



## Land use alteration strategy to improve forest landscape structural quality in Radhanagar forest range under Bankura District

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### Abstract

In a forest landscape, landuse pattern is changing due to intrusion of anthropogenic activities. Such kind of human necessities restructured the existing landscape pattern which brings imbalance in regional biodiversity. Radhanagar Forest Range (RFR) in Bankura district has been faced same kind of activates since 1960. As a result, forest patch becomes isolated and structurally complex in nature which is an important cause for extinction of wild animal. To control this damage forest department increased forest area through several plantation schemes in vacant or barren land. But plantation areas were not appropriate in the question of structural forest quality in this region. The present study seems that forest structural quality is a vital consideration for balancing biodiversity, in concern of several ecological processes like species movement, connectivity, colonization and edge contrast. Suitable forest patch structure may possible when appropriate areas i.e. forest encroached areas will be select for plantation. To prove this statement, study considers two types of landuse alteration into forest land i) all barren land altered into forest and ii) selected encroached areas altered into forest land in RFR. ArcGIS 10.3 version software is used for technical map editing and preparing these spatial alteration maps. After that several landscape ecological indexes like Total Core Area Index (TCAI), Mean Core Area (MCA) at 300 m specified edge depth, Total Edge (TE), Edge Density (ED), Area Weighted Mean Shape Index (AWMSI), Area Weighted Mean Patch Fractal Dimension (AWMPFD) and Mean Patch Size (MPS) are calculated using FragStat 4.2 version software to compare both spatial alteration forest qualities. Comparison analysis explains that encroached areas alteration into forest land is qualitative to improve forest structural quality. It is interesting to know that less area will be planted in encroached area to get utmost forest structural qualities.

**Keywords:** Landuse pattern, Biodiversity, Extinction, Plantation, Spatial alteration, Forest landscape

### Introduction

The landscape in Bankura and adjoining districts tremendously modified and transformed by several development activities like unscientific clear cutting of forest and forest regeneration, agricultural and settlement expansion, industrial establishment, road network development, mining activities etc. (Kulandaivel, 2010, DasChoudhury, *et. al.* 2013). For this reason, landscape becomes more heterogeneous and biological diversity is just extreme case (Chatterjee, 2016). Some indigenous species get extinct due to landscape alteration specially clearing of forest cover (O' Malley, 1908; DasGupta, 1989; Singh, 2006.). Haphazard and frequent movement of existing animal species due to unscientific land alteration causes conflict in this region (Mandal, 2018, Desai, *et. al.* 2010). Behind such circumstances forest landscape qualities are responsible (Sukumar, 2003). Qualities in concern of forest

habitat size, connectedness, connectivity, proximity and plant species diversity determine several animal ecological processes (Li, 2007; Joshi, *et. al.* 2010; Forman, 1995; Fahrig, 2003; Rybicki, 2013). All these processes control by forest shape, core or interior, amount of edge and gap distance. According to many landscape ecologists, habitat shape is very essential consideration to manage forest landscape (McGarigal *et.al* 2005; Forman, 2009; Ewers & Didham, 2006). Therefore habitat is the leading component of landscape for ecological conservation. Ecological problems are also related to landscape mosaic pattern. Such patterns are habitat fragmentation, habitat encroachment and disturbance. Habitat fragmentation now becomes a special issue in ecological conservation (Cushman, *et. al.* 2010, Forman, 2014) and it is one of the most important problems which imbalance ecosystem in a region (Farina, 2006).

RFR forests shape is very much fragmented due to agricultural encroachment. It makes disturbance through the penetration of anthropogenic activities inside the forest core (Kumar, *et. al.* 2010; McGarigal *et.al.* 2009). It is one of the most important causes of frequent expose of wild animal (Sukumar, 2003; Desai, *et. al.* 2010). Similar movement pattern is also found in this region. In spite of any kind of measures are not taken to protect forest fragmentation in RFR as well as in this district. Yet forest cover has been increased through Joint Forest Management (JFM) by plantation in barren land since 1980 (Sudhakar and Raha, 1994). All initiatives or land alteration encourage or discourage forest cover without consider fragmentation and forest shape structure. Therefore, plantations in vacant or barren land are commonly found in this region (Mandal, *et. al.* 2014) and forest encroachment rate due to agricultural expansion are mostly common (Singh, 2006, Mandal, 2018). These programs are gradually prompt forest isolation greater than before. As a result wildlife activity in this region becomes an extreme issue especially elephant movement and conflict.

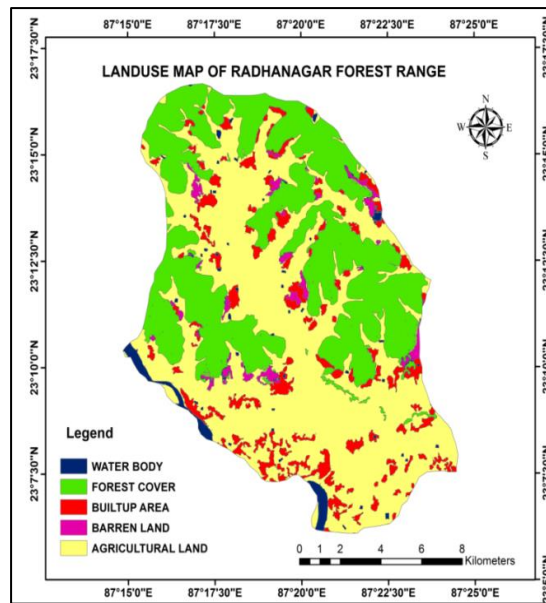
Habitat structural composition factors control many ecological activities. Poor habitat structure such high fragmentation, less core area, lower effective connectivity doesn't create balance ecology. In a human altered landscape, an appropriate landuse alteration is always meaningful to manage or increase habitat structural quality (Fernando, *et. al.* 2008). Generally, in a forest landscape plantation in vacant land is the process to develop forest qualities. Similar procedure is taken in RFR. But the question is that this land alteration strategy is scientific in the question of forest structural qualities? Therefore, the present study searches the appropriate areas or land for plantation into forest land which may scientific. This present research also tries to find which lands are to be taken for plantation to improve forest habitat quality. That enhance amount of forest core, forest area and lowers the edge effect, edge complexity as well as fragmentation which makes balances in regional biodiversity.

## **Materials and Methods**

### **Study area**

Radhanagar forest range in Bankura North Forest Division is ecologically an important region. Forest cover of this range is the second largest dominant land cover (Fig-1) after agriculture land use. Due to forest regeneration after 1980 forest cover increased (Sudhakar and Raha, 1994; Forest Report, 2017) and it's become a suitable ecological area for many migratory animal species (Singh, 2006). But forest becomes extremely patchy and structurally fragmented (Chatterjee, *et. al.* 2014; Mandal, 2018). Agricultural land expansion, animal husbandry, small scale industrial setup and housing establishment are the major causes of it (Singh, 2006; Kulandaivel, 2010). Therefore landscape alteration is very urgent to manage and control this type of complex structure.

Figure 1: Land use land cover map of RFR, IRS P6 LISS –III satellite image 2016.



### Methods

The present study theoretically taken two types of land for plantation and alter into forest in map to compare which land is appropriate for plantation. These are all Barren Land (fig-1) and some specific Encroached Areas (fig-4). Generally forest covers increased through alteration of barren land by forest plantation. But forest plantation is not a meaningful concept to increase forest habitat quality until considering habitat structural factors. Habitat quality depends on maximum forest core, minimum edge effect, less fragmented patch and undisturbed activities like road in a forest patch. All these factors related to habitat structure but not in amount of forest.

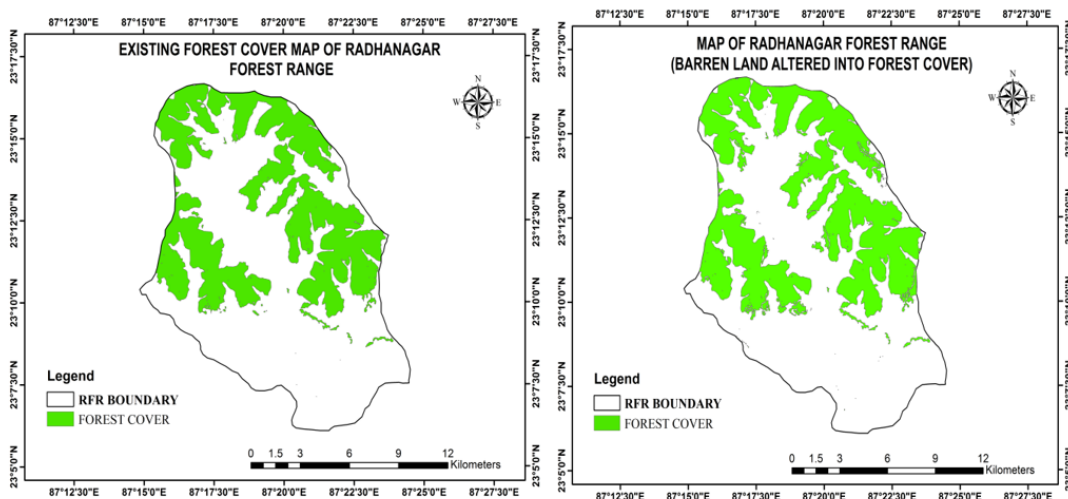


Figure 2: Existing forest landscape under RFR.

Figure 3: All barren land altered into to forest cover under RFR by reclassify method.

To get the actual scenario of the forest patches structure a classified categorical map has been prepared for that particular forest range (fig-2). In this map, work at first altered total barren land to forest (fig-

3) then altered some selected encroached areas (Fig-4) into the forest habitat separately through ArcGIS-10.3 version software. After preparation of these three map several ecological indices calculated to get the value of indices like Total Core Area Index (TCAI), Mean Core Area (MCA) at 300 m specified edge depth, Total Edge (TE), Edge Density (ED), Area Weighted Mean Shape Index (AWMSI), Area Weighted Mean Patch Fractal Dimension (AWMPFD) and Mean Patch Size (MPS) are measured through FragStat 4.2 software. After that study compares these indices values to understand which type of alteration will more ecologically important to enrich forest qualities?

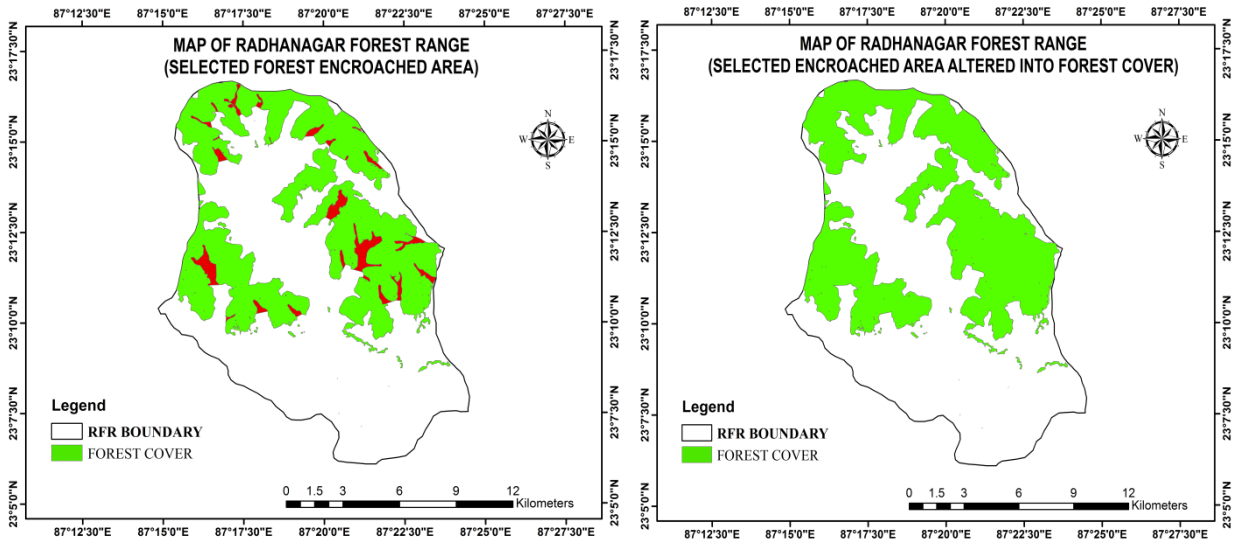
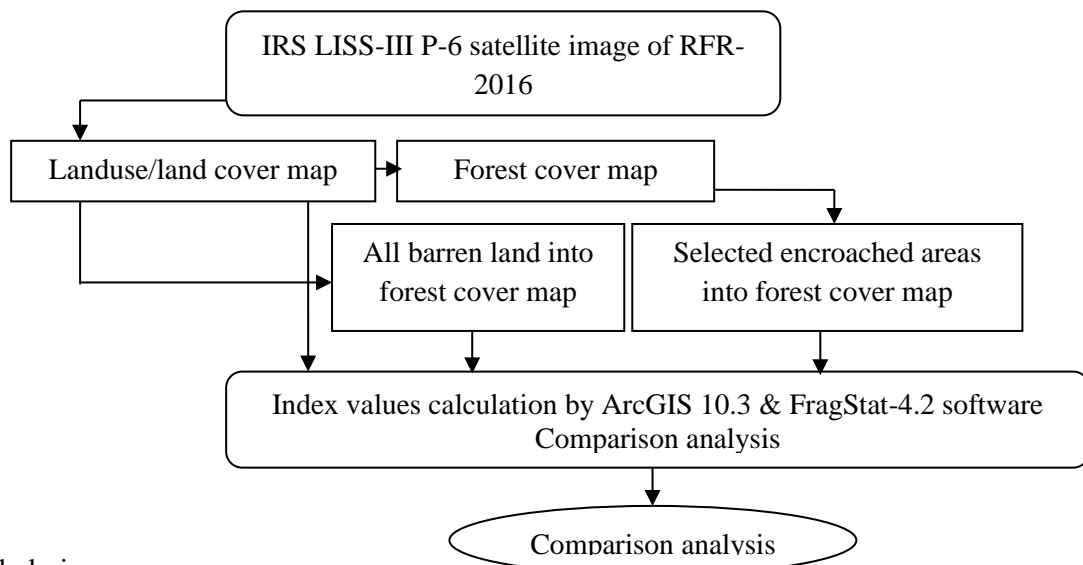


Figure 4: Selected areas (red marked) altered into forest land by shape editing.

Figure 5: Forest cover map after altered specific encroached area in RFR



Research design

Table 1: Used methods their description and unit after McGarigal and Marks 1995

Index	Method	Description	Unit
MCA	$MCA = \frac{\sum_{j=1}^n a_{ij}^c}{n_1} \left( \frac{1}{10,000} \right)$	$a_{ij}^c$ = core area ( $m^2$ ) of patch ij based on specified- edge depth (300m). $n_1$ =number of patches in the landscape of patch type (class) i	Hectares
TCAI	$TCAI = \sum \frac{a_{ij}^c}{a_{ij}} (100)$	$a_{ij}^c$ = core area ( $m^2$ ) of patch ij based on specified- edge depth (300m). $a_{ij}$ = area ( $m^2$ ) of patch ij	%
TE	Sum of perimeter of all corresponding patches		m
ED	$ED = \frac{\sum_{k=1}^m e_{ik}}{A} (10,000)$	$e_{ik}$ = total length (m) of edge in the landscape involving patch type (class) i A = total landscape area ( $m^2$ )	m/ha
AWMSI	$AWMSI = \sum_{j=1}^n \left[ \left( \frac{.25 p_{ij}}{\sqrt{a_{ij}}} \right) \left( \frac{a_{ij}}{\sum_{j=1}^n a_{ij}} \right) \right]$	$p_{ij}$ = perimeter (m) of patch ij $a_{ij}$ = area ( $m^2$ ) of patch ij $n_i$ = number of patches in the landscape of patch type (class) i.	None
AWMPFD	$AWMPFD = \sum_{j=1}^n \left[ \left( \frac{2 \ln .25 p_{ij}}{\ln a_{ij}} \right) \left( \frac{a_{ij}}{\sum_{j=1}^n a_{ij}} \right) \right]$	$a_{ij}$ = area ( $m^2$ ) of patch ij $p_{ij}$ = perimeter (m) of patch ij n = number of patches in the landscape of patch type (class) i.	None
MPS	$MPS = \frac{\sum_{j=1}^n a_{ij}}{n_1} \left( \frac{1}{10,000} \right)$	$a_{ij}$ = area ( $m^2$ ) of patch ij class $n_i$ = total number of patches in ij class	Hectares

The present study accepts these indices because ecological significance of landscape will be quantified by these indices. These measures are commonly used in landscape configuration assessment for management purpose. To understand the patch dominance MPS index is very useful method. It represents mean patch area in corresponding class. Higher value indicates better quality in a landscape (McGarigal, *et. al.* 2009). Structural shape of the landscape will be understood by AWMSI and AWMPFD. The index value when increased it shows increase shape complexity. High shape complexity is related to more structural fragments which are not qualitative in ecological manner (Flather and Bevers 2002; Haila 2002; Cushman 2006; Forman, 2010; Fahrig 2003). Patch core is another consideration to understand landscape qualities. A specific edge depth is very essential to demarcate core area. The present study considers 300 m edge buffer or distance depending on forest patch size in RFR to calculate core area matrix. The accepted indices MCA and TCAI high values indicate better forest qualities because it offers large amount of core and high percentage of core area in a landscape.

## Results and Discussion

The Existing Forest Cover (EFC) is 7340.75 ha and number of forest patch is 23 in RFR. Forest cover increases in both alterations from existing situation i.e. 377.5 ha in case of Barren Land Alteration (BLA) to forest and 630.25 ha in case of Encroached Area Alteration (EAA) to forest. Normally, MPS will must rises in both cases due to increases of forest cover. Positive trend is found in EAA. MPS increase to 27.41 ha from EFC (Fig-6). But in BLA the trend is negative -77.96 ha due to increase patch number i.e. 23 to 32. Extend number of patch increases edge in the landscape (Dramstad, *et. al* 1996; McGarigal, *et. al.* 2002; Fahrig, 2013). Similar result is found in BLA. TE length is 352200 m which enlarged 66300 m from EFC and it also promote ED because landscape area is same. In case of EAA both TE and ED values are decrease from EFC (Fig-6). These results predict that forest habitat qualities will better in the question of edge contrast and patch dominance in case of EAA than BLA and also EFC.

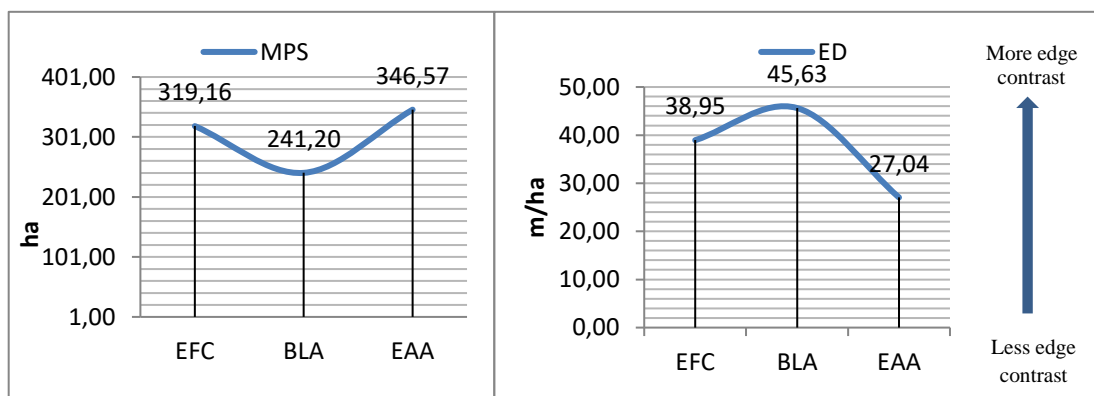


Figure 6: Graphical presentation of MPS and ED values of same three conditions

Forest patch structural character is another consideration to understand both forest condition qualities in RFR. AWMSI and AWMPFD are taken to compare forest shape structure qualities in between three conditions. It is seemed that shape complexity is high in BLA than EFC. Rather shape complexity decreases (Fig-7) in EAA which is 3.19 from 4.54 AWMSI of EFC. Similar trend also found in AWMPFD.

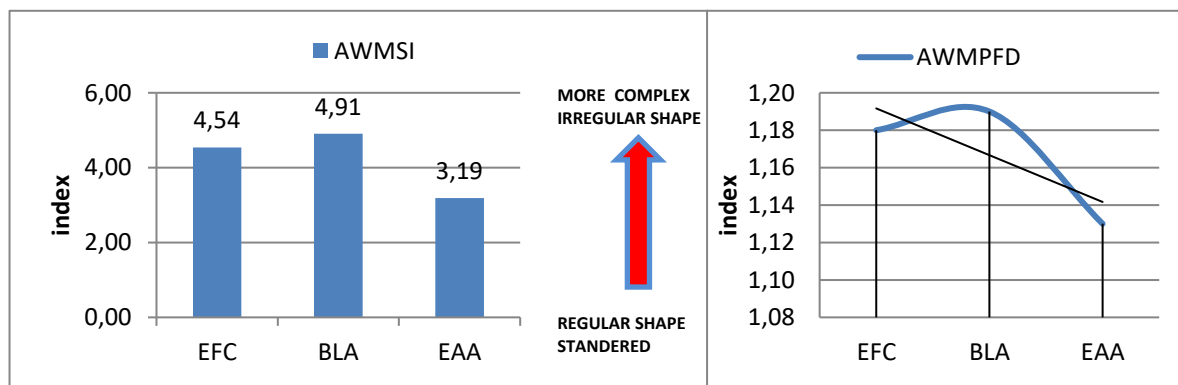


Figure 7: Graphical presentation of AWMSI and trend of AWMPFD values of same three conditions

Another component is core or interior of the forest habitat which is a significant ecological factor to support animal for their colonization (Couvillion, 2005; Li, *et. al.* 2007 Mandal, 2018). Forest core development and conservation is one of the sound full objectives in forest management strategy (Schmiegelow, *et. al.* 2002; McGarigal, *et. al.* 2005). To determine core area and its characteristics

MCA and TCAI are used at 300 m edge depth for both maps in RFR. The comparison measures show that MCA value rises (Fig-8) in EAA from both cases due to similar patch number with existing landscape and forest area enlargement. But MCA value declines in case of BLA though enlarge of forest area because number of forest patches increased by scatter alteration. Percentage of core area (TCAI) also increased in EAA 68.51 % from both maps i.e. 53.98% in EFC and 51.07% in BLA. The core amount is losing (-2.91%) in case of BLA due to increase structural shape from EFC.

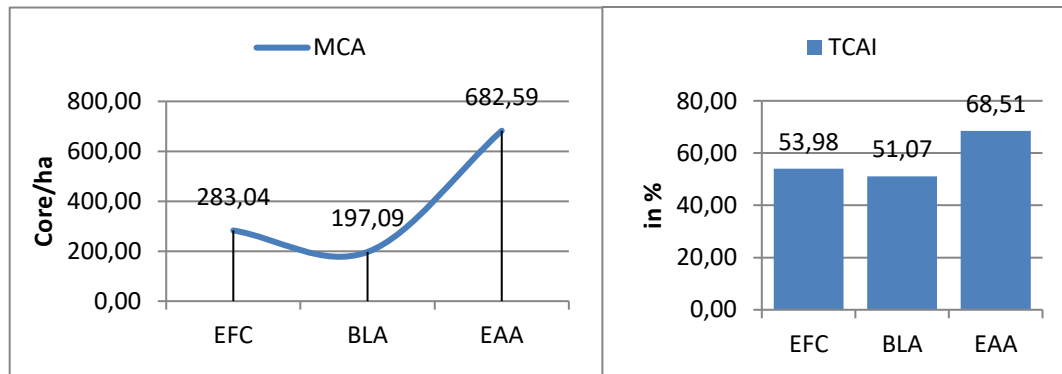


Figure 8: Represents the nature of core area indices in three condition in RFR

All graphical representation of landscape indices signifies that forest plantation is strongly appropriate in encroached areas. The present work proves that forest plantation in isolated point only increases forest areas but it raise several ecological demerits. This landuse alteration process is also responsible for more geographical and structural fragmentation which causes wildlife extinction (Lande, 1988; Sjögren-Gulve, 1994; Leakey and Lewin, 1995), decolonization (Crooks, 2002), decolonization leads human animal conflict (Carr and Fahrig 2001; Cushman 2006; Carr *et al.* 2002) and ultimately make ecosystem imbalance. Few amount of agricultural areas inside the forest i.e. encroached areas when altered in forest land it may qualitative than all barren land converted into forest in RFR. It has been found that not only forest shape structure but other ecological factors like forest habitat dependency (larger core area), dominancy (individual large patch area) and gap (inter patch distance) between forest habitat patches also qualitative through such type of EAA into forest in RFR. This spatial alteration into forest raises forest core, decreases forest isolation, edge influence, and increases amount of forest area. To balance forest ecosystem in a region these are very sensitive characters (Forman, 2014; Drohan, *et al.* 2012) in a forest landscape. Therefore, it should be keep in mind that appropriate land must be select for plantation to improve or manage forest habitat quality (Banks, *et al.* 2005).

## Conclusion

Map is the simplest form of model of real earth (Farina, 2006; Forman 2010; Cushman, *et al.* 2010). The study uses landuse and land cover map to prepare a simplest model of habitat conservation by proper spatial alteration. A minor but appropriate landuse change in forest how increase habitat quality that shows this work by comparing habitat structural ecological indices. Social forestry, Joint Forest Management, Forest Protection Committee, society for specific animal protection etc. are so many well organisations have to improve habitat quality through the proper instruction and landuse alteration in forest land for habitat structural management.

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