Quantification of Habitat (Forest) Shape Complexity through Geo-Spatial Analysis: An Ecological Approach in Panchet Forest Division in Bankura, West Bengal

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Authors' contributions

This work was carried out in collaboration between both authors. Author MM designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript and managed the analyses of the study. Author NDC managed the literature searches. Both authors read and approved the final manuscript.

Original Research Article

ABSTRACT

Landscape consists of different landuse and land cover whatever it natural or queasy-natural. Each and every unit of landscape plays a considerable role in ecosystem ecology. When forest cover habitat considered as an unite of landscape, the entire ecological system being reciprocal with it. Spatial attributes of the landscape, landuse and land cover's structure and composition directly related with quality of the habitat. Habitat shape is one of the unique characters of the landscape which is regulating many ecological processes. Habitat fragmentation and loss of habitat, these two important ecological processes of the landscape equivalently connected with habitat shape complexity. In Panchet forest division forest patches are structurally fragmented due to complex shape. For the purpose of the study 27 forest patches are digitized from the map of Panchet forest division by using ArcGIS 10.3 version software. Study tries to investigate the habitat quality through habitat shape analysis. To know the nature of shape complexity and habitat loss of these forest patches three indices (SI, ERI and PPACI) have been taken. These indices results represent that

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Joypur, Kalabagan, Gobinadapur being larger forest patches in spite of their shape complexity is become high. To manage this situation that is habitat quality enhancement study also recommends some approaches relate with habitat loss and habitat fragmentation.

Keywords: Habitat; landscape; shape complexity; habitat fragmentation; habitat Loss.

1. INTRODUCTION

The relations of habitat size and boundary in form of shape are very substantial for ecological process [1]. Habitat patch shape is determined as a two dimensional border of an area of homogenous landscape. Patch shape is the key attributes for species movement and material transfer whether it is linear, curvilinear or circular [2]. Though it is natural but conducted very much by human activities to reshape it. According to him patch shape measurable attributes are elongation, convolution, interior and perimeter [3]. These entire components are ecologically functional and influences inter patch connection in form of small-mammal migration [4] and it also influenced animal forage behavior argued by [5]. Convolution of a patch shape that is the nature of coves and loves are responsible to determine the habitat fragmentation processes and its nature. Habitat loss due to agricultural encroachment raises the irregularity of the shape of the habitat. By this process area sensitive species become more frequent because losses of interior portion of the habitat. Core area is also depends on patch shape. More irregular patch has fewer cores than standard path shape. Highly convoluted patch has a larger amount of edge that is favor for edge specific species. This controversial aspect core area and edge are generally species specific relationship but both are connected with patch shape factor. Human activities responsible for reducing natural vegetation, fragile animal community, and altered landscape mosaic dramatically restrict regional ecosystems by disturbing landscape structure [6]. Similarly land mosaic of Panchet forest division in Bankura district also restructure by human activities like road network development, agriculture and forest regeneration program. The existing landscape offers fragmented habitat shape.

2. STUDY AREA

Bankura district be made up of three forest division Bankura North, Bankura South and Panchet forest division. The present study is going on Panchet forest division which latitudinal position is 22º53N to 23º12N and longitudinal is 87º03E to 87º42E. Geographical area of the Panchet forest division is 1355.62sqkm (Fig. 1). Approximate fourth quarter of the landscape is covered by forest after first dominating agricultural landuse. Most of forest patch had been planted and composed by sal (*Shorea robusta*) trees with dry deciduous nature. The landscape of the region is traditionally altered by human activities. South-Eastern rail way from Khargapur to Adra section and also NH-60, SH-2 penetrates into the division. Development of horticulture in this region disturbed indigenous habitat by clear cutting forest and occupying barren land and it also responsible for habitat shape become more complex [7]. In Panchet forest division forest patch become isolated and the edge of the forest patch adjacency maximum with agricultural landuse. Therefore the edge of the forest habitat is sharp with clear outline border. After 1980 through Joint Forest Management (JFM) forest area of this region increased habitat area as per State Forest Report [8]. But shape of the habitat become more complex and regional fragmentation increased due to scatter plantation in barren land and open forest area. Enlarged habitat size ecologically important when its shape regionally balanced rather then it causes some ecological phenomenon which creates social disturbances like species movement related disturbance, loss of properties and species extinction.

3. DATA SOURCE

The present work is continuing through satellite image analysis by some geometric question. The base map, forest habitat patch map has been prepared from open source googol image by point to point polygon shape cropping method. By this way 27 polygons (forest patch) has been cropped for analysis. The patch named as a nearest village name. After getting the shape of the habitat it is running by specific software like ArcGIS 10.3 version and FRAGSTAT 5 version to quantify the ecological value of it for purpose of the study.

4. OBJECTIVES

Habitat structure is the spatial character of the landscape. Structural pattern of the habitat

invented by natural phenomenon and also by human activities like agricultural expansion, industrial development, settlement establishment etc. Sins from independence the same work had been done in Panchet forest division and forest patch become complex to more complexes in nature. The existing habitat structure how much irregular that determine by the study in ecological point of view. To measure the nature of complexity of habitat and construct a proposal to decrease complexity the work is taking by specific objectives.

1. Demarcate forest patch as a habitat in the study area.
2. Quantify habitat shape complexity in respect of slandered geometric shape.
3. Proposal will be set up for managing irregularity of the habitat.

5. METHODS OF ANALYSIS

Point of ecological interest the present study considered circle is the slandered shape because the selected forest patch has in polygon shape with vector format. To quantify irregularity or complexity at first each and every patches circled with radius of its longest axis (Fig. 2). Perimeter and area relationship is the major factor to investigate the habitat patch shape in field of habitat loss, encroachment, edge effect, amount of core or interior and fractal nature of it. It should be kept in mind all quantify indices deviation from circular pattern of the habitat depicted positive or negative character of the so-called patch.

1. Shape index (SI) [9]

$$SI = \frac{p}{\sqrt{a^2}} \text{ Adjusted by circle}$$

p is perimeter of the patch and a is area of the patch. When SI is 1 the patch is circular and increasing value indicate more irregular from circle standard.
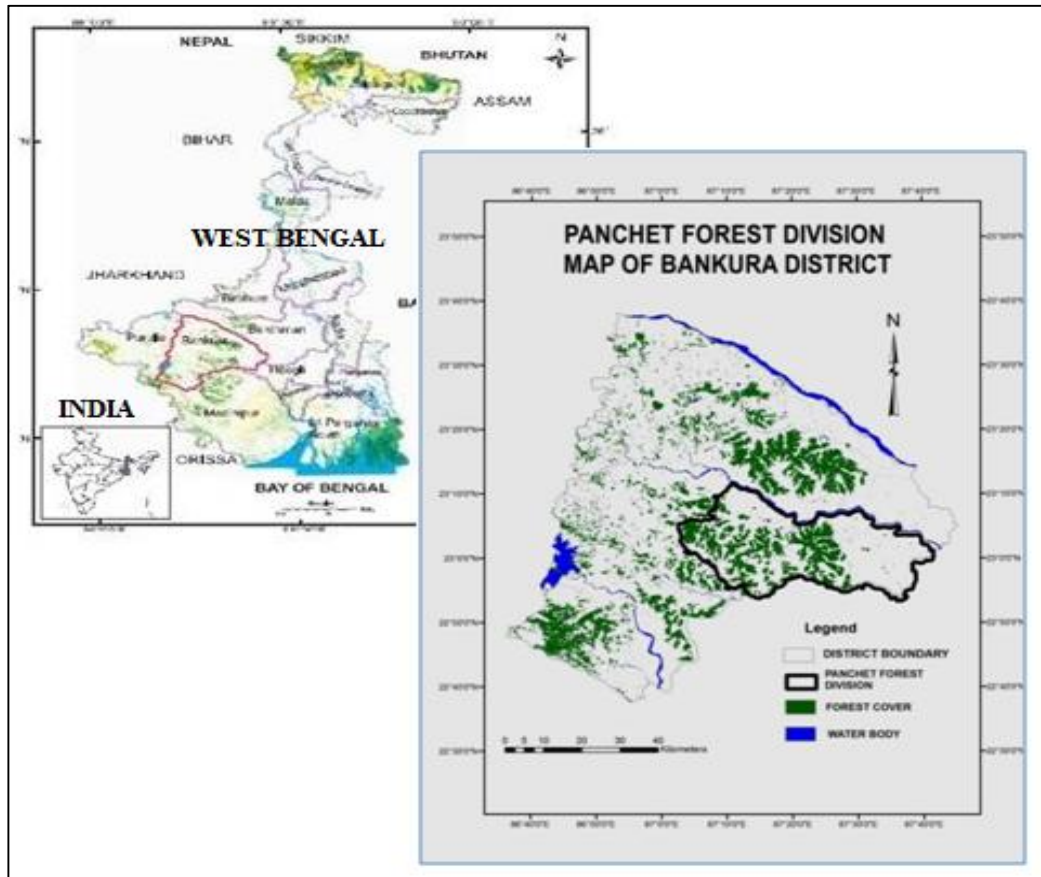

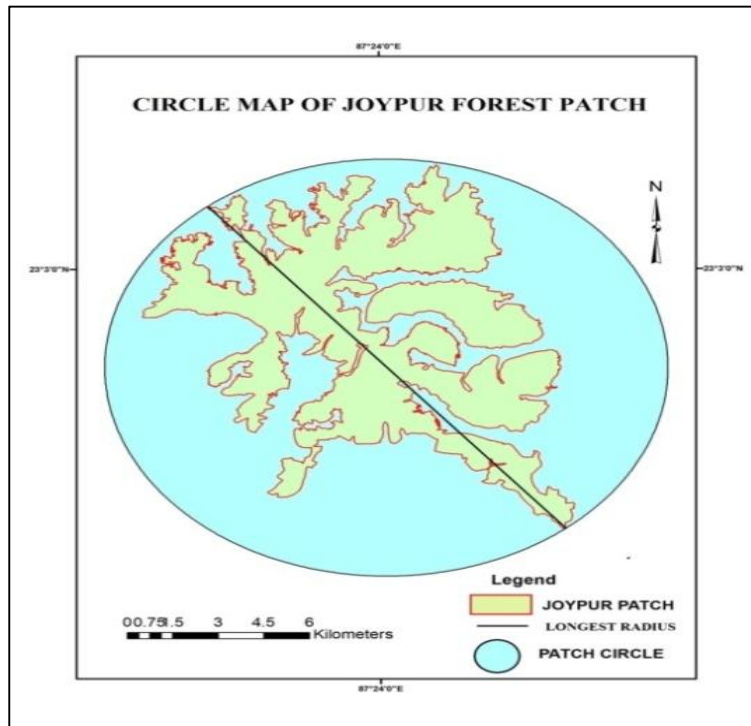**Fig. 1. Location map of the study area Panchet forest division in Bankura district.**

Fig. 2. The map of Joypur forest patch adjusted by a circle when radius is the half of patch longest axis

2.   A. Encroachment rate index (ERI)

$$ERI = 100 - \left[\frac{a^h}{a^c} \times 100 \right]$$

a^h area of the habitat patch and a^c area of the circle of that patch radius with longest axis. ER when 0 habitat patch has without encroachment. Increasing the value of ERI denotes rate of encroachment is high.

B. Patch perimeter adjusted circle area index ($PPACI$)

$$PPACI = \frac{p^a}{pc^a} \times 100$$

p^a Patch area in sq./m. pc^a patch perimeter adjusted circle area in sq/m. the index value always greater than 0, and when 100 patch area and perimeter adjusted circle area is same.

6. RESULT AND DISCUSSION

After analysis all forest patch in Panchet forest division the study got a meaningful result. Forest habitat size has a great importance on ecology of the landscape. Similarly in the study area Joypur

forest habitat patch has abundant dominancy due to its large size than the small patches like Metiala, Chakshrikishnapur, Pearibandh, Asthasol etc. Here in the point of present research view, in the field of habitat shape structural arrangement ignored the size of the habitat because all forest patches are not in same size. Study look for the habitat shape positivity with ecological response with landscape, which one is the suitable shape for ecological importance and which one is less? To rich this view point three types of analysis have been done.

6.1 Shape Index

The complexity of the habitat patch is a common character in the landscape mosaic. It is a matter of fact that high complex habitat patch does not offers batter quality for especially large herbivore animal. The study found that   Joypur (7.36), Upper part   of Arrha (6.60), Valuka East (4.03) are the high value of SI (Shape index) due to encroachment of the habitat by other landuse like agricultural land expansion.   The lowest value found in Asthasole (1.32), Sabrakona(1.39), Amdangra(1.68) respectively near to the circle standard shape (Fig. 4).

Table 1. Quantify value of circle adjusted forest of Joypur patch and existing forest patch shape

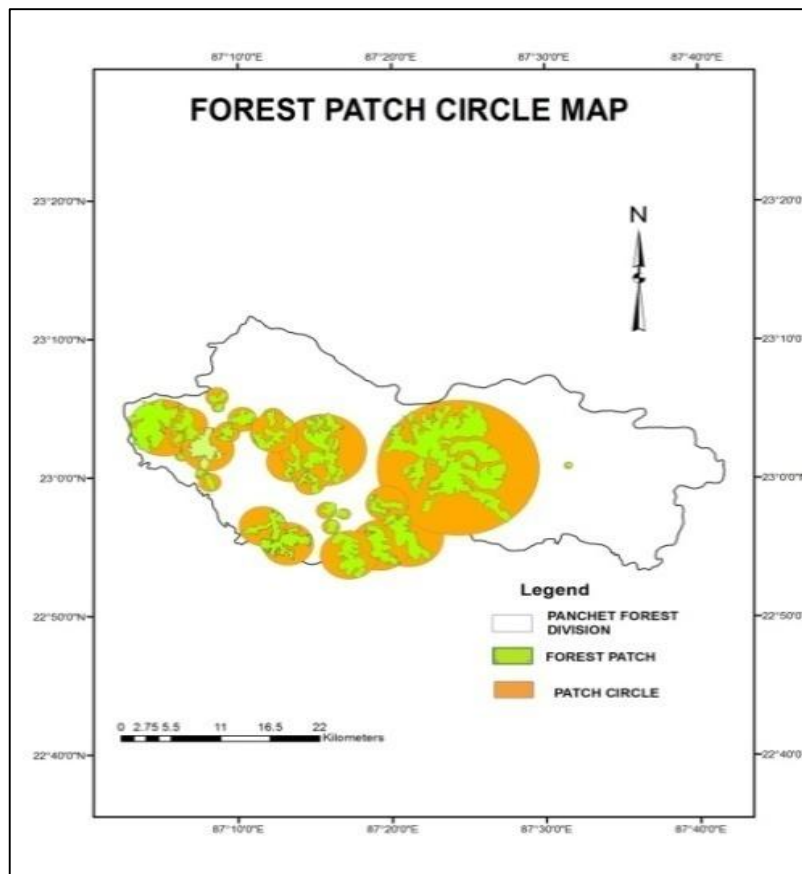| Factors	Habitat patch	Patch circle
Area	81973085sq.m	254771000sq.m
Perimeter	254630.4735 m.	56582.5 m.
Shape index	7.36481	1

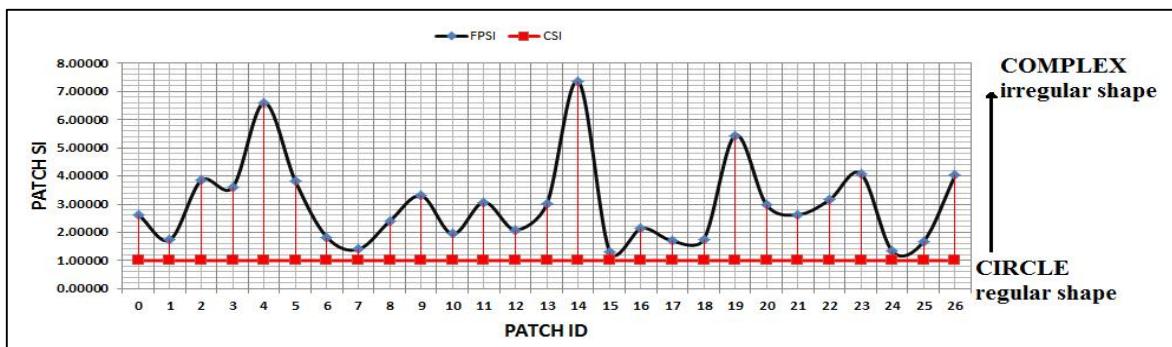**Fig. 3. Patches with rounded circle considering longest axis of the habitat patch in Panchet forest division**

Fig. 4. The patch shape complexity form circle standard, where FPSI Forest Patch Shape Index and CSI Circle Shape Index

It is interesting to know that Joypur, Uppar part Arrha and Chandabelia forest patch are larger patch in spite of they are more irregular in shape. It is observed that when habitat patch become larger, the rate of irregularity also higher. The index shows that these habitat patches also high fragmented in nature. Sometime linear fragment of habitat is acting as stepping stone for dispersal of animal. Same situation has been found in case of wild pig and elephant movement near these patches. Both side and in-between of this fragment, human landuse tremendously are destroyed by trampling of elephant. By this sense they are become ecologically less significant than small patch like Asthasole, Sabrakona, Metiala upper, Chakeshayampur etc.

6.2 Encroachment Rate

Habitat loss assessment is very difficult in human intervening landscape. If considered the shape of the habitat is standard form (circle) from which habitat encroached by different activity then it

can be assumed by geometric calculation. In the present study it is accepted that all patches encroach from circle shape. To considered this method the result of all habitat patches depicted that the rate of encroachment is high in Majuriprasadpur (80.06), Peardoba1 (73.78), Upper Peardoba, Kalabagan habitat patch. Rather low encroachment found in Chakshyampur, chatrakrishnanagar (28.26), Metiala, Athasol forest patch (Fig. 5). It is seems that agricultural land encroaches into the forest land is a common phenomenon near in high ERI habitat patches. Not only agricultural land but also attached barren land is considered as an encroached area into circle of the habitat patch. Anyhow, if this agricultural and barren land altered into forest land by plantation then these patches will be ecologically suitable habitat. In case of Joypur forest patch linear intrusion by agriculture land is found but its circle shape adjusted with its patch shape, therefore the value of ERI its didn't increases. Joypur forest patch will become most suitable habitat in this region if maintain its shape structure.
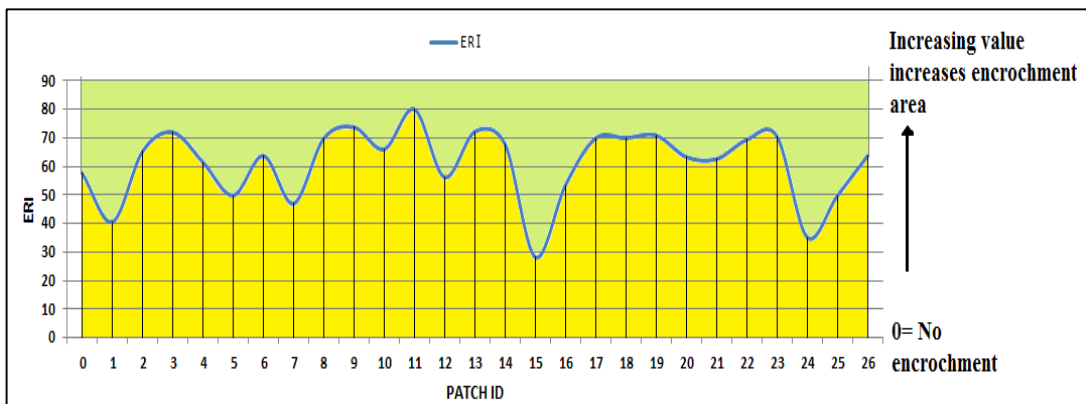

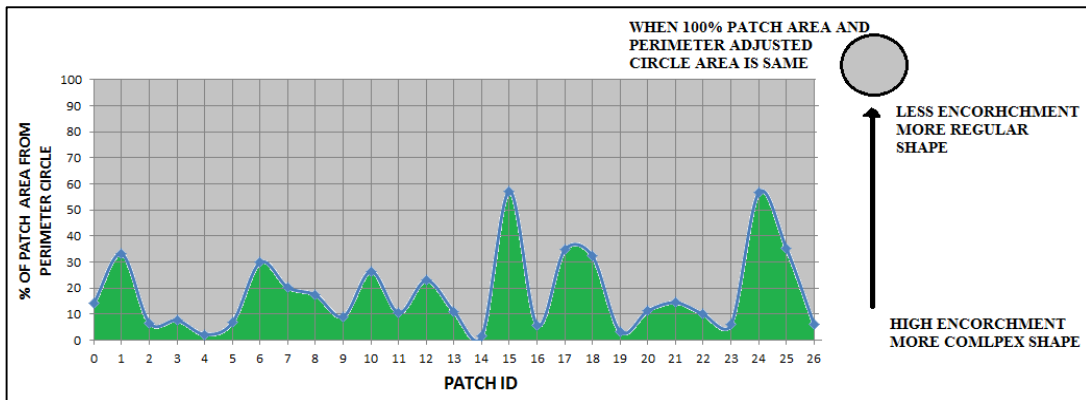**Fig. 5. Graphical representation of patch wise difference in (ERI) Encroachment Rate Index**

Fig. 6. Graphical presentation of percentage of habitat area in its perimeter adjusted circle area
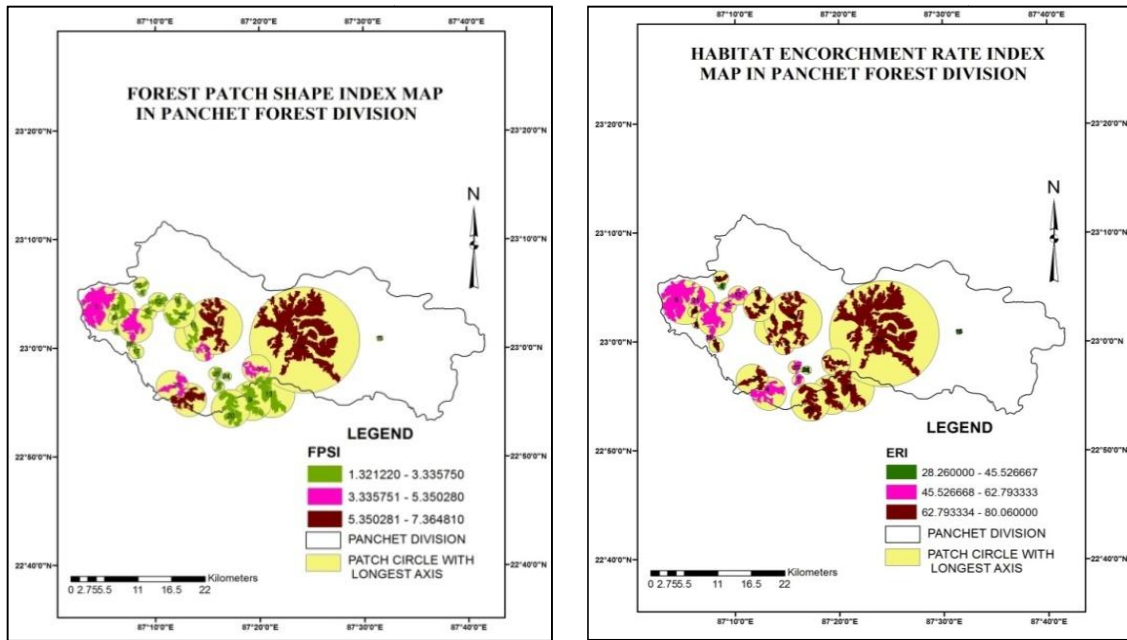
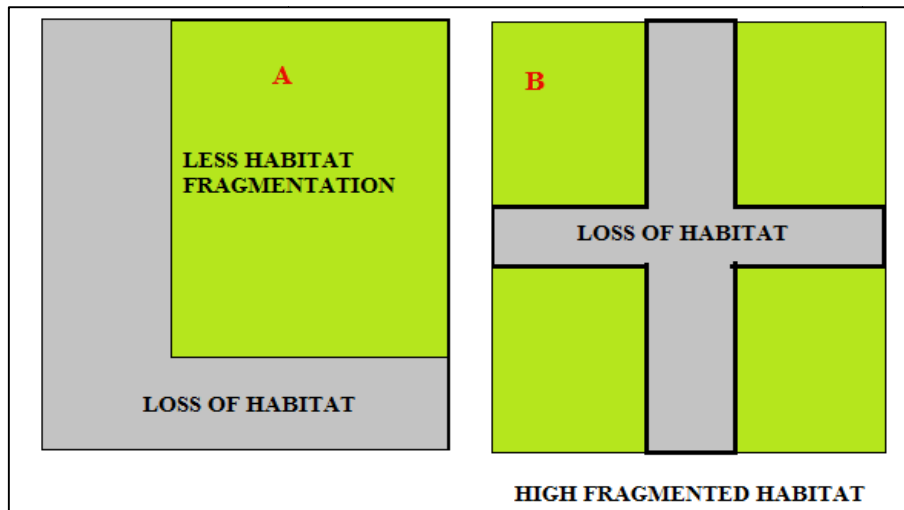**Fig. 7 and 8. The different quality forest habitat patch in SI and ERI in Panchet forest division**

Fig. 9. Relation in between A and B habitat patch. Both of the habitat losses habitat area in same quantity but nature of habitat fragmentation is quite difference.

7. CONCLUSION

After discussed the results study conclude that the larger patches in Panchet forest division have more complex than small size patch. These high complex forest patches are ecologically meaningful in present time [10]. Therefore managing approaches will take at first for those forest patches like Joypur. Kalabagan, Gobindapur etc.

8. MANAGING PLAN

The present study discussed about the forest habitat patch which one is more ecologically qualitative and which one less? High fragmented or encroachment habitat patch have possibility to decline its shape complexity. When complexity of the habitat patch is decline ecological quality will be growing up. To decrease complexity take some necessary

activities and awareness related with habitat structure.

1. Control forest clear cutting in the question of habitat loss and habitat fragmentation. It should keep in mind forest clearing is directly related with habitat loss but not in fragmentation.
2. Forest regeneration on that place of the habitat which is encroached by other landuse practices.
3. Establishment of industry and infrastructure development, it should keep away from outside of the habitat patch with its longest axis.
4. To increase connectivity between two habitat patch use to adjoining barren land by plantation for better corridor for the moving species.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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