2011) in a geographical area of about 77, 169 km<sup>2</sup>. The study area has a total forest cover of 22, 508 km<sup>2</sup> which is 34.65% of the total geographical area (Source: India State of Forest Report, 2017). It lies within the Deccan Plateau biogeographic zone (Rodgers and Panwar, 1988) and dominant vegetation type is dry deciduous forests (Champion and Seth, 1968). This area also harbours a population of about 200 tigers or more, both inside and outside PAs. This area is dissected by 45,790 km of roads (as on March 2016) with consists of National Highways, State Highways, District Roads and Village Roads (Source: Public Works Department, Maharashtra).

# THE TIG - SAW PUZZLE

Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

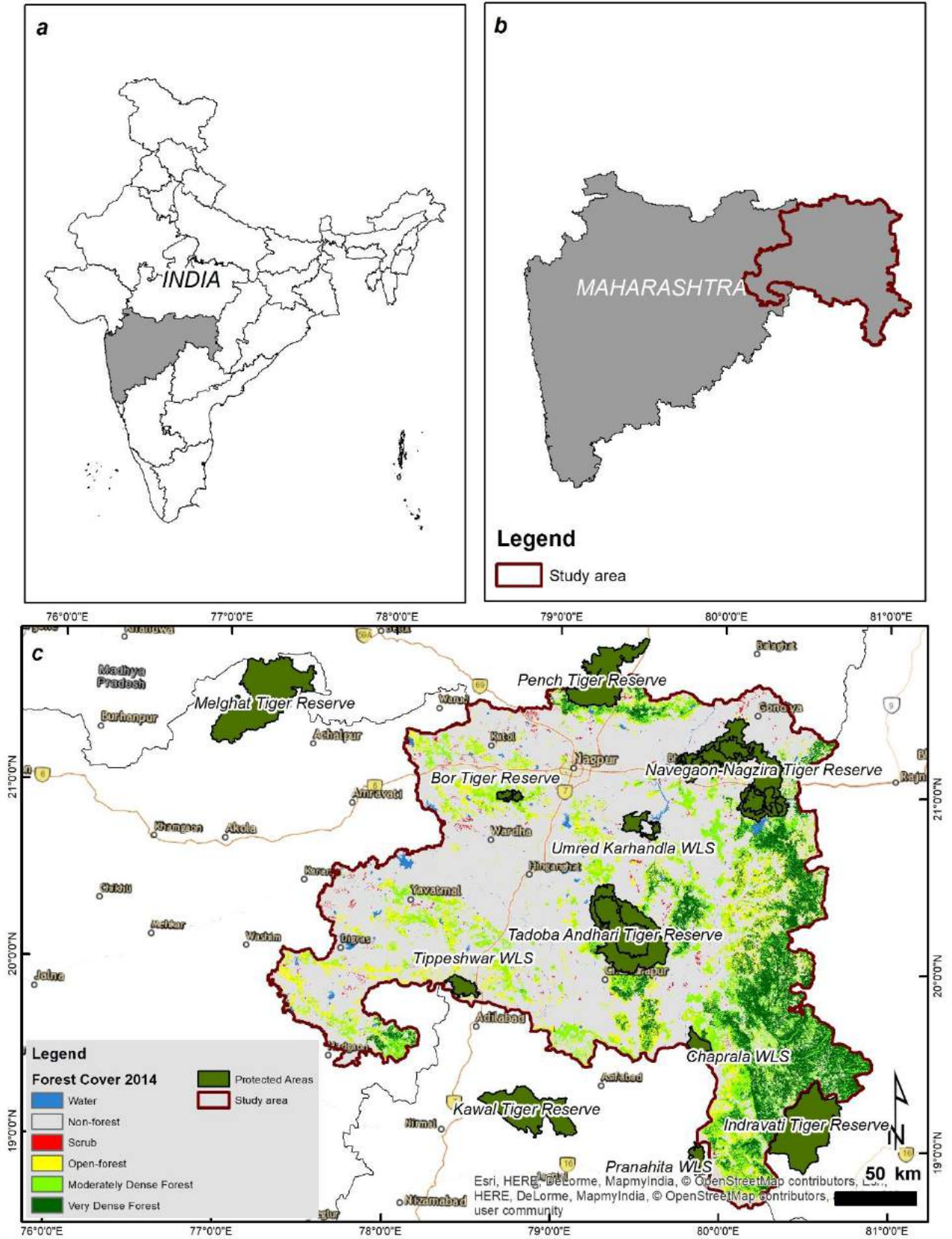
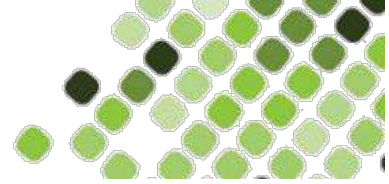
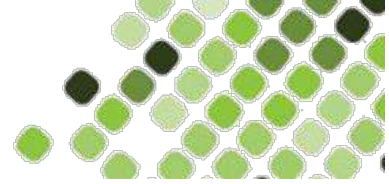


Figure 1: Eastern Vidarbha Landscape, Maharashtra, India







## Methods and Materials

Forest cover data for the year 2014 at a spatial resolution of 23.5 m was obtained from Forest Survey of India. Three classes (very dense, moderately dense and open forest) were segregated from this dataset. Individual patches measuring 1 km<sup>2</sup> and above in area were identified and their patch statistics were calculated (area, perimeter and area-perimeter ratio). The daily average movement of a tiger in this landscape, as calculated from data on tiger movement from radio collars, is 302.33 m. Therefore we considered patches which are more than 300m away from their nearest neighbor, as isolated, thus adding to fragmentation of the habitat in the landscape. We identified such isolated patches in three forest classes (very dense, moderately dense and open forest) and provided descriptive patch statistics (range: minimum and maximum, mean and standard deviation). Roadless areas in the landscape were also mapped following Ibisch et al., (2016) using road data downloaded from OpenStreet Maps.

## Results and Discussion

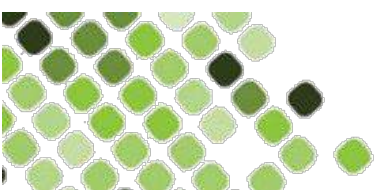
Table 1 shows the human population (Census of India, 2011), total area and area under different forest cover classes (India State of Forest Report, 2017). The district of Gadchiroli has the highest percentage of forest cover (69.41%), followed by Gondiya (36.74%), Chandrapur (35.72%), Bhandara (24.61%), Nagpur (20.41%), Yavatmal (19.19%) and Wardha (13.68%).

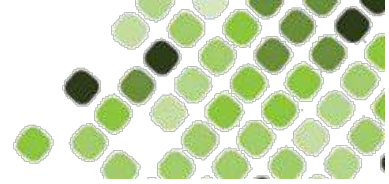
**Table 1:** Human population and areas statistics of forests in the seven districts of the study area

S. No.	District	Human population	Area (sq. km.)				% of TGA	
			Total Area	Very Dense Forest	Moderately Dense Forest	Open Forest		Total Forest
1	Bhandara	12,00,334	4,087	171	567	268	1,006	24.61
2	Chandrapur	22,04,307	11,443	1,326	1,570	1,191	4,087	35.72
3	Gadchiroli	10,72,942	14,412	4,706	3,339	1,959	10,004	69.41
4	Gondiya	13,22,507	5,234	892	733	298	1,923	36.74
5	Nagpur	46,53,570	9,892	402	909	708	2,019	20.41
6	Wardha	13,00,774	6,309	10	410	443	863	13.68
7	Yavatmal	27,72,348	13,582	123	1,107	1,376	2,606	19.19
<b>TOTAL</b>		<b>1,45,26,782</b>	<b>64,959</b>	<b>7,630</b>	<b>8,635</b>	<b>6,243</b>	<b>22,508</b>	<b>34.65</b>

## Forest patch characteristics

All the analysis was done on three major forest categories: very dense, moderately dense and open.





### ***Very dense forest (VDF)***

VDF is present in 28,340 patches covering a total area of 9351.92 km<sup>2</sup> (Range: 0.005 – 1157.5;  $\bar{x}$  = 0.33, SD = 11.89) in the study area. Only 406 of these patches are larger than 1 km<sup>2</sup> and cover an areas of 8,115.2 km<sup>2</sup>, with a mean area of  $\bar{x}$  = 19.99 (SD = 97.13). Among these patches, 70 are more than 300 m (Range: 312.92 – 12,265.86,  $\bar{x}$  = 3681.93, SD = 2740.21) from the nearest forest patch and have been considered as fragmented due to isolation with respect to tiger movement. These isolated patches cover an area of 159.03 km<sup>2</sup>.

### ***Moderately dense forest (MDF)***

MDF is present in 78,833 patches covering a total area of 10,895.54 km<sup>2</sup> (Range: 0.005 – 240.11;  $\bar{x}$  = 0.13, SD = 2.29) in the study area. Only 1189 of these patches are larger than 1 km<sup>2</sup> and cover an areas of 7070.13 km<sup>2</sup>, with a mean area of  $\bar{x}$  = 5.95 (SD = 17.71). Among these patches 306 are more than 300 m (Range: 360 – 29,348.42,  $\bar{x}$  = 7256.62, SD = 5180.08) from the nearest forest patch and have been considered as fragmented due to isolation with respect to tiger movement. These isolated patches cover an area of 641.97 km<sup>2</sup>.

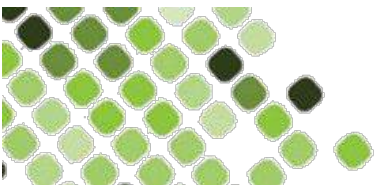
### ***Open forest (OPF)***

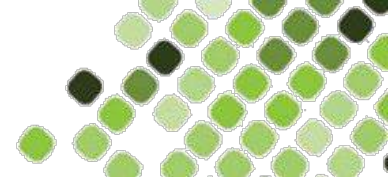
OPF is present in 70,236 patches covering a total area of 10,895.54 km<sup>2</sup> (Range: 0.005 – 106.03;  $\bar{x}$  = 0.11, SD = 1.01) in the study area. Only 1017 of these patches are larger than 1 km<sup>2</sup> and cover an area of 4099.47 km<sup>2</sup>, with a mean area of  $\bar{x}$  = 4.03 (SD = 7.38). Among these patches 315 are more than 300 m (Range: 312 – 117,646.08,  $\bar{x}$  = 30,674.57, SD = 27,642.06) from the nearest forest patch and have been considered as fragmented due to isolation with respect to tiger movement. These isolated patches cover an area of 779.07 km<sup>2</sup>.

The district-wise statistics of forest patches is provided in Table 2

### **Roadless area**

When the area of influence of a road extends to 1 km on both sides, it affect 3,390.51 km<sup>2</sup> of forests in the study area. It leaves roadless areas measuring a total of 48,333.56 km<sup>2</sup> which is about 62.63% of the total geographical area. Only 15,894.29 km<sup>2</sup> (32.88%) of the total roadless areas are covered by forests. The fragmentation caused by roads creates 517 new patches which are less than 1 km<sup>2</sup> and covers a total area of 246.38 km<sup>2</sup>.



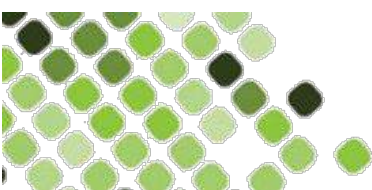
**Table 2:** Details of different sizes of forest fragments across 7 districts of EVL, Maharashtra

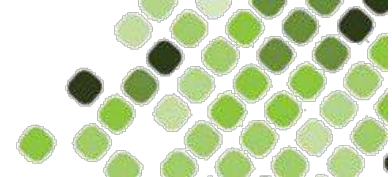
<b>Bhandara</b>	<b>Very Dense Forest</b>		<b>Mod. Dense Forest</b>		<b>Open Forest</b>	
Size Class (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)
<b>1 to 5</b>	14	2.21	29	2.28	55	1.97
<b>5 to 10</b>	2	7.22	6	7.11	2	6.04
<b>10 to 50</b>			7	33.11	1	17.01
<b>50 to 100</b>	1	81.05	3	88.63		
<b>100 to 500</b>	1	209.38				
<b>Above 500</b>						

<b>Chandrapur</b>	<b>Very Dense Forest</b>		<b>Mod. Dense Forest</b>		<b>Open Forest</b>	
Size Class (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)
<b>1 to 5</b>	56	2.22	182	2.19	174	2.08
<b>5 to 10</b>	6	6.57	26	7.35	26	7.06
<b>10 to 50</b>	6	14.30	21	20.42	15	16.14
<b>50 to 100</b>	1	79.64	3	67.43		
<b>100 to 500</b>	2	213.37	1	113.96		
<b>Above 500</b>	1	680.68				

<b>Gadchiroli</b>	<b>Very Dense Forest</b>		<b>Mod. Dense Forest</b>		<b>Open Forest</b>	
Size Class (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)
<b>1 to 5</b>	151	2.0157	410	2.00972	251	2.08513
<b>5 to 10</b>	19	6.237	38	6.57012	25	7.07008
<b>10 to 50</b>	20	22.881	19	18.738	27	20.7652
<b>50 to 100</b>	3	62.932	2	61.8941	1	58.4271
<b>100 to 500</b>	3	308.55	4	197.314		
<b>Above 500</b>	4	821.82				

<b>Gondiya</b>	<b>Very Dense Forest</b>		<b>Mod. Dense Forest</b>		<b>Open Forest</b>	
Size Class (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)
<b>1 to 5</b>	54	2.28	104	2.02	38	1.87
<b>5 to 10</b>	12	6.55	8	7.59	5	6.28
<b>10 to 50</b>	7	21.98	9	23.49	2	16.84
<b>50 to 100</b>	1	68.39				
<b>100 to 500</b>	2	216.55	1	153.31		
<b>Above 500</b>	1	966.67				



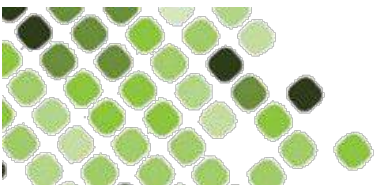


Nagpur	Very Dense Forest		Mod. Dense Forest		Open Forest		
	Size Class (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)
	<b>1 to 5</b>	25	2.01	100	2.20	144	1.94
	<b>5 to 10</b>	3	8.19	13	7.53	8	5.80
	<b>10 to 50</b>	4	20.59	12	20.99	3	12.55
	<b>50 to 100</b>	3	80.69	1	70.82	1	50.83
	<b>100 to 500</b>			2	118.47		
	<b>Above 500</b>						

Wardha	Very Dense Forest		Mod. Dense Forest		Open Forest		
	Size Class (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)
	<b>1 to 5</b>	1	1.67	40	2.34	48	1.93
	<b>5 to 10</b>			6	6.36	7	6.41
	<b>10 to 50</b>			3	21.30	10	14.01
	<b>50 to 100</b>			1	53.44	1	73.80
	<b>100 to 500</b>			1	131.48		
	<b>Above 500</b>						

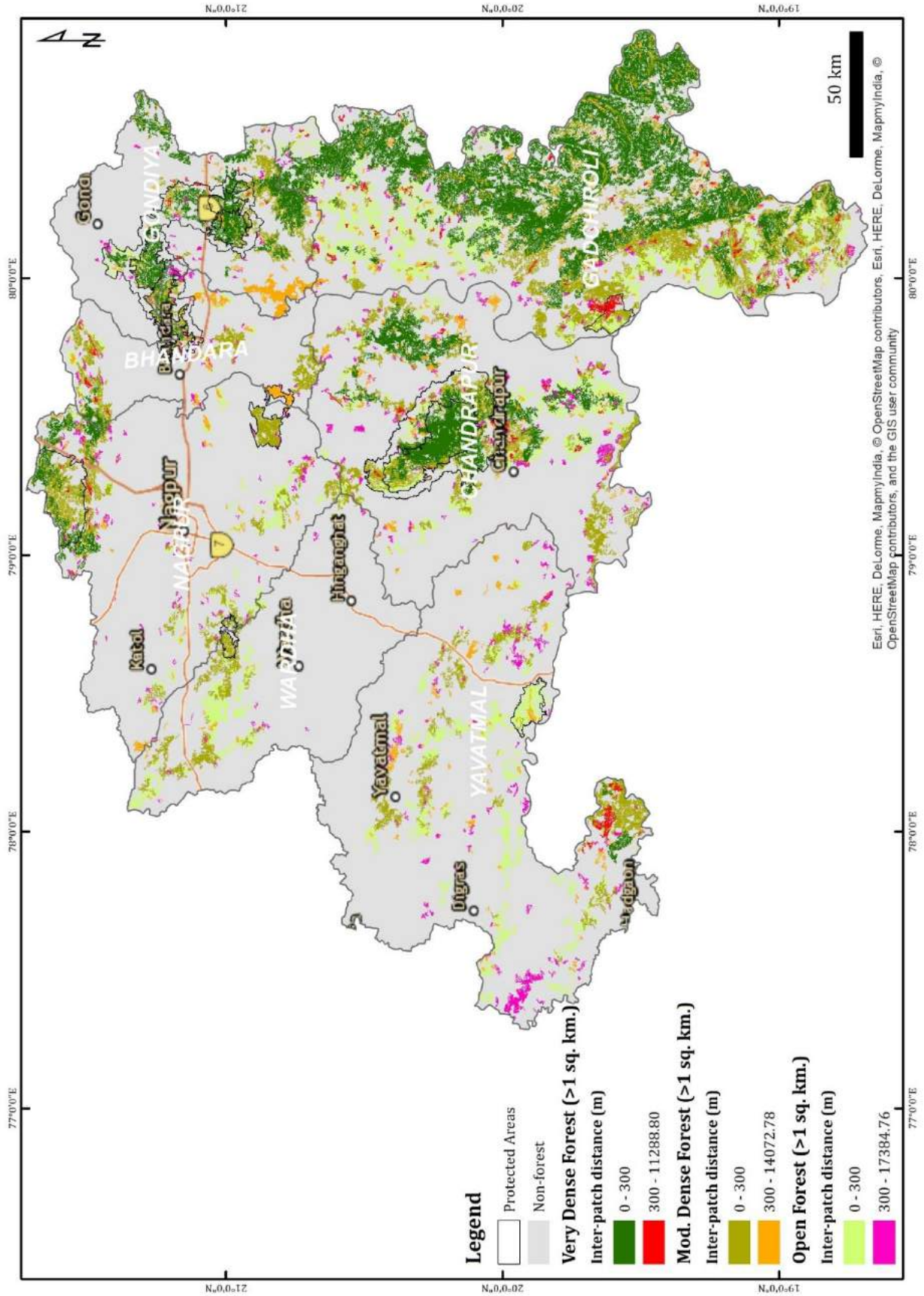
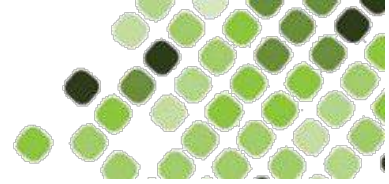
Yavatmal	Very Dense Forest		Mod. Dense Forest		Open Forest		
	Size Class (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)	No of fragments	Mean patch size (sq km)
	<b>1 to 5</b>	8	1.70	118	1.78	156	2.01
	<b>5 to 10</b>	2	5.76	15	6.90	28	7.21
	<b>10 to 50</b>	2	43.99	15	20.42	18	21.00
	<b>50 to 100</b>			1	54.79	1	86.80
	<b>100 to 500</b>			1	205.12	1	106.03
	<b>Above 500</b>						

The spatial location of forest fragments in the landscape is shown in Figure 2 and Figure 3 shows location of forest fragments with respect to roads in the landscape. Figure 4 (a, b, c) – Figure 10 (a, b, c) show spatial location of forest fragments, forest fragments with respect to range and beat boundaries, and forest fragments with respect to roads for the districts Bhandara, Chandrapur, Gadchiroli, Gondiya, Nagpur, Wardha and Yavatmal respectively.

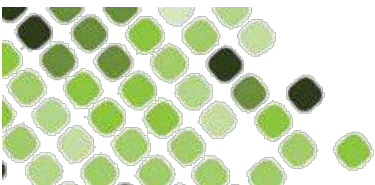


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

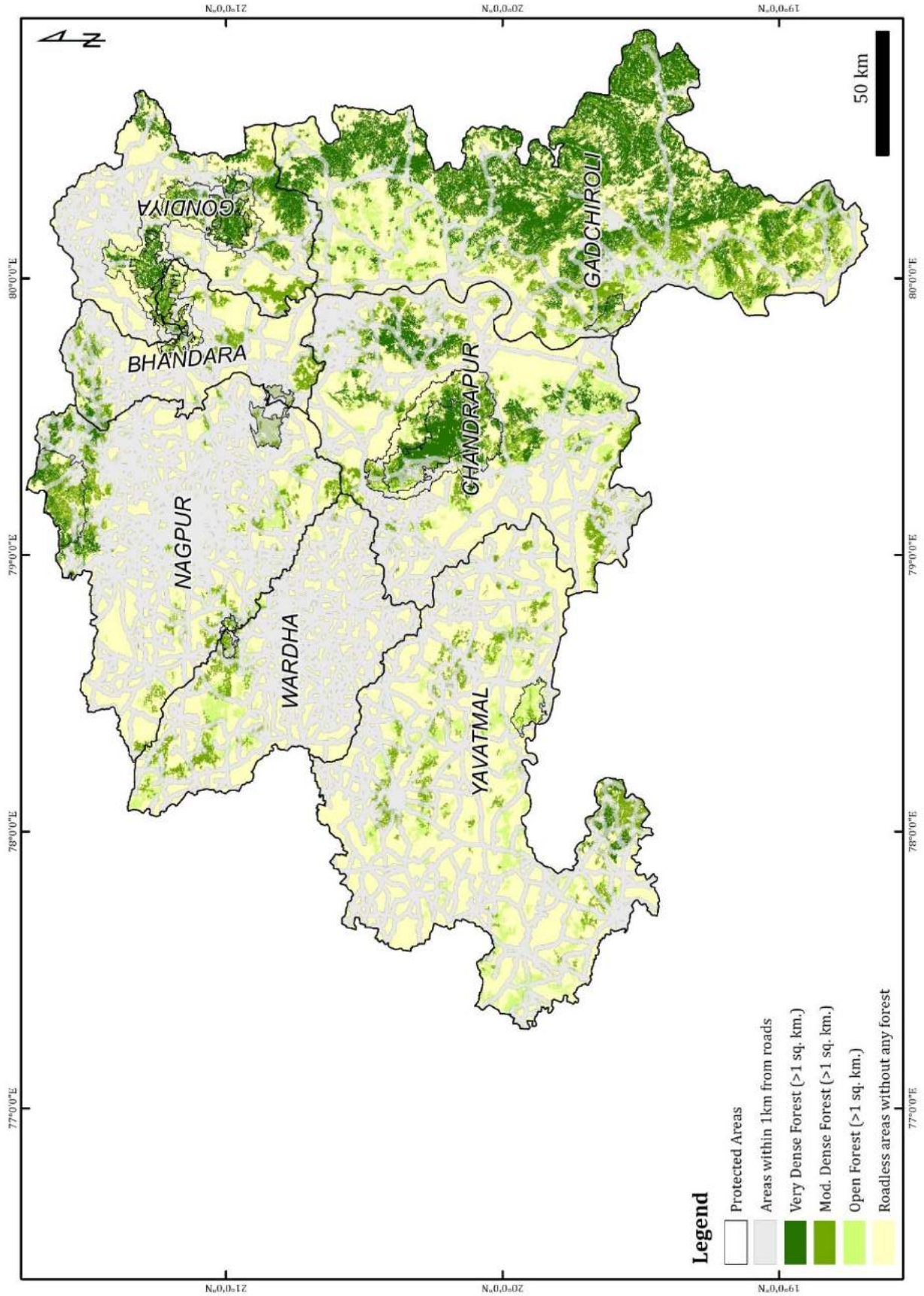
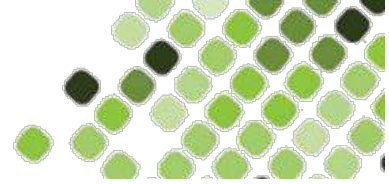


**Figure 2:** Forest fragments in Eastern Vidarbha Landscape, Maharashtra

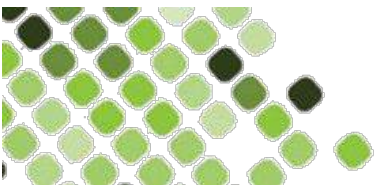


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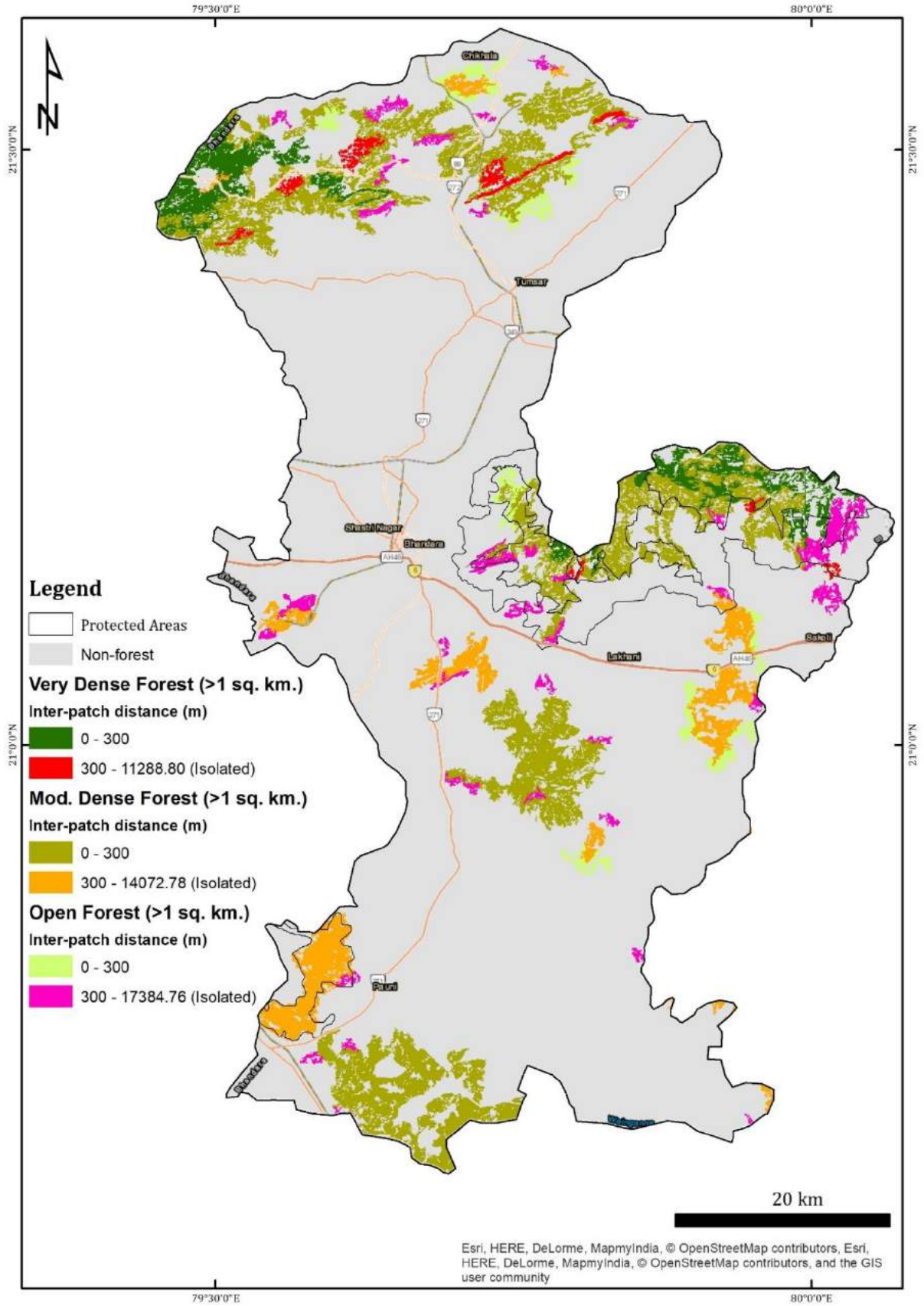
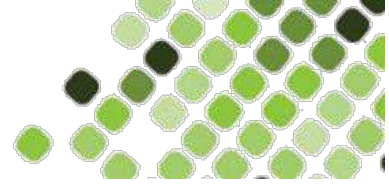


**Figure 3:** Forest fragments in Eastern Vidarbha Landscape, Maharashtra with respect to road network

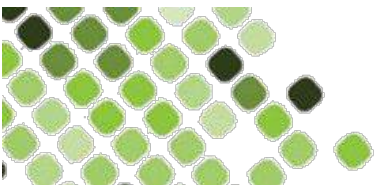


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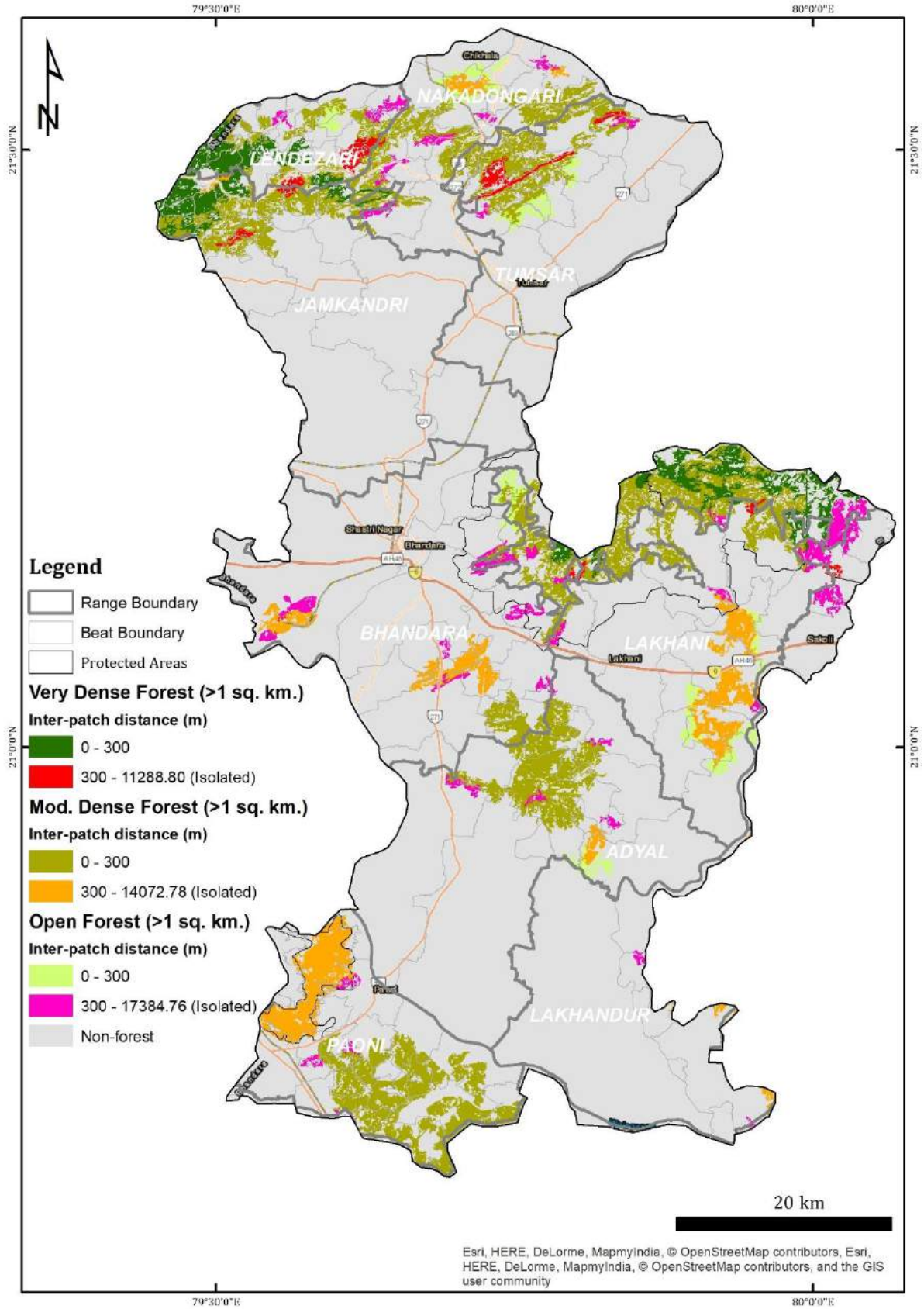
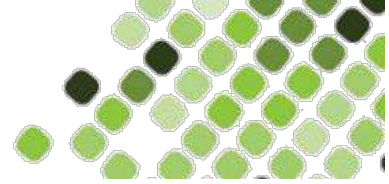


**Figure (4a):** Forest fragments in Bhandara District of Eastern Vidarbha Landscape, Maharashtra



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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra



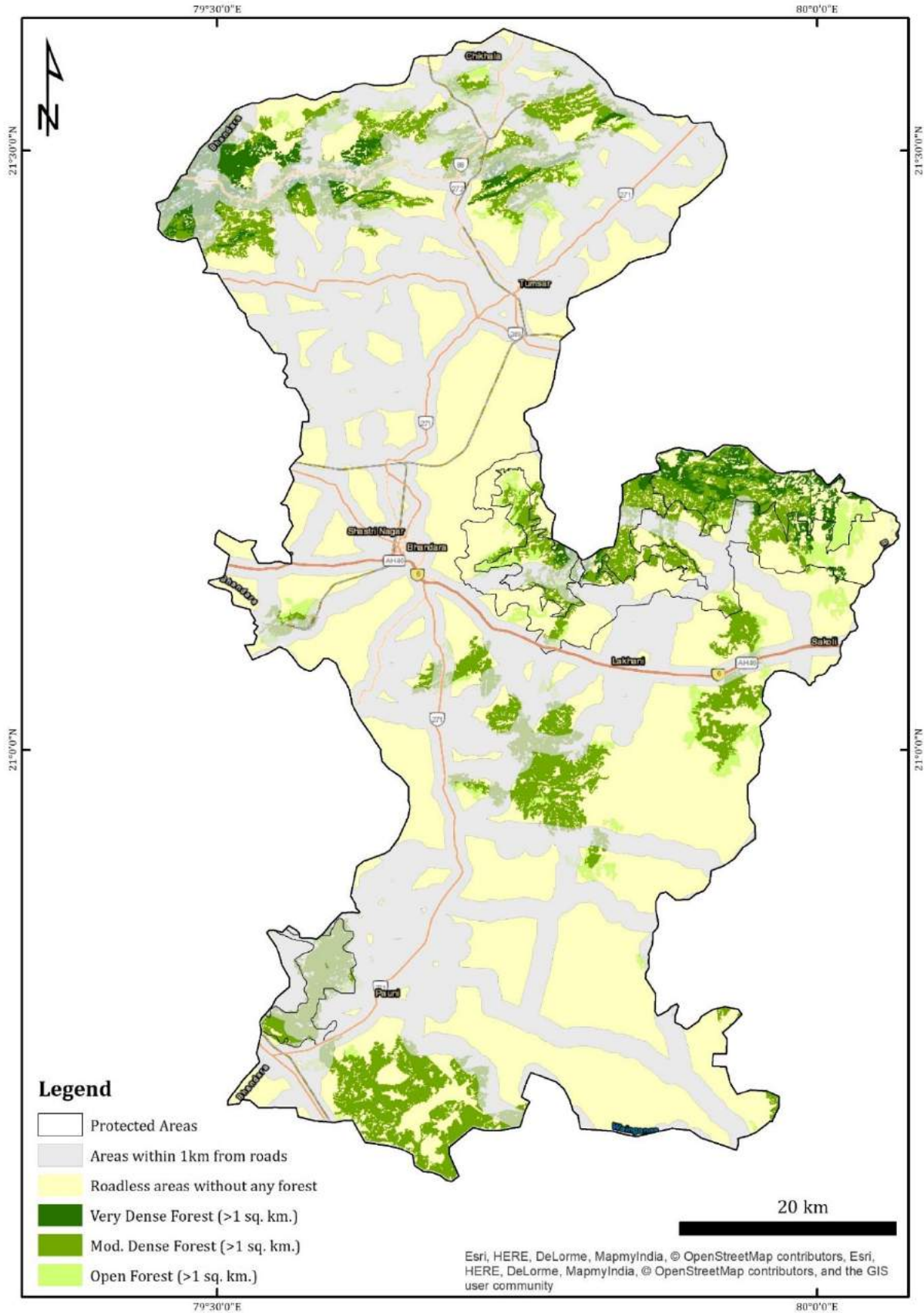
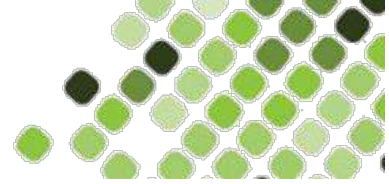
**Figure (4b):** Forest fragments in Bhandara District of Eastern Vidarbha Landscape, Maharashtra with respect to range and beat boundaries



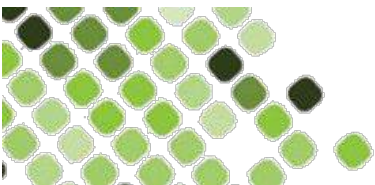


# THE TIG - SAW PUZZLE

Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

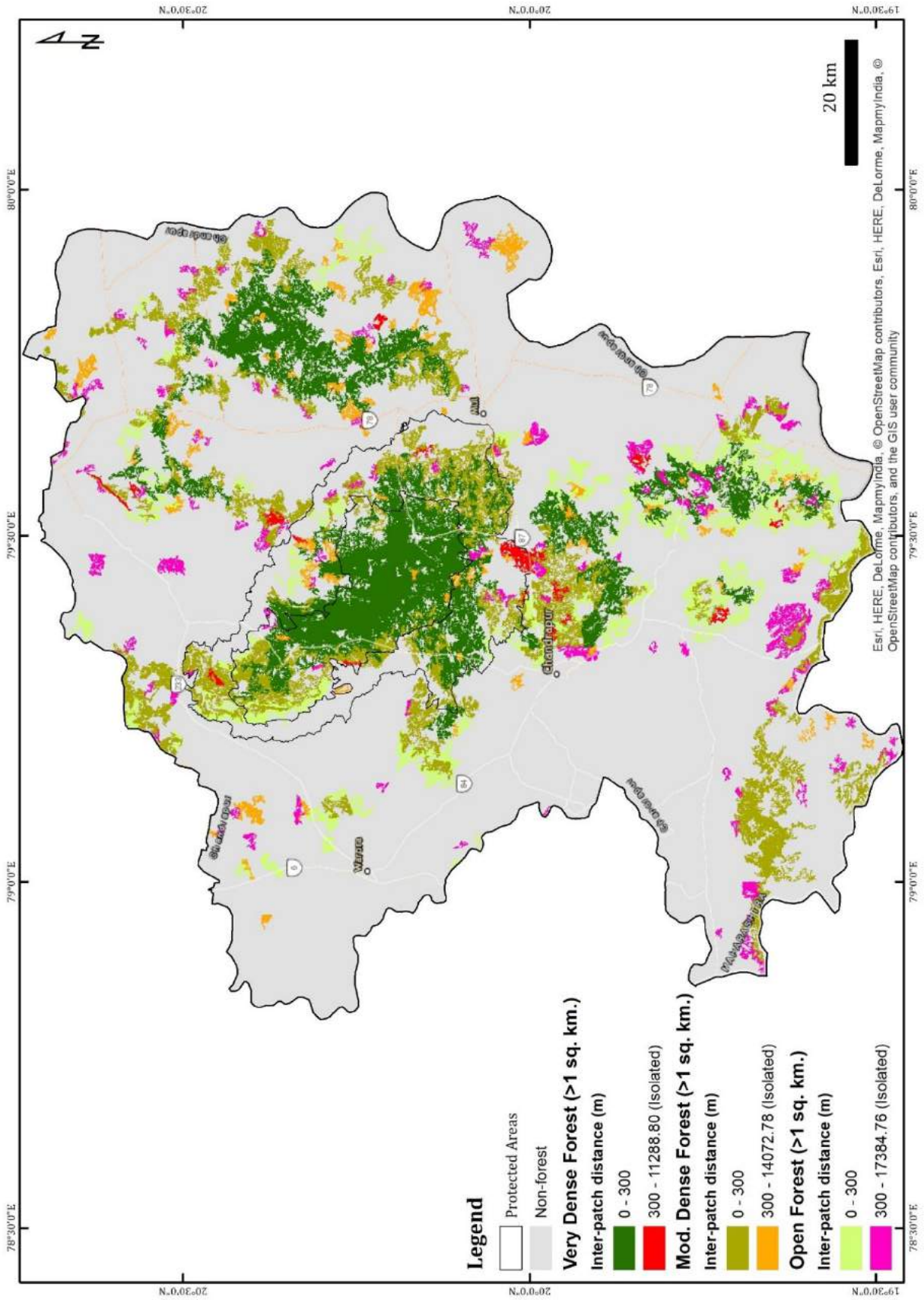
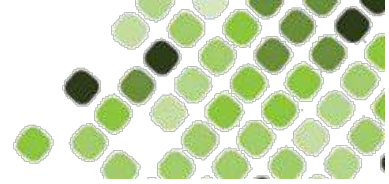


**Figure (4c):** Forest fragments in Bhandara District of Eastern Vidarbha Landscape, Maharashtra with respect to road network

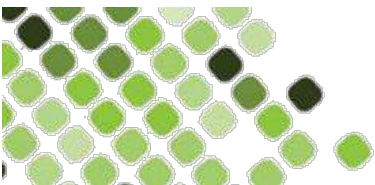


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra



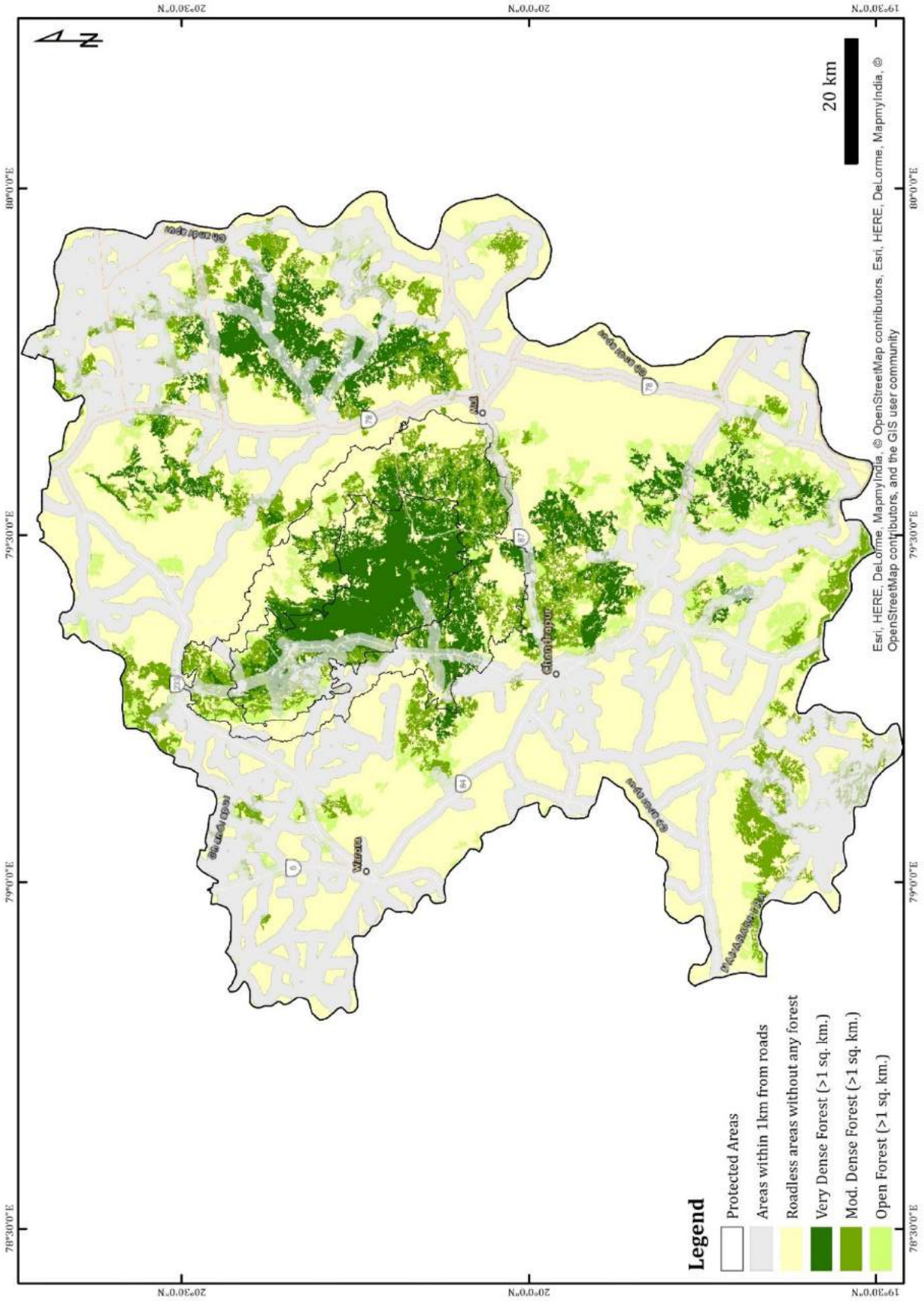
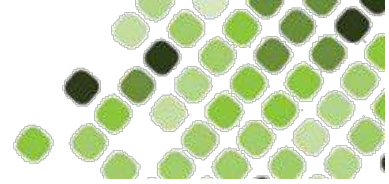
**Figure (5a):** Forest fragments in Chandrapur District of Eastern Vidarbha Landscape, Maharashtra



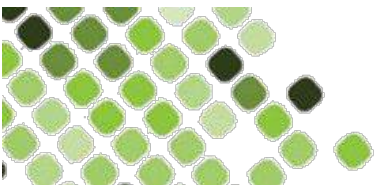


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

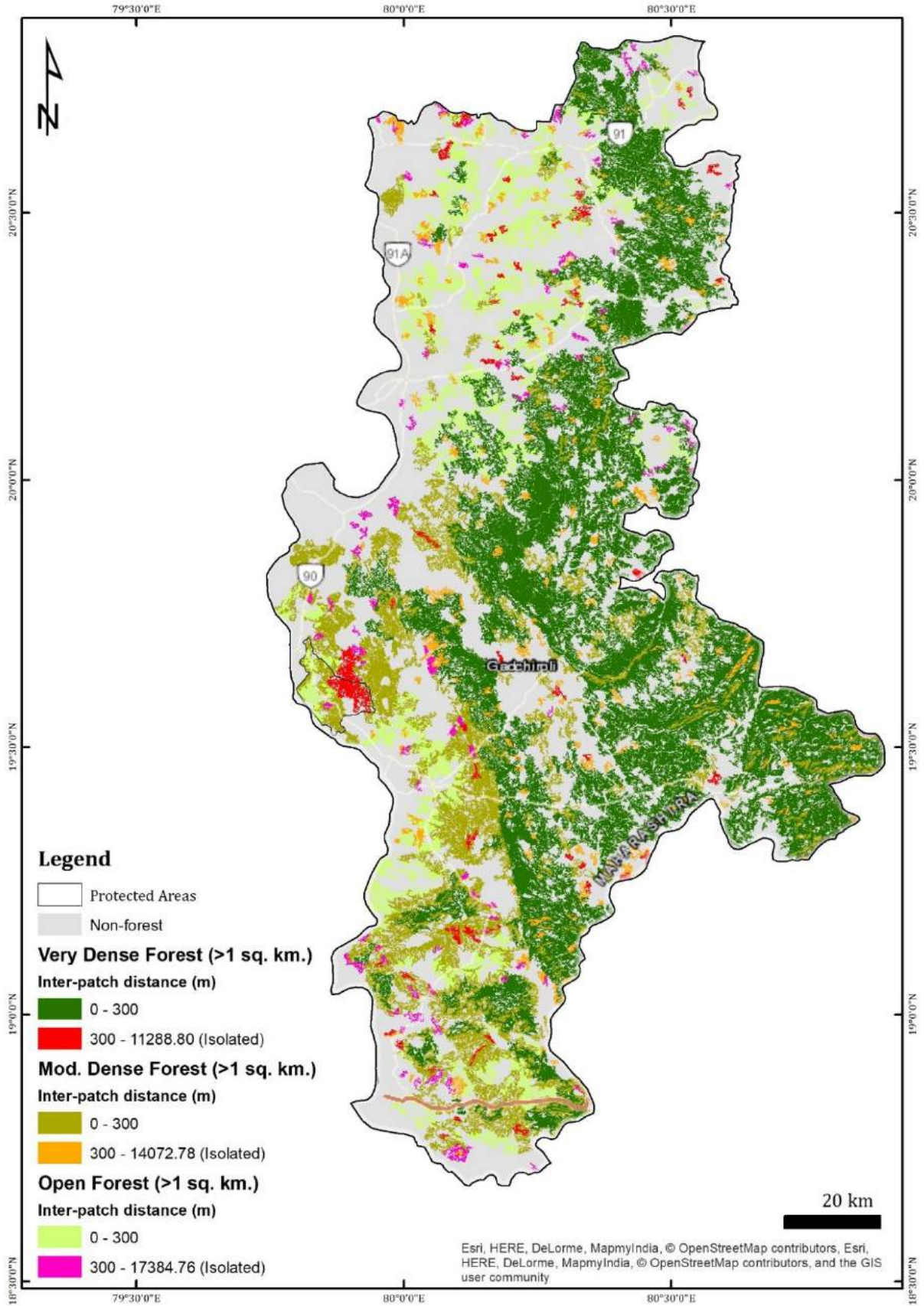
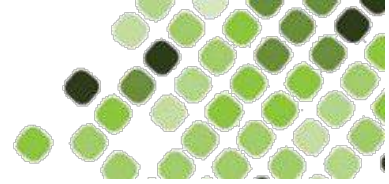


**Figure (5c):** Forest fragments in Chandrapur District of Eastern Vidarbha Landscape, Maharashtra with respect to road network



# THE TIG - SAW PUZZLE

Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

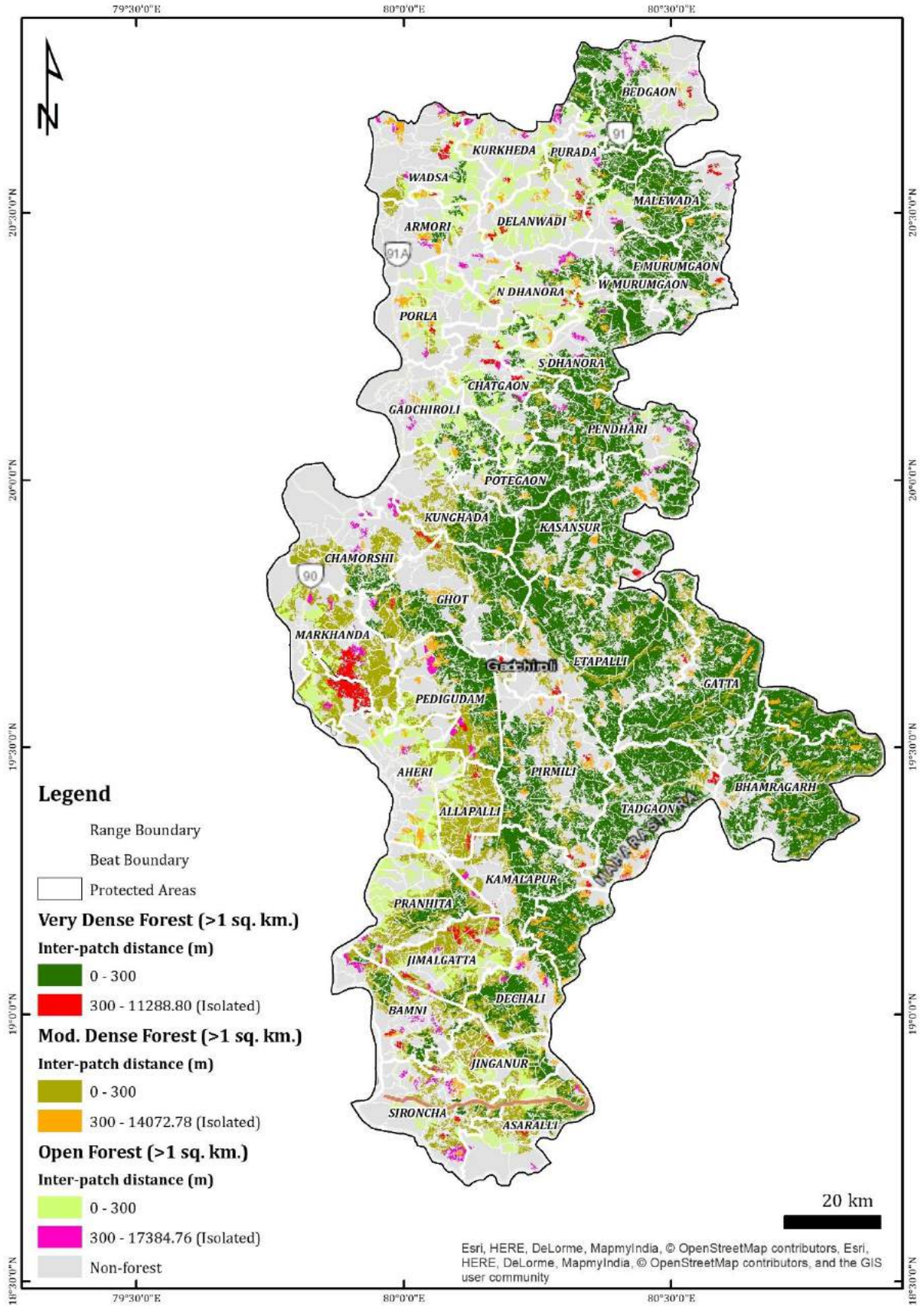
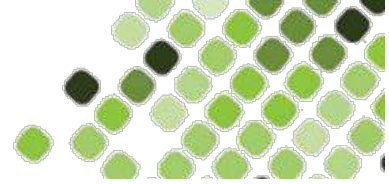


**Figure (6a):** Forest fragments in Gadchiroli District of Eastern Vidarbha Landscape, Maharashtra

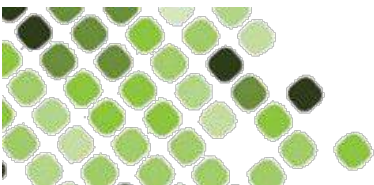


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

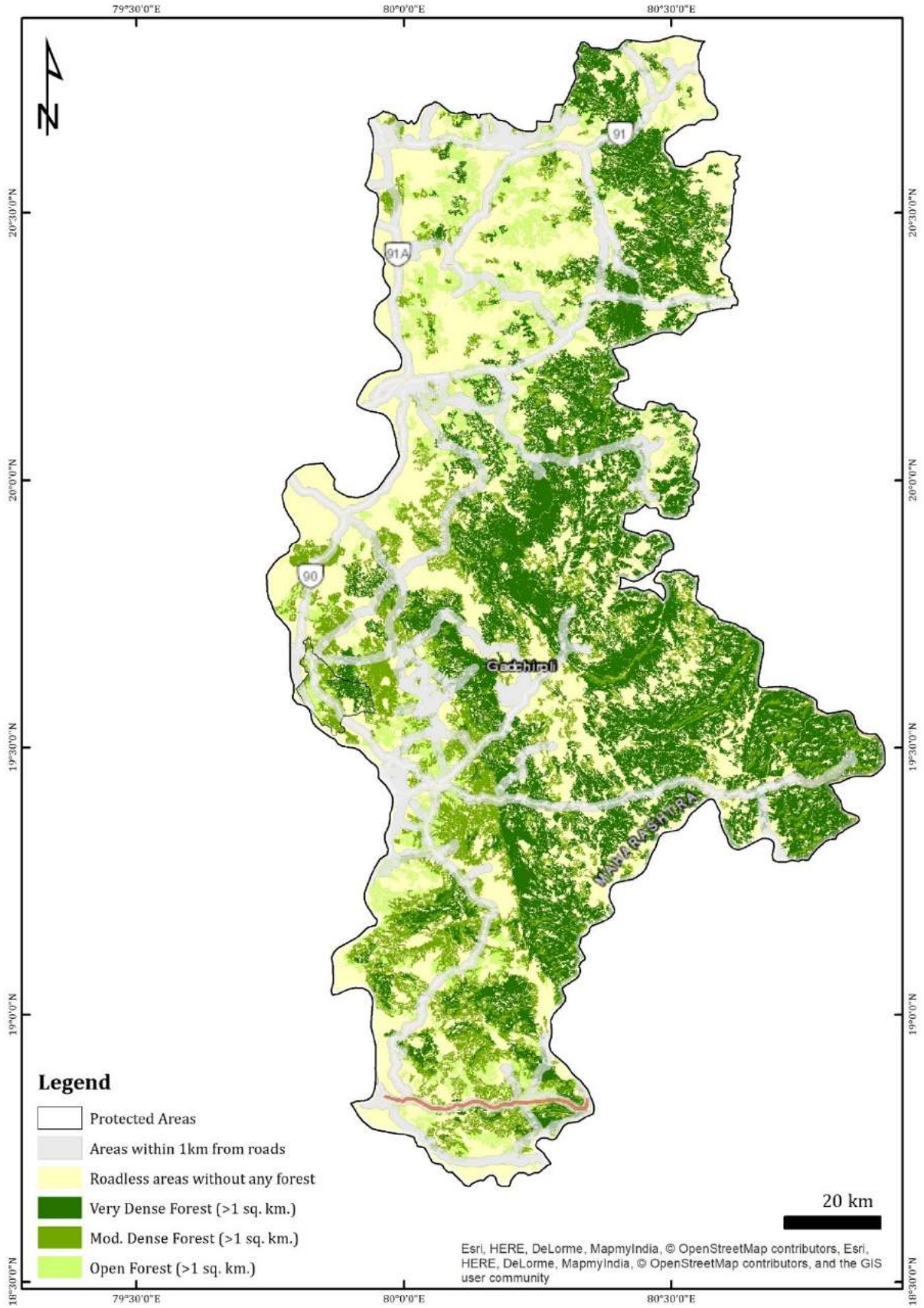
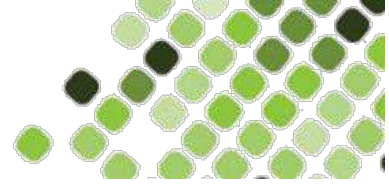


**Figure (6b):** Forest fragments in Gadchiroli District of Eastern Vidarbha Landscape, Maharashtra with respect to range and beat boundaries

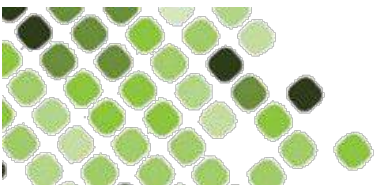


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

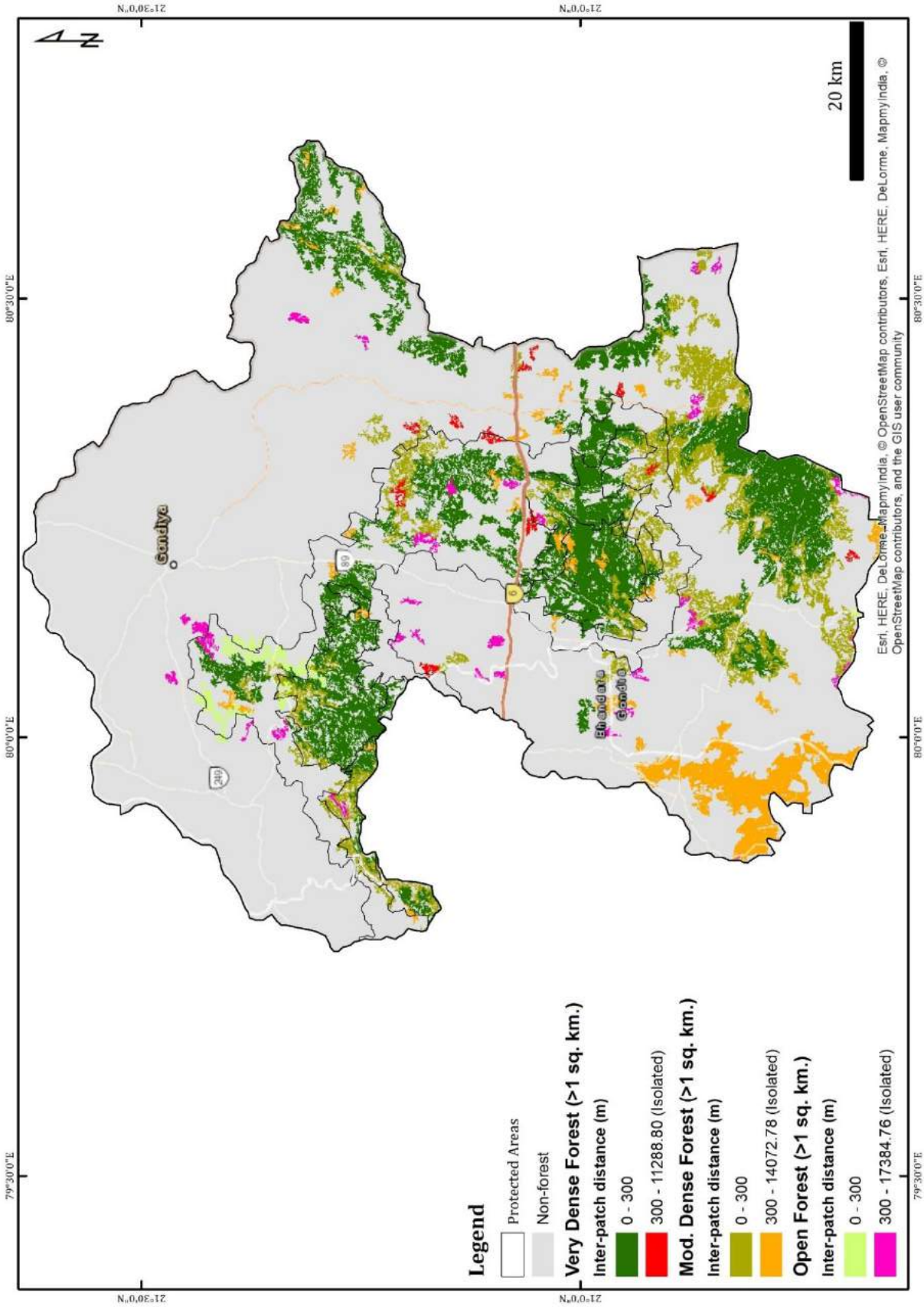
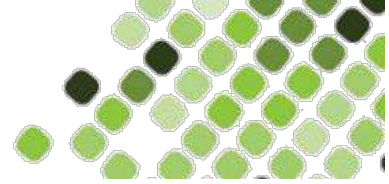


**Figure (6c):** Forest fragments in Gadchiroli District of Eastern Vidarbha Landscape, Maharashtra with respect to road network

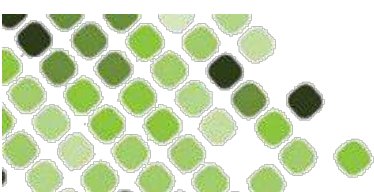


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra



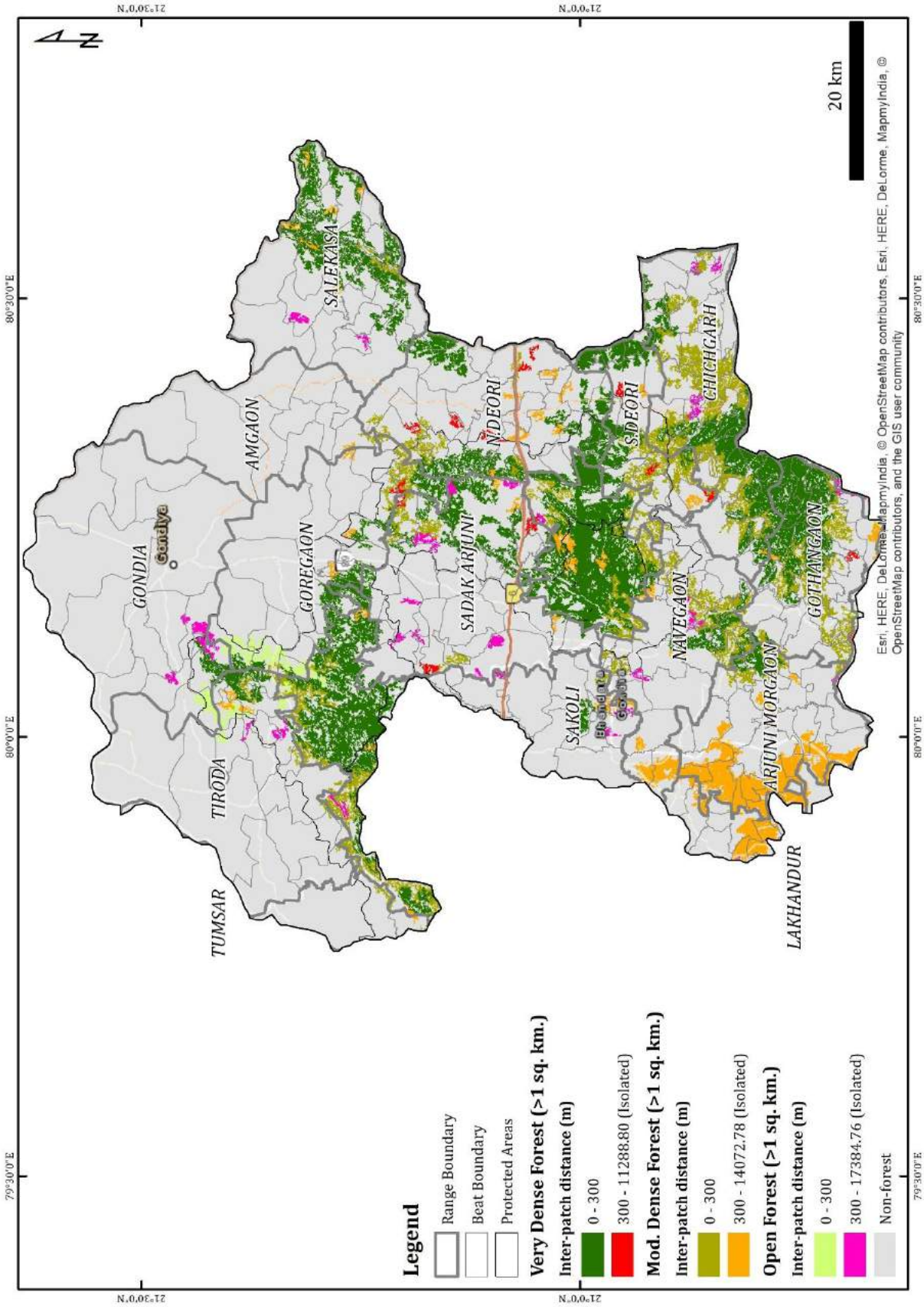
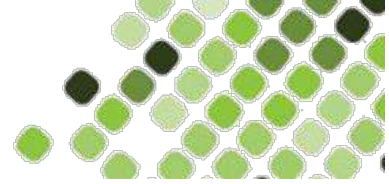
**Figure (7a):** Forest fragments in Gondiya District of Eastern Vidarbha Landscape, Maharashtra



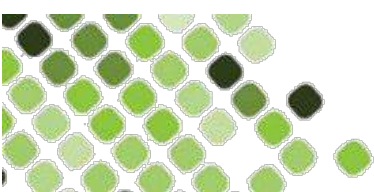


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

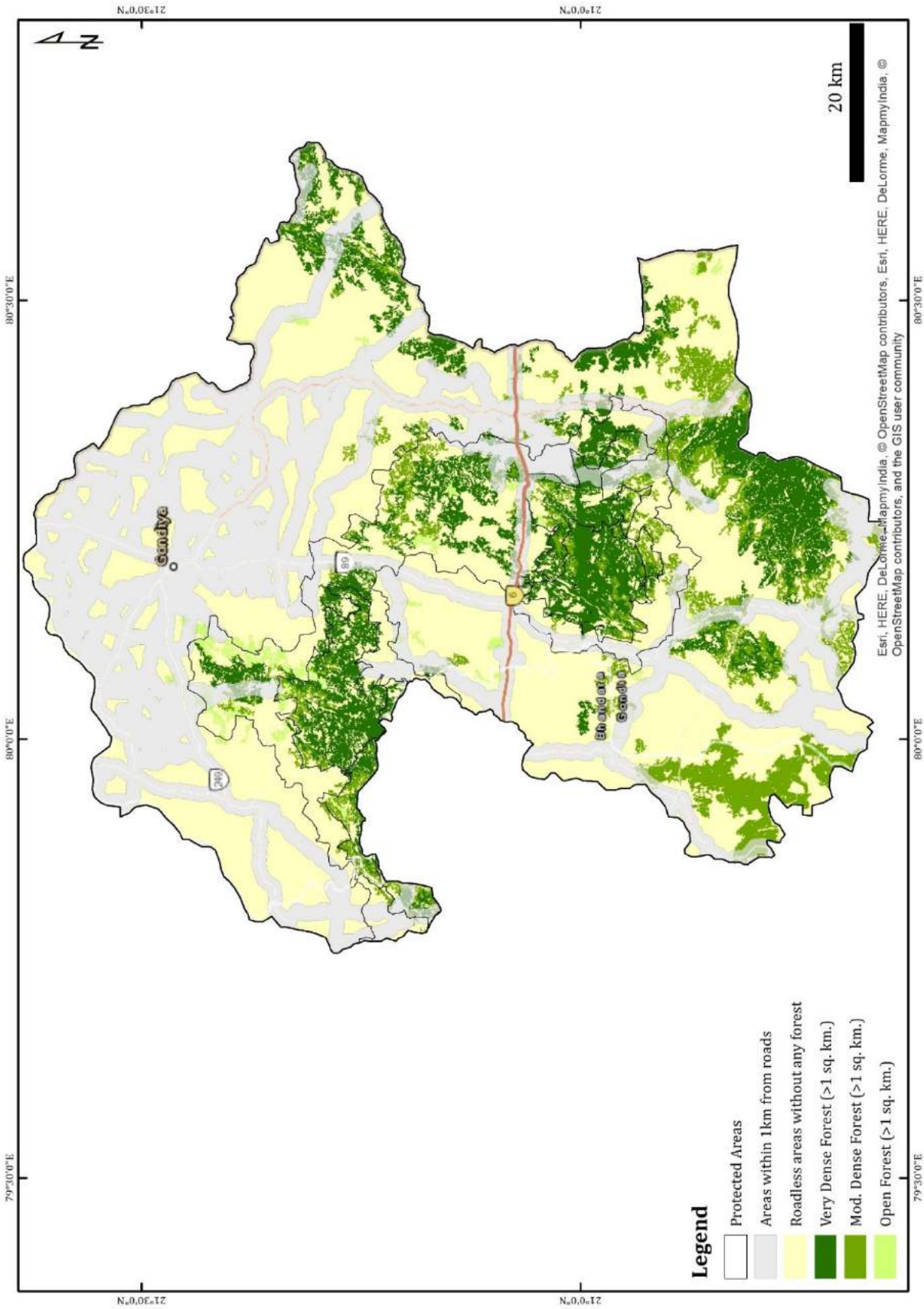
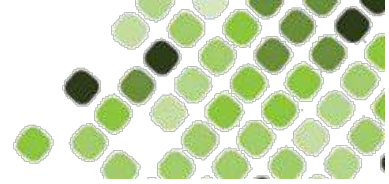


**Figure (7b):** Forest fragments in Gondiya District of Eastern Vidarbha Landscape, Maharashtra with respect to range and beat boundaries

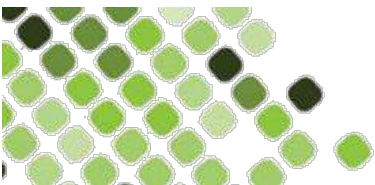


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

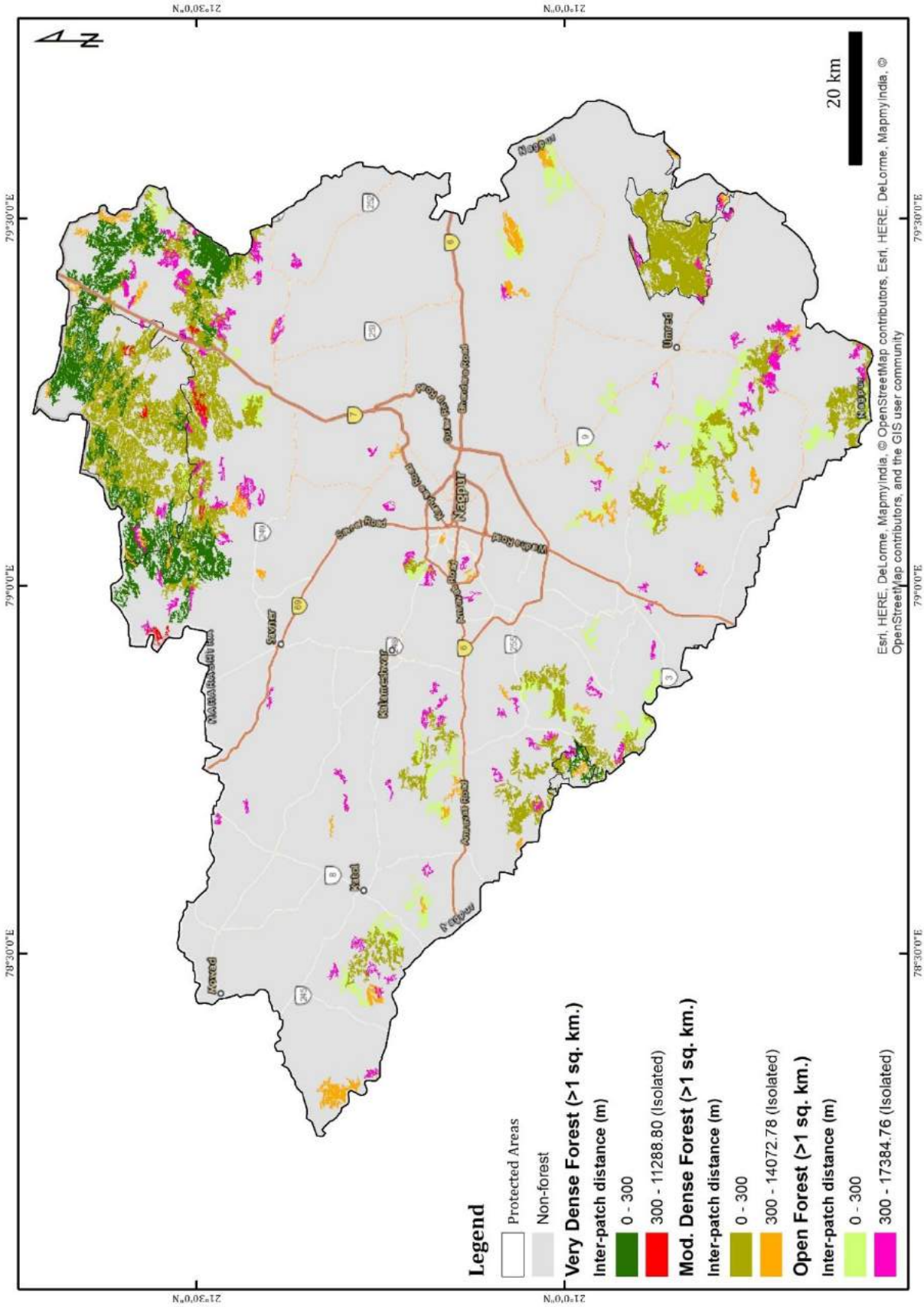
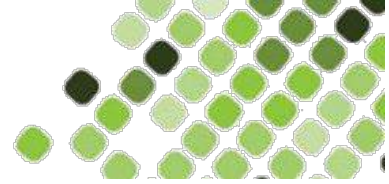


**Figure (7c):** Forest fragments in Gondiya District of Eastern Vidarbha Landscape, Maharashtra with respect to road network



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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra



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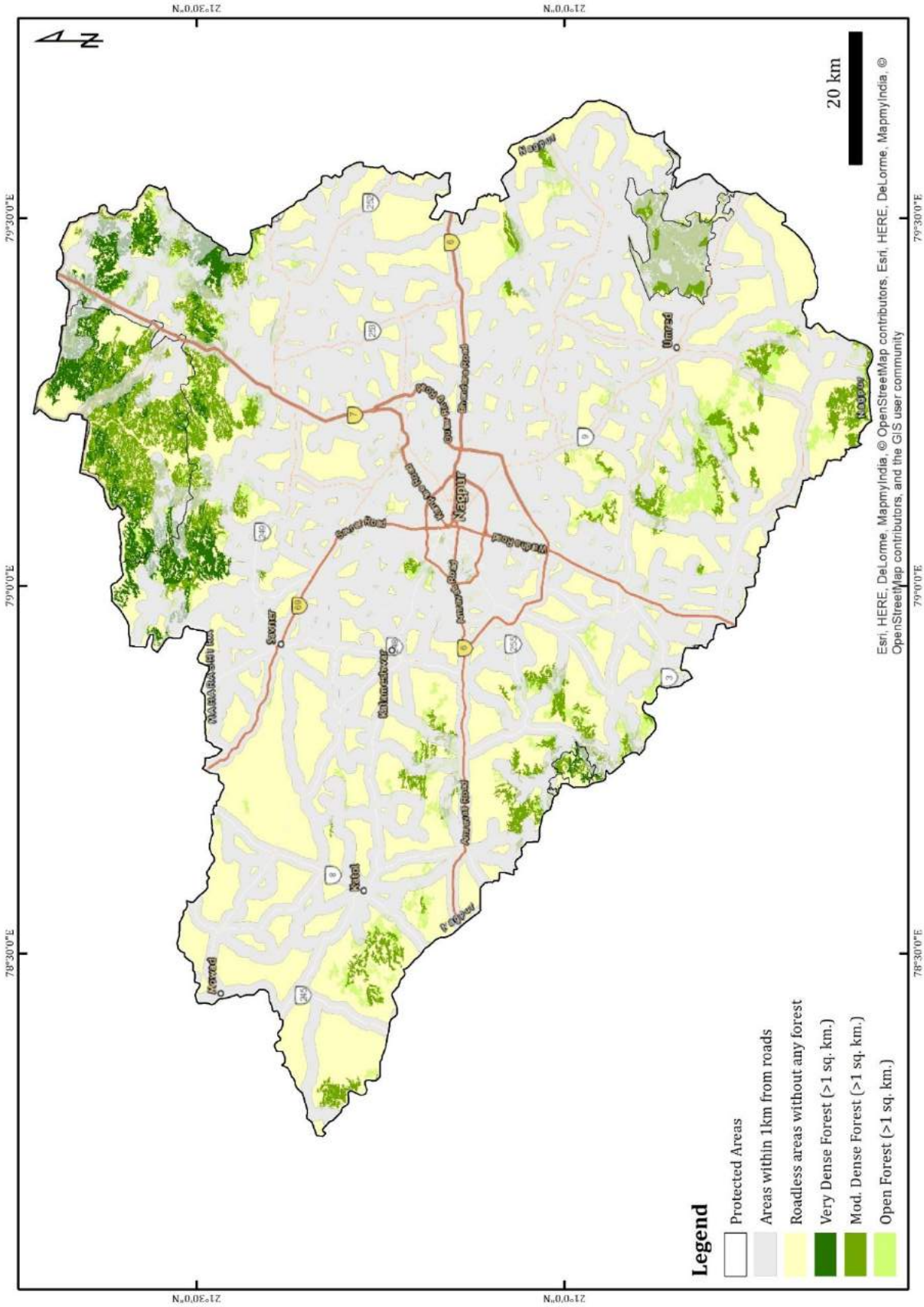
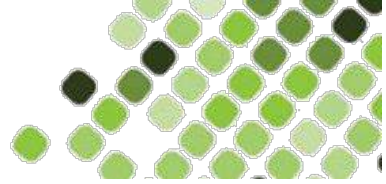
**Figure (8a):** Forest fragments in Nagpur District of Eastern Vidarbha Landscape, Maharashtra





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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

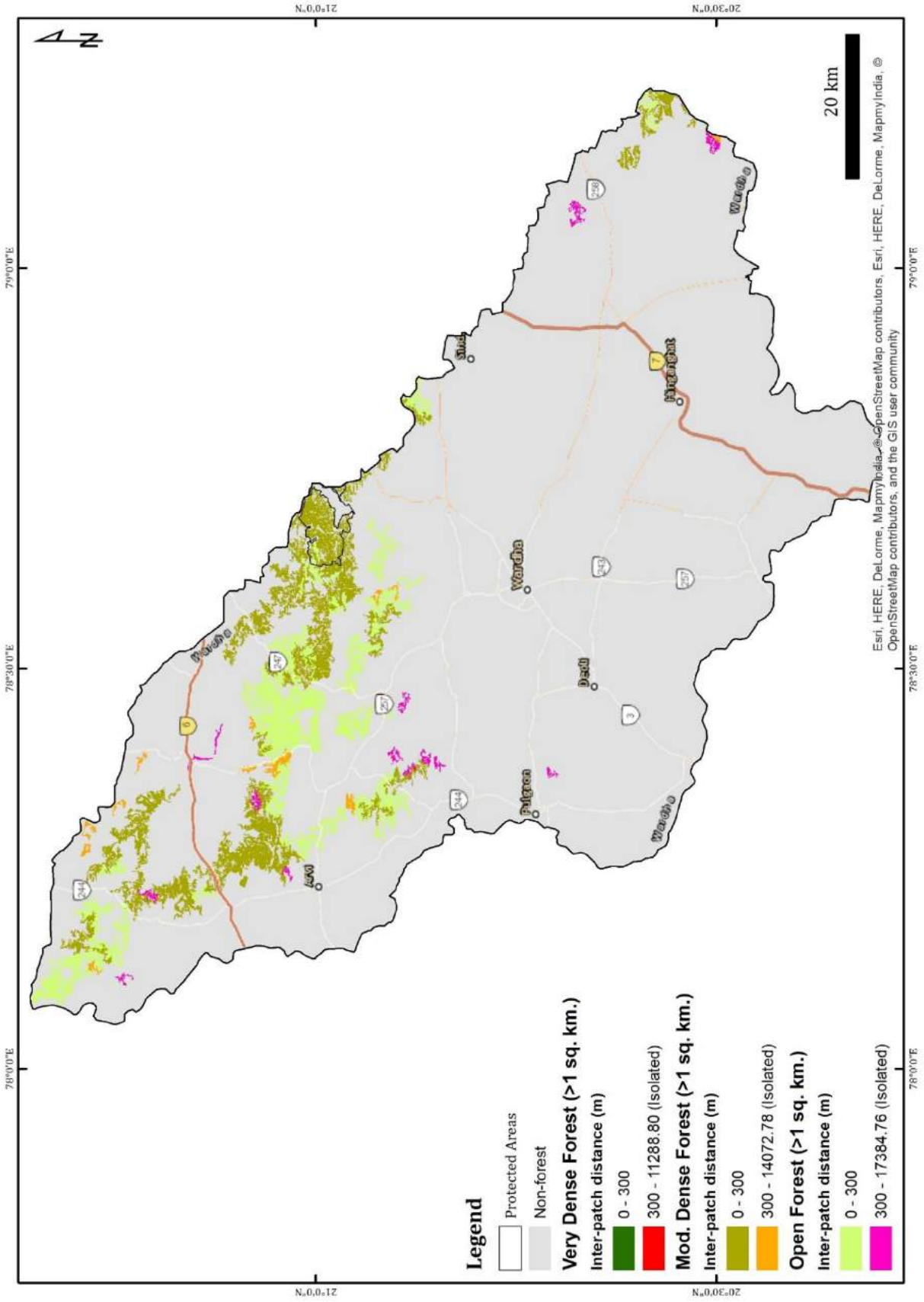
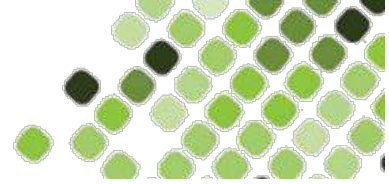


**Figure (8c):** Forest fragments in Nagpur District of Eastern Vidarbha Landscape, Maharashtra with respect to road network

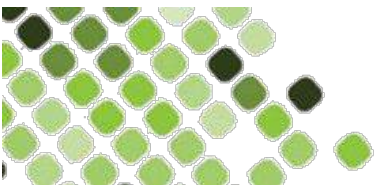


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

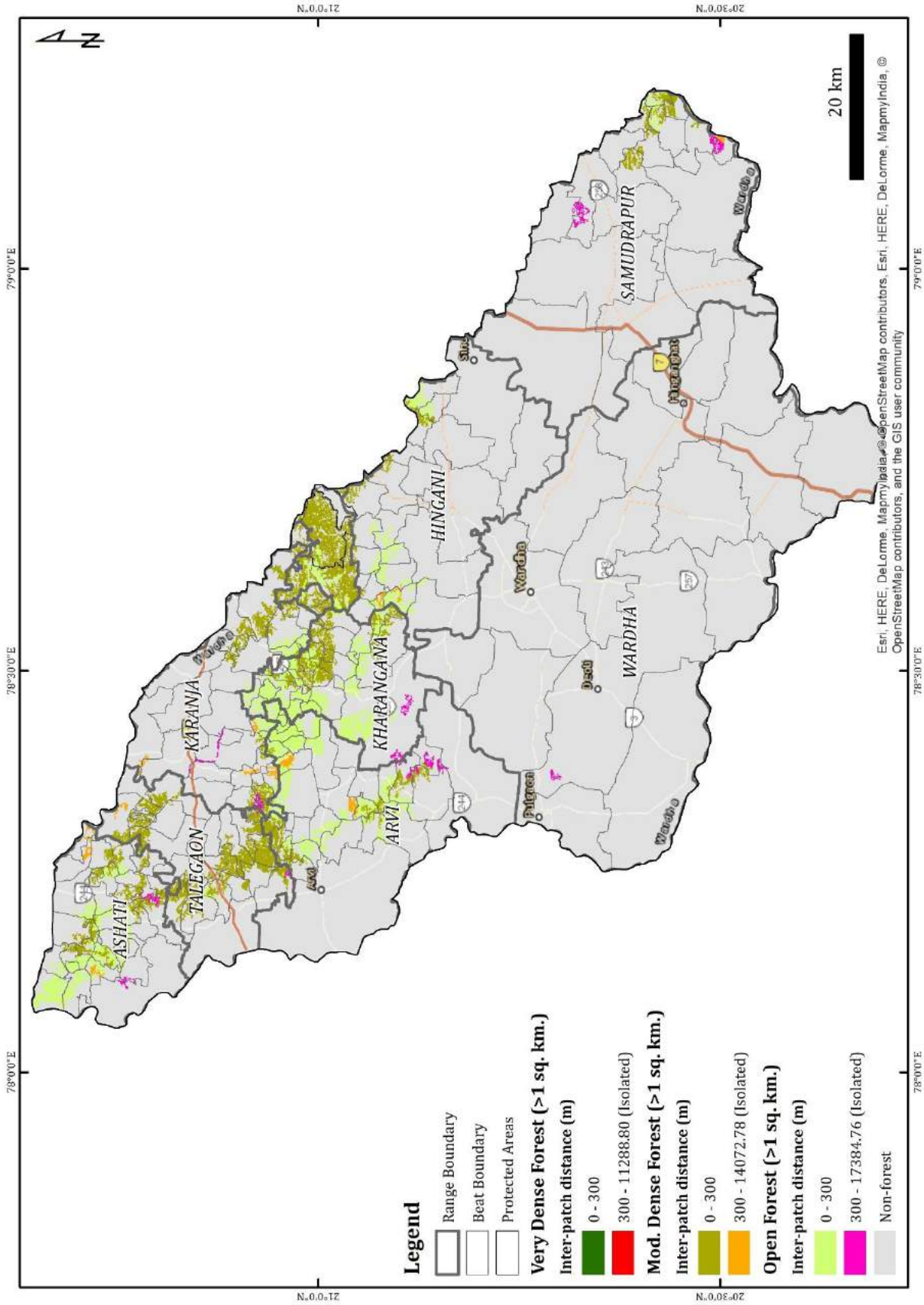
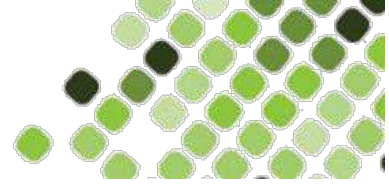


**Figure (9a):** Forest fragments in Wardha District of Eastern Vidarbha Landscape, Maharashtra

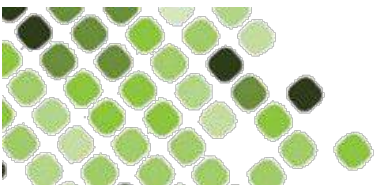


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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra

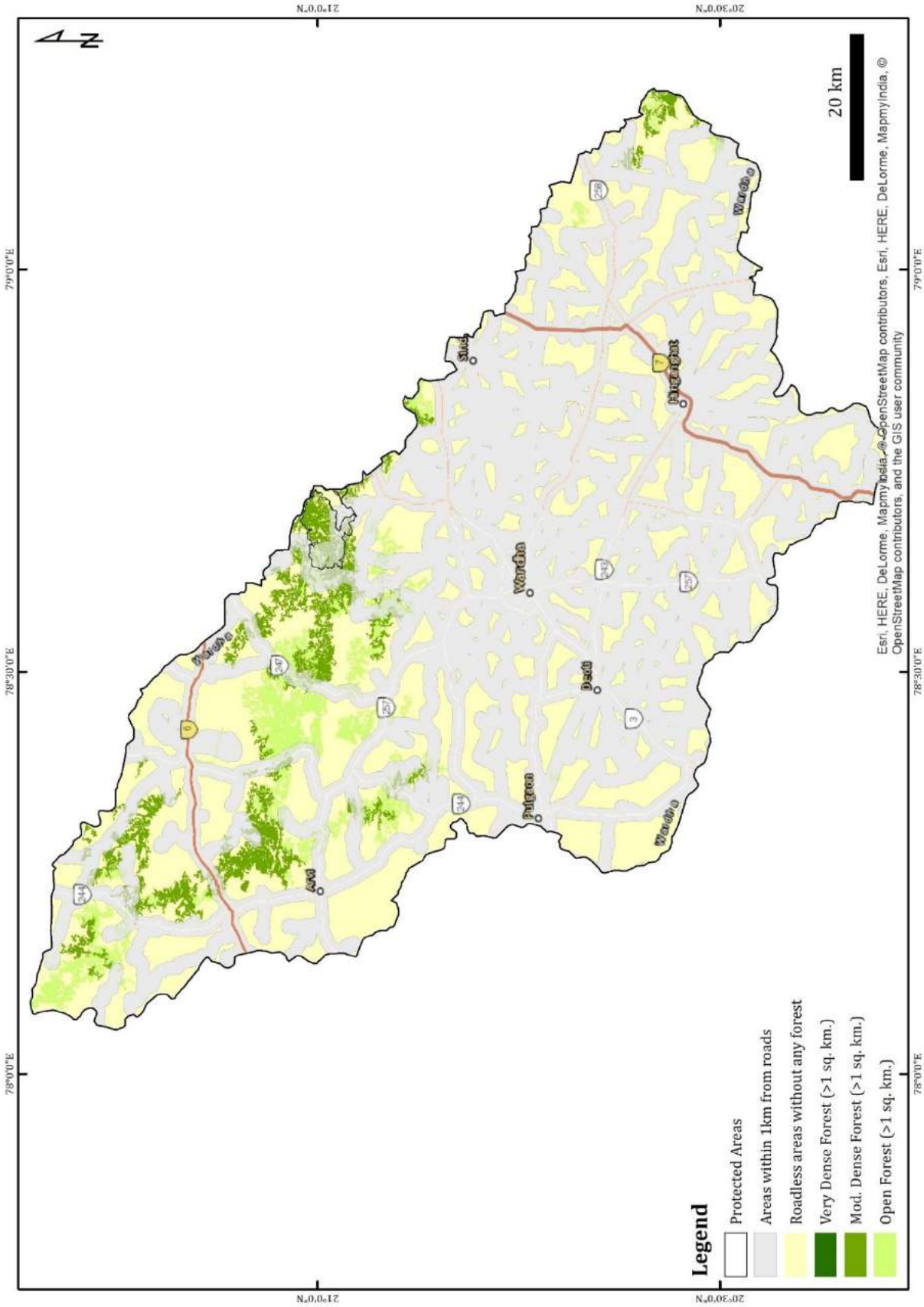
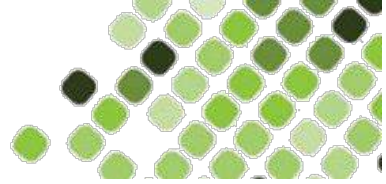


**Figure (9b):** Forest fragments in Wardha District of Eastern Vidarbha Landscape, Maharashtra with respect to range and beat boundaries

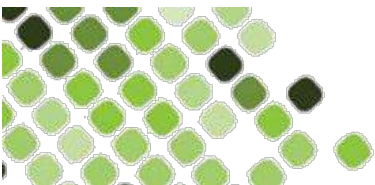


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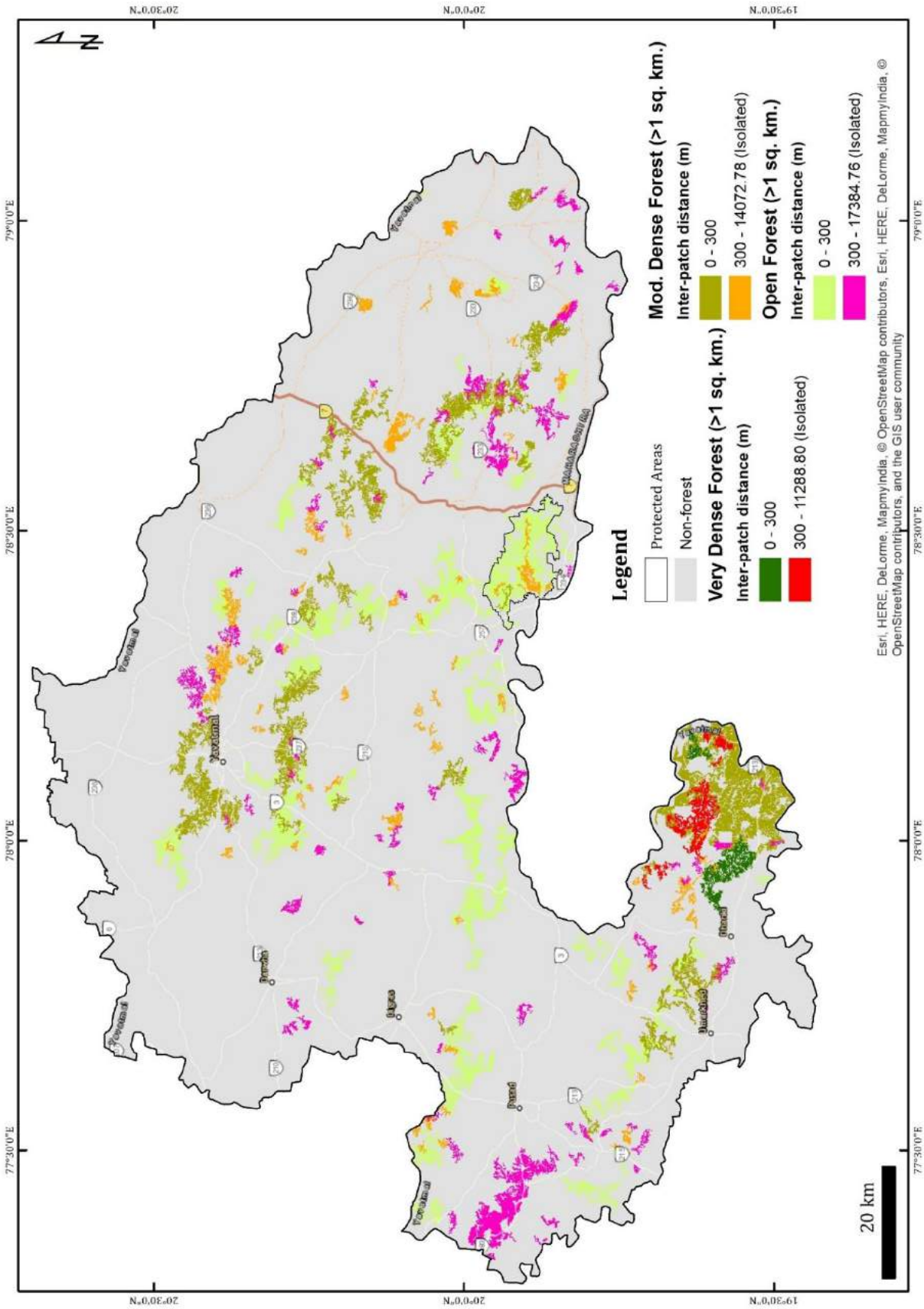
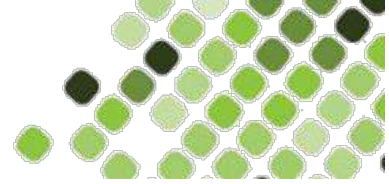
Forest Fragments in Eastern Vidarbha Landscape, Maharashtra



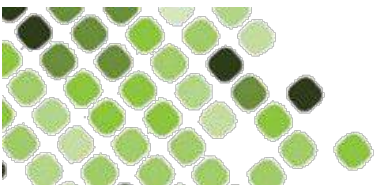
**Figure (9c):** Forest fragments in Wardha District of Eastern Vidarbha Landscape, Maharashtra with respect to road network

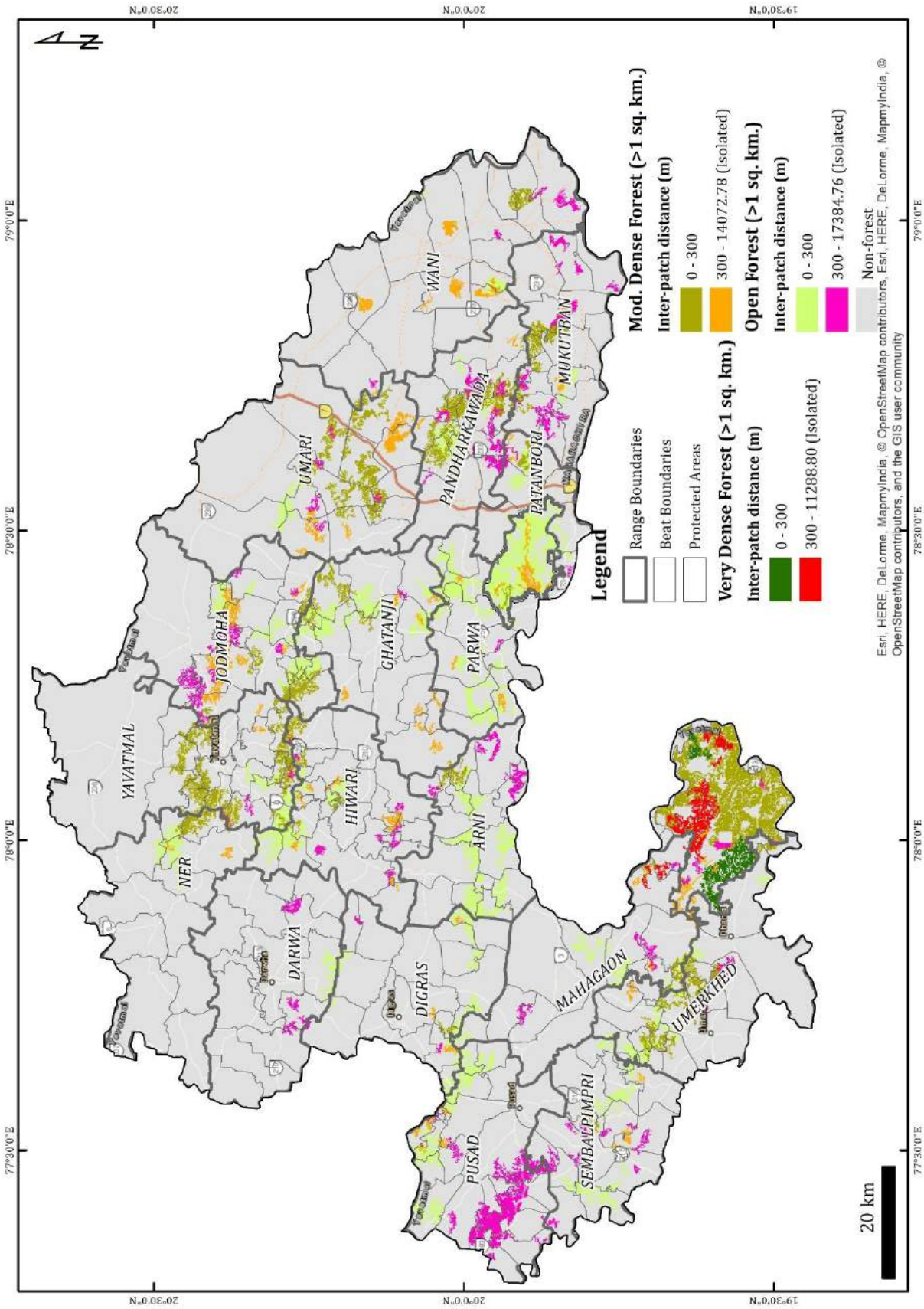
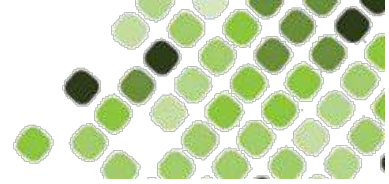






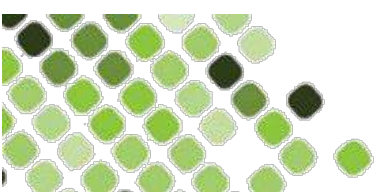
**Figure (10a):** Forest fragments in Yavatmal District of Eastern Vidarbha Landscape, Maharashtra





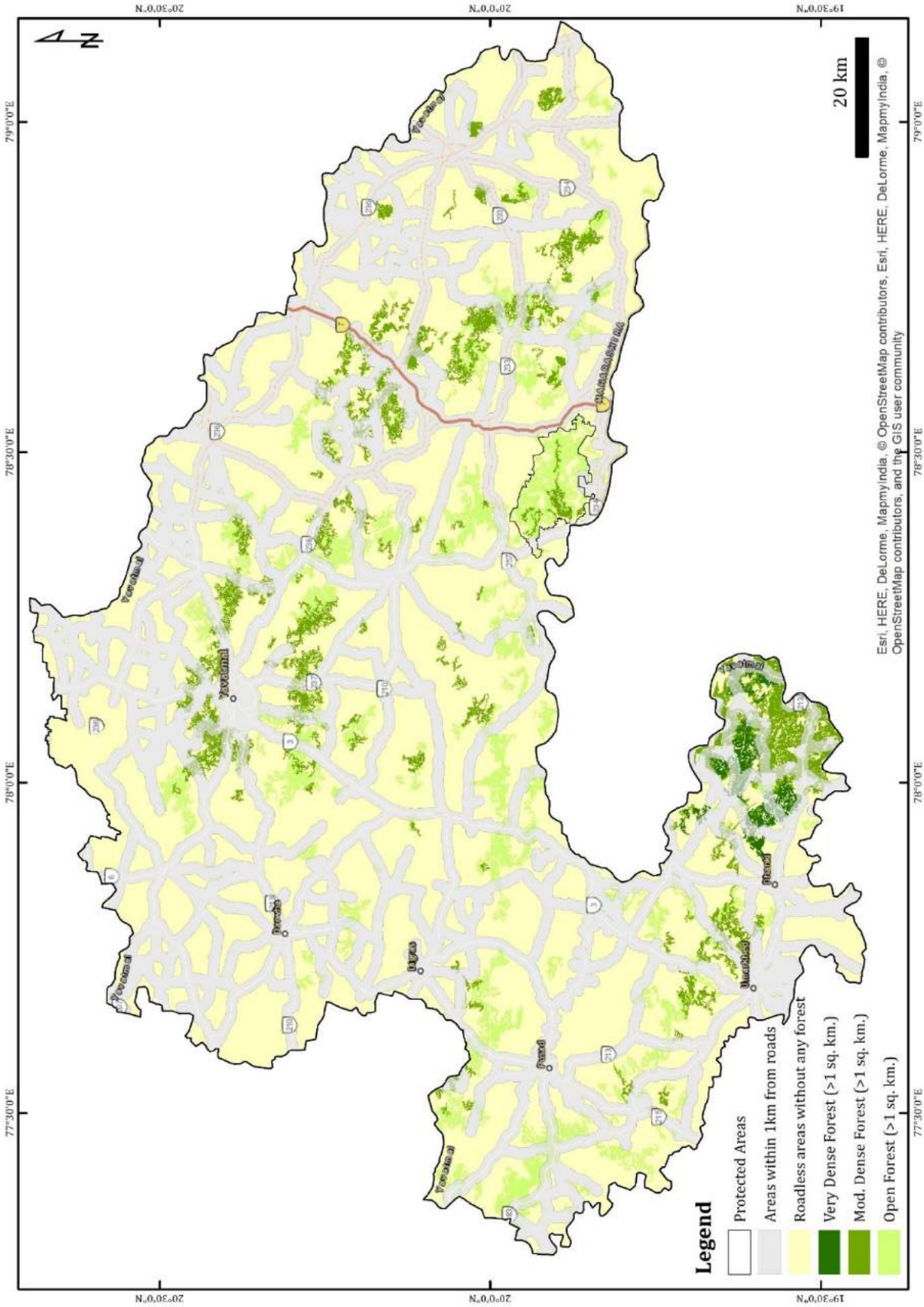
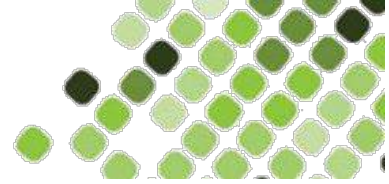
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**Figure (10b):** Forest fragments in Yavatmal District of Eastern Vidarbha Landscape, Maharashtra with respect to range and beat boundaries

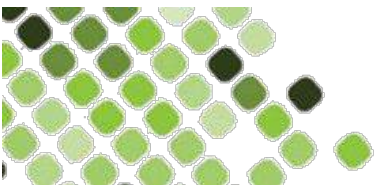


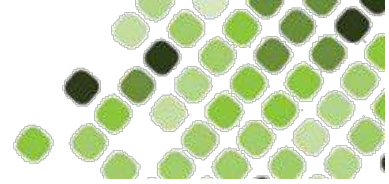
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Forest Fragments in Eastern Vidarbha Landscape, Maharashtra



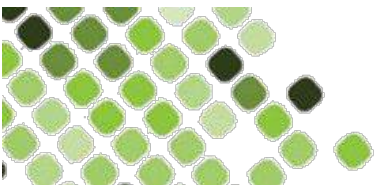
**Figure (10c):** Forest fragments in Yavatmal District of Eastern Vidarbha Landscape, Maharashtra with respect to road network

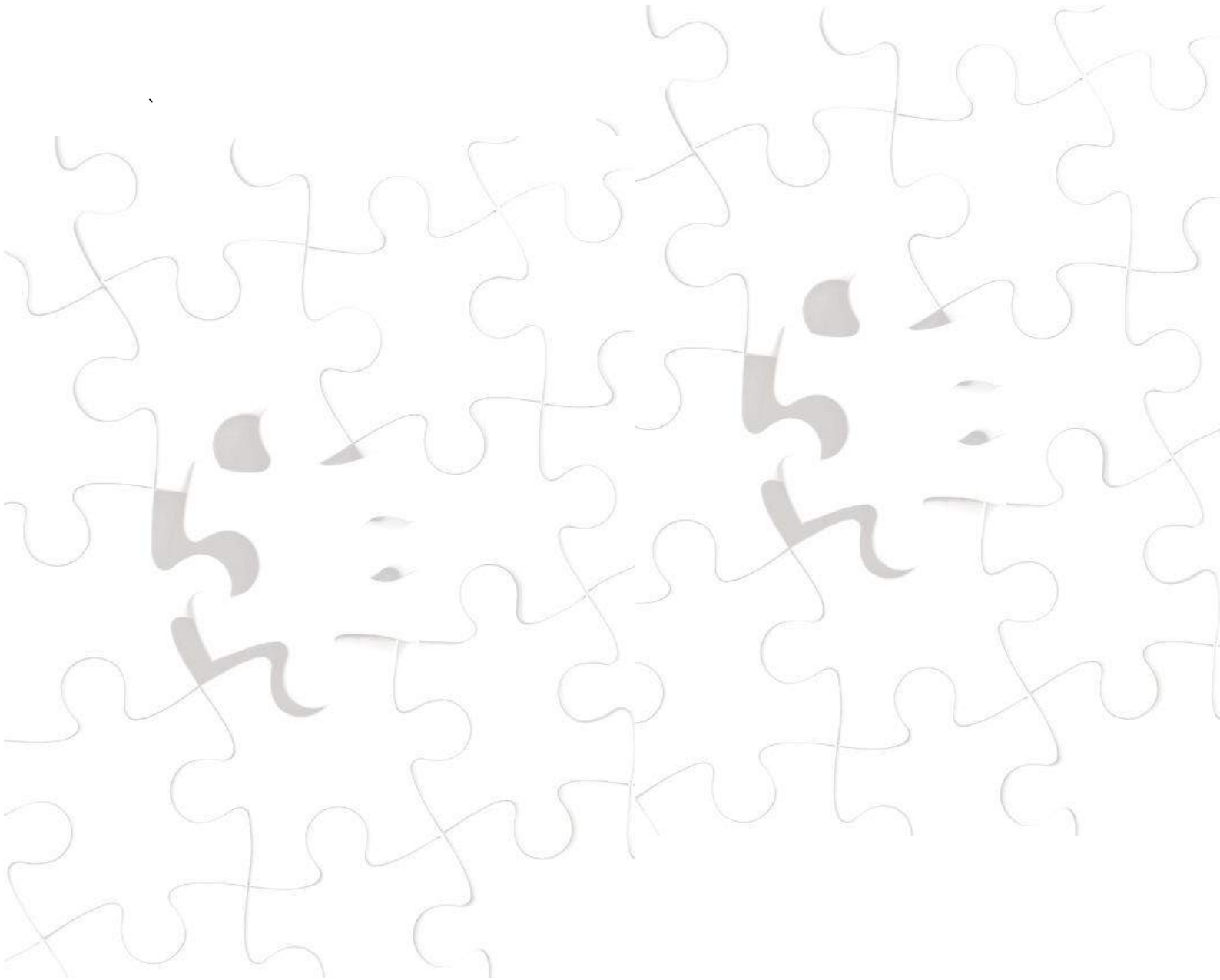




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