EDGE EFFECT ANALYSIS OF PERI-URBAN NATURAL ECOSYSTEM DETERIORATION; BAHIRAWAKANDA TERRAIN, KANDY, SRI LANKA

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Abstract

Ecosystems are constantly threatened by the poorly regulated development impact in the developing world. Rapid urban development and inadequate management of the ecosystems are the main reasons for this. This is mainly due to the rapid urban developments and inadequate concern of managing natural ecosystems. Using the remote sensing field this research intends to investigate the ecological deterioration of natural terrain due to the rapid urbanization process. The field of remote sensing is not widely used in analysing urban issues in Sri Lanka. This study focuses on understanding and calculating the ecological impact with reference to Kandy Bahirawakanda natural peri-urban terrain ecosystem based on remote sensing field. There are four ecological impact indexes that can be used to measure the impact using remote sensing technology. This paper uses the edge effect index as the measuring device to measure the increase of isolation of ecological patches. This approach provides a clear insight in to how a single ecological patch fragments into the separate patches and the increase of gaps between those patches. This provides a very good physical and visual indication of one important aspect of the destruction of natural ecosystems.

Keywords: edge effect, remote sensing, patch isolation, peri-urban, natural ecosystem.

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1. Introduction

Rapid and aggressive urban expansion in last few decades has caused massive decline and even total loss of connectivity in Urban terrain landscapes leading to challenges (Kowe, Mutanga and Dube, 2021) in maintaining good Urban natural ecosystems. These ecosystems are vital for the urban population and the environment and fulfil a verity of useful ecological tasks. For example, these systems may mitigate the heat island effect, provide a habitat for local flora and fauna and provide soothing vistas for the inhabitants.

However, in some of the urban areas, these ecological clusters are becoming more and more isolated, less dense and declining in size due effects from transit network developments and legal and illegal encroachments due to property developments (Ranaweera, Jayasinghe and Abenayake, 2021). These threats will lead to problems in balance of urban terrain ecosystem Biodiversity, environmental condition and urban microclimate (Wijayawardana *et al.*, 2020). Of these urban areas, peri-urban areas are the most vulnerable as they still retain significant ecosystems which face development pressure.

Therefore, it is important to analyse this impact. There are four ecological impact indices (increased patch isolation, edge effects, impact of fragmentation and habitat buffer) that can be used to measure the deterioration of peri-urban natural ecosystems using remote sensing technology(Spiesman, Stapper and Inouye, 2018).This paper analyses the impact of fragmentation using the edge effect index as the measuring device to measure the increase of isolation of ecological patches. This approach provides a clear insight in to how a singular ecological patch fragments into the separate patches and the increase of gaps between those patches.

2. Literature Review

2.1. PERI-URBAN NATURAL ECOSYSTEMS

Peri-urban areas are often defined as transitional zones between rural and urban areas, where the characteristics of both commonly overlap. These areas, for example, feature a wide range of land-use patterns, from agricultural and forestry to residential and industrial applications. Natural Ecosystems in these regions are called peri-urban natural ecosystems (figure 1). ('CDKN-PB-Peri-urban-ecosystems-India_Web.pdf', no date)

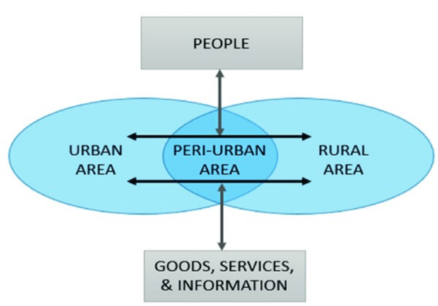


Figure 1: Concept of peri-urban areas and the rural–urban-region (Source:Samat et al,2020)

Peri-urban environments, which can feature valuable protected biotopes, preserved woods, prime agricultural fields, and significant wetlands often provide crucial ecosystem services for city dwellers (Douglas, 2006). From an economic, environmental, and social perspective, peri-urban areas represent very complex territorial spaces. However, despite their complexity, both urban and peri-urban inhabitants rely on the various peri-urban ecosystem services that these places provide(Lee, 2015).

2.2. IMPACT ON PERI-URBAN NATURAL ECOSYSTEMS DUE TO RAPID URBANIZATION

Rapid urbanization and increased human activity at the peri-urban areas has created immense pressure on peri-urban ecosystems leading to their deterioration and sometimes total loss. (Degradation-and-Loss-of-Peri-Urban-Systems.Pdf, n.d.) The influence of urban growth on peri-urban ecosystems varies depending on whether growth is characterized by expanding sprawl or increasing population density in these areas (Degradation-and-Loss-of-Peri-Urban-Systems.Pdf, n.d.). Urban areas do not function in isolation, but rather as part of a "sphere of dependency" on their surroundings and ecosystems. As a result of the degradation of these ecosystems these dependencies may be de-linked.

Sprawl: Migration into peri-urban areas effectively extends the urban border, frequently changing the usage of peri-urban lands and resulting in losses in air quality, water supply, drainage and erosion control, and food production services.

Density: Population growth inside existing urban bounds raises resource demand and stress on the peri-urban ecosystem, resulting in water quality degradation, waste treatment issues, and increased storm susceptibility, especially in coastal areas. It's worth noting that density can have good repercussions in terms of improving service delivery efficiency.

> *Cities do not function in isolation, but rather as part of a "sphere of dependency" on their surroundings and ecosystems. As a result of the degradation of these ecosystems, ecosystem services that support urban and peri-urban populations are lost Green vegetation covers the peri-urban territory, which absorbs pollutants and heat, but destroying these peri-urban natural ecosystems affects the process of filtering harmful substances from the nearby atmosphere. A "heat island" effect can emerge when previously permeable and shady environments become dry and solid, resulting in higher temperatures in a region.*
> *('Degredation-and-Loss-of-Peri-Urban-Systems.pdf', no date)*

> *Different types of criteria can be used to assess the natural ecosystem impact. , Edge effects, increased patch isolation, Impact of fragmentation, Habitat loss these metrics are commonly used to evaluate the impact on natural ecosystems.*
> *(Spiesman, Stapper and Inouye, 2018)*

2.3. INCREASED EDGE EFFECT

Due the above mentioned degradation large contiguous landscapes tens to break in separate patches. Boundaries or transition zones between two nearby landscape patches or land cover types are known as ecological edge. Edge effects are often described using three terms: shape, depth, and magnitude.(Porensky and Young, 2013) . The functional form of the response curve across an edge is called edge response shape.

Edge-effect depth (or distance) can be characterized in a variety of ways, but it generally refers to the physical distance at which one patch's effects penetrate an adjacent patch. (Harper and Macdonald, 2011)

Pa = Perimeter (m) of patch Pa

Energy, nutrients, and organisms move over the mutual border of adjacent ecosystems. As a result, an ecosystem near the point of contact with another ecosystem may experience changes to its species composition, structure, and ecological processes. The distance, d, at which these changes enter the habitat has been used to evaluate the strength of edge effects.

('Edge_effects_in_fragmented_forests_impli.pdf', no date)

Many edge effects are spatially and temporally flexible. Naturally, edge effects get less as one moves deeper into natural ecosystems, but many edge phenomena also differ noticeably even within the same habitat fragment or landscape.

(Laurance et al., 2007)

Age of habitat edges, edge aspect, combined effects of multiple nearby edges, fragment size, adjoining matrix vegetation structure, seasonality, influxes of animals or plant propagules from nearby degraded lands, extreme weather events, and fires are all factors that may promote edge-effect variability.

(Laurance et al., 2007)

There are three different kinds of edge effects on the fragments: (1) abiotic effects, involving modifications to the environment brought on by proximity to a structurally different matrix; (2) direct biological effects, involving modifications to the abundance and distribution of species brought on by the physical conditions nearby (for example, through desiccation, wind throw, and plant growth), and determined by the physiological tolerances of species to the edge. (3) Indirect biological.

('Edge_effects_in_fragmented_forests_impli.pdf', no date)

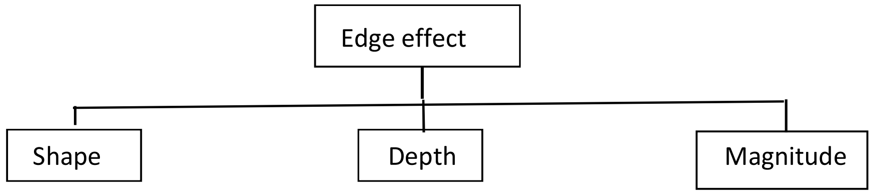
With differing edge properties and various matrices around them, edge effects have been observed in a wide range of natural ecosystem types. However, we are still unable to identify any distinct overall trends.

At least three potential confounding factors poor design, inconsistent methods, and simplifying of the perception of edge and edge effects have clouded any potential generalizations. The inadequate design may be partly to blame for the results on edge effects being inconsistent.

(Harper and Macdonald, 2011)

Landscape patterns and ecosystem processes are increasingly being recognized as being driven by ecological edges. Edges can grow so numerous in fragmented and patchy ecosystems that their impacts saturate the entire landscape. Recent research in such ecosystems has found that the existence or proximity of other nearby edges might modify edge effects.

(Porensky and Young, 2013)



2.4. THEORETICAL FRAMEWORK AND RESEARCH METHODOLOGY

The analysis has been done by monitoring three selected ecological patches by using remote sensing and geographic information system (GIS) over a 20-year period in the selected area, from 2000 to 2020.

The edge effect index as explained the literature review is used to analyse the selected area. Remote sensing field method were used as the primary analysis method as it has the least-cost path for an analysis of this nature with some inaccessible places.

Three components of edge effect (Figure 2) are used as the measuring tools. Relevant formulas and calculations are shown in the case study section.

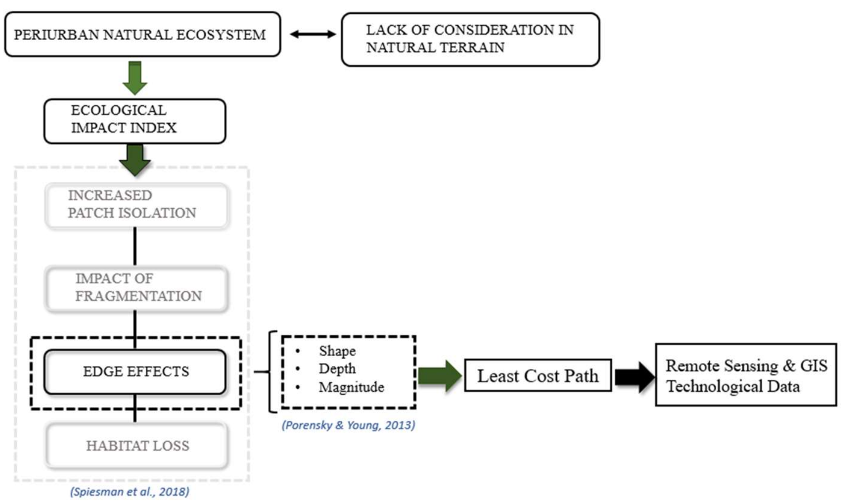


Figure 2: Theoretical Framework (Source: Compiled by Author)

By considering previous studies on a similar subject and the kind of data required for the study's analysis, the methodology of the study is developed (Figure 3). The mixed method, which makes use of both qualitative and quantitative data, was applied. Main data are generated and analysed using remote sensing software

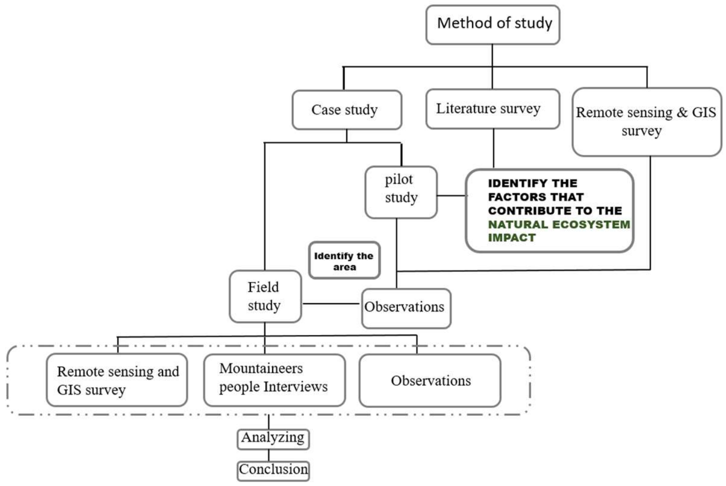


Figure 3: Research Methodology Chart (Source: Compiled by Author)

The methodology consists of three components; First, studying and identifying peri-urban natural ecosystems from the Sri Lankan context as a case study and second, identifying the ecological impact index which is suitable for analysing the area, third, quantify the impact on peri-urban natural ecosystem using remote sensing and the above index. In this investigation uses ArcGIS and ERDAS software for satellite imagery analysis and remote sensing data preparations. Here, through those software analyse the case study area over 20 years of period to obtain the deterioration of edge effect and future predictions.

First component is established in section 3.1, the Second in literature survey (2.3) and theoretical framework (2.4) and the third in section three.

3. Data Presentation of the Case Study Analysis

3.1. CASE STUDY

Bahirawakanda is a natural terrain consisting of peri-urban natural ecosystems which is in the vicinity of the Kandy town. During the last two decades the ecosystem of this area bored the brunt of the effects of the rapid urbanization process in the Kandy city area. Two and half Square kilometre (2.5km^2) area in Bahirawakanda is chosen for this investigation (Figure 4). Area was limited to this patch only due to time and accessibility constraints which did not allow further investigations in to adjoining several patches.

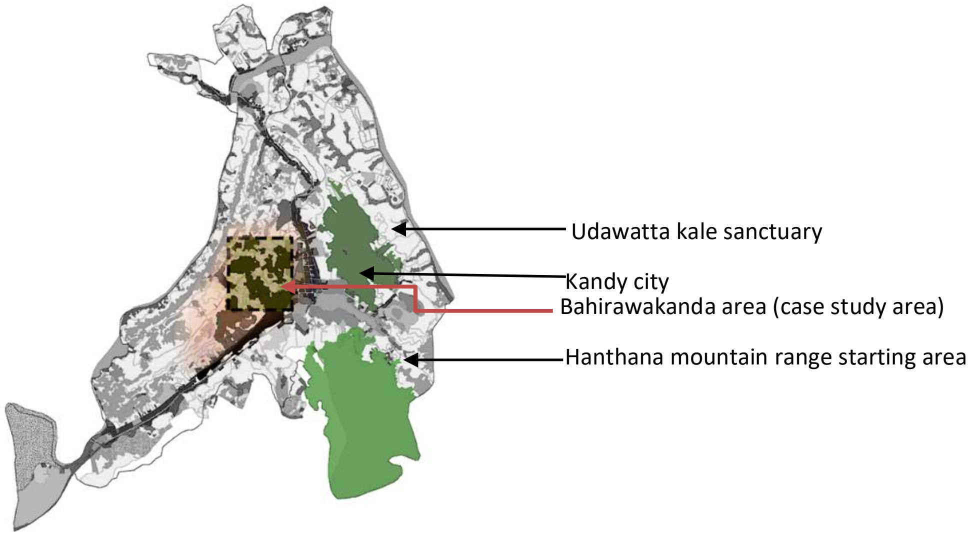


Figure 4: Case study selection criteria (Source: compiled by author)

3.2. EDGE EFFECT IN THE SELECTED AREA

In the following section the selected area will be analysed under the 3 subcategories of the edge effect; shape, depth and magnitude.

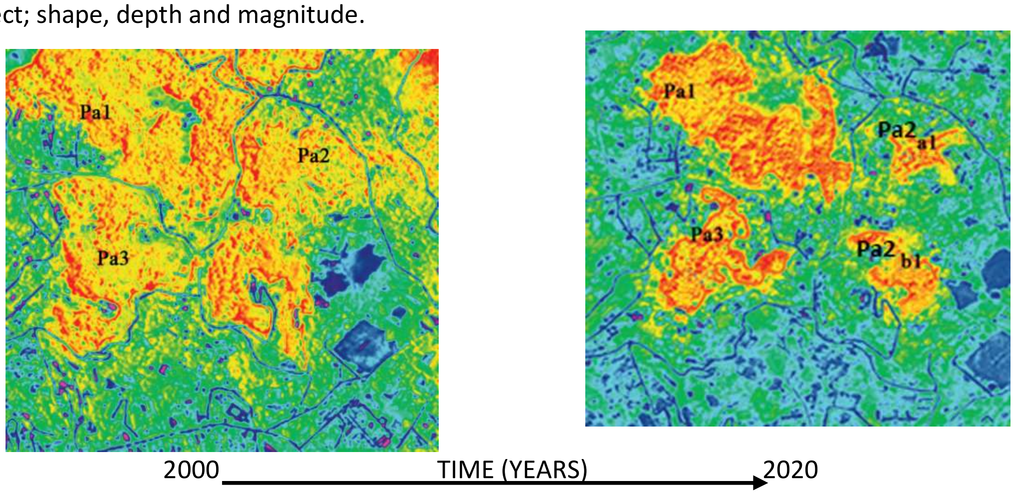


Figure 5: Selected main three patches in case study area (Bahirawakanda area)
(Source: compiled by author)

3.2.1. SHAPE

The functional form of the response curve across an edge is called edge response shape. This section looks at how the patch's edge has changed with time. Only the shape of the edge facing the adjacent patches was analyzed.in the study period.

3.2.1.1. Pa1 Ecological Patch

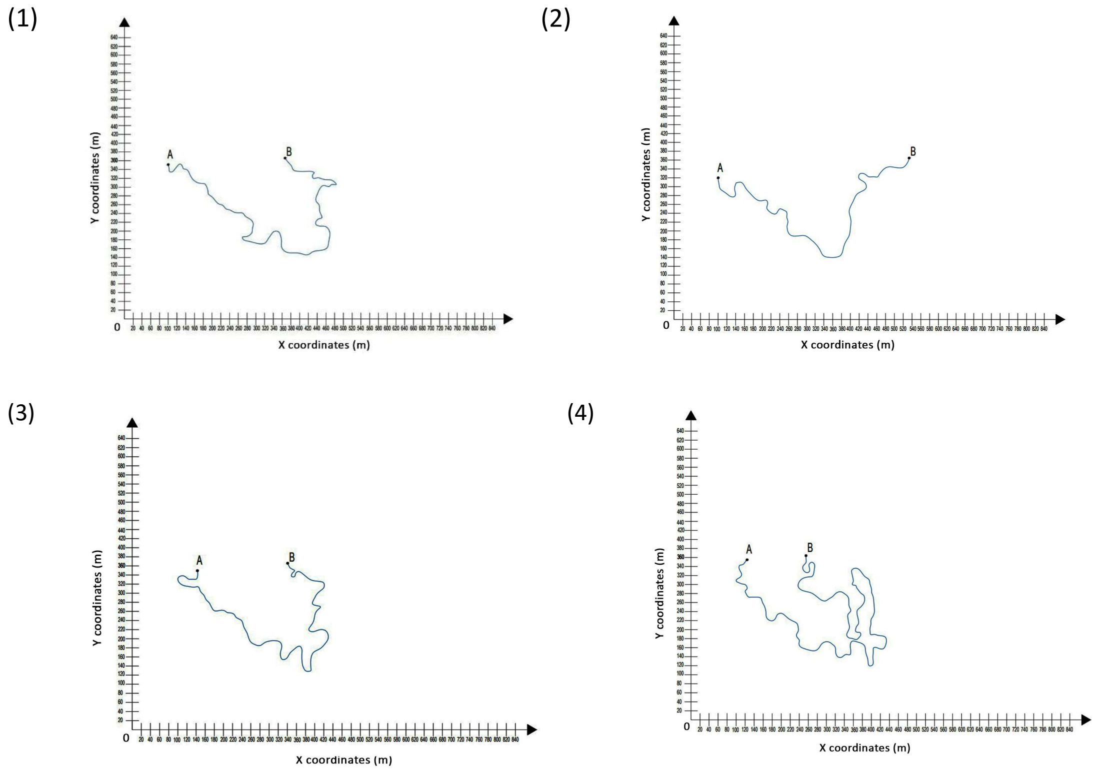


Figure 6: From (1) 2000 to 2005, (2) 2005 to 2010, (3) 2010 to 2015 and (4) 2015 to 2020 these graphs indicate the change in the shape of the Pa1 ecological patch's edge that faces the Pa2 and Pa3 patches. (Source: Remote sensing and GIS data through, compiled by author)

The change in the shape of the Pa1 ecological patch's edge that faces the Pa2 and Pa3 patches can be identified using the above RS data. When comparing point A and point B from 2000 to 2010, there is a significant difference that can be seen. (Fig: 6)

Point A $_{2000}$ (100,337) → Point A $_{2010}$ (100,352)

Point B $_{2000}$ (532,363) → Point B $_{2010}$ (363,364)

Point A only shifted down, however point B shifted more to the left and decreased by a few amounts. As a result, the morphology of the Pa1 patch changed dramatically from 2000 to 2010.

Between 2010 and 2020, there was a lot of internal fragmentation in the Pa1 ecological patch. As a result, point A and B were substantially altered. (Fig: 6)

Point A $_{2010}$ (100,352) → Point A $_{2020}$ (122,358)

Point B $_{2010}$ (363,364) → Point B $_{2020}$ (257,362)

As a result, the Pa1 ecological patch's edge shape has changed dramatically during the study period.

3.2.1.2. Pa2 Ecological Patch

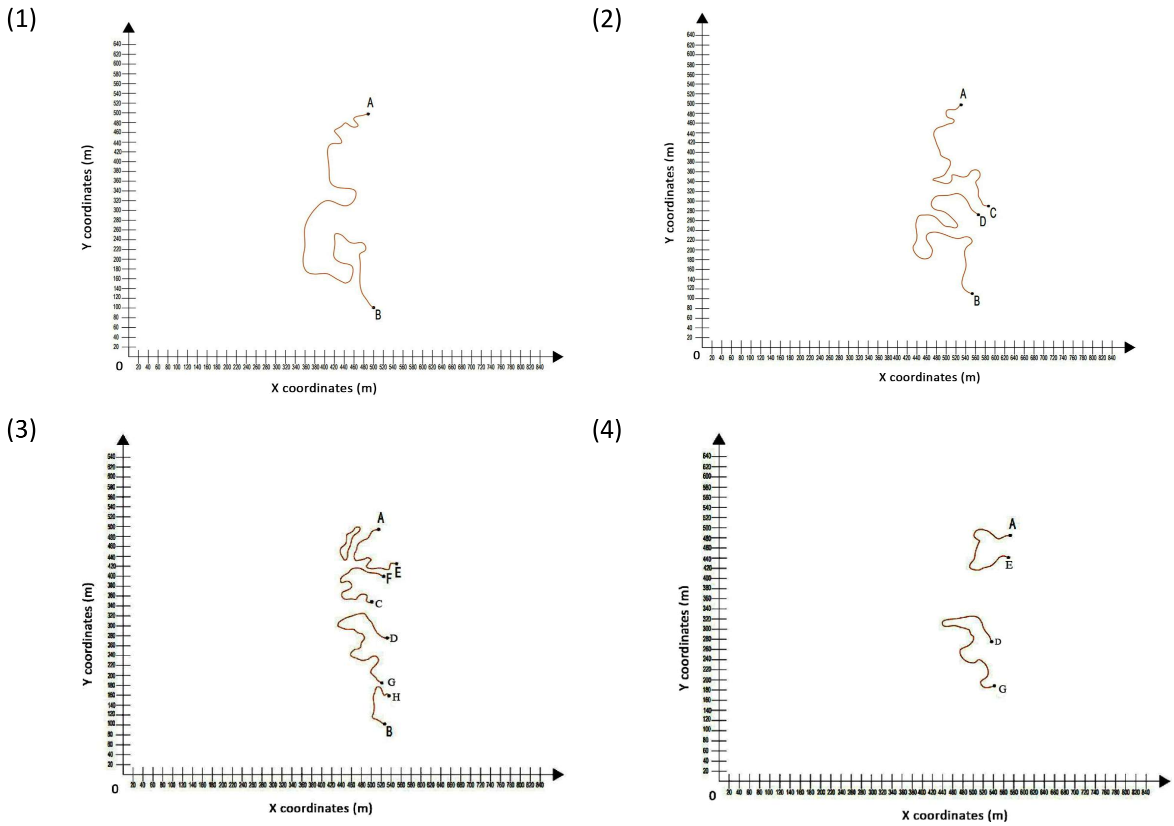


Figure 7: From (1) 2000 to 2005, (2) 2005 to 2010, (3) 2010 to 2015 and (4) 2015 to 2020 these graphs indicate the change in the shape of the Pa2 ecological patch's edge that faces the Pa1 and Pa3 patches. (Source: Remote sensing and GIS data through, compiled by author)

Considering the figure 6 RS data from 2000 to 2010 the point A and B coordinates are,

Point A $_{2000}$ (488,499) → Point A $_{2010}$ (530,498)

Point B $_{2000}$ (500,100) → Point B $_{2010}$ (556,110)

According to these coordinates can identify point A shifted right and shifted down, point B shifted left and went up, from 2000 to 2010. In 2005 to 2010 (Fig: 7 no.2) the Pa 2 patch fragmented another two patches due to that there are two new coordination points can identified. Those coordinates are C $_{2010}$ 585,290 and D$_{2010}$ 565,272. Result of this fragmentation, the shape of the Pa2 ecological patch's edge that faces the Pa1 and Pa3 patches changed significantly.

By 2015, Pa2 the ecological patch was further fragmented, due to that, there are new coordinates can be identified. Point E (551,424), point F (523,400), point G (521,185), and point H (538,159) (Fig: 7 no.3) furthermore from 2010 to 2015 considering the points C and D can identified C coordinates shifted left on X -axis and went up on Y -axis. The D coordinates shifted left than point C on X-axis, and went up than C coordinates on Y-axis. (Fig: 7 no.3)

Point C $_{2010}$ (585,290) → Point C $_{2015}$ (501,348)

Point D $_{2010}$ (565,272) → Point D $_{2015}$ (257,362)

By 2020, point A had shifted significantly left on the X-axis, but not significantly down on the Y-axis. From 2000 to 2015 there are point B coordinates, it also has not changed significantly, and by 2020 the patch that includes point B is completely fragmented. Therefore, B coordinates in 2020 do not exist. (Fig: 7 no.4)

Point A $_{2000}$ (488,499) → Point A $_{2020}$ (572,485)

Point B $_{2000}$ (500,100) → Point B $_{2015}$ (556,110) → Point B $_{2020}$ (- , -)

Furthermore by 2020, there are no Point F and C coordinates, the reason for this is that the patch containing those points is completely fragmented. (Fig: 7 no.4)

Considering figure 6: no .3 and 4, the coordinates of point D have changed significantly from 2015 to 2020, however the coordinates of point G have not changed much.

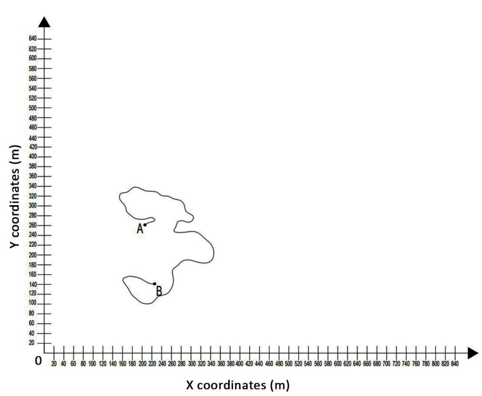
Point D $_{2015}$ (257,362) → Point D $_{2020}$ (538,277)

Point G $_{2015}$ (521,184) → Point G $_{2020}$ (541,189)

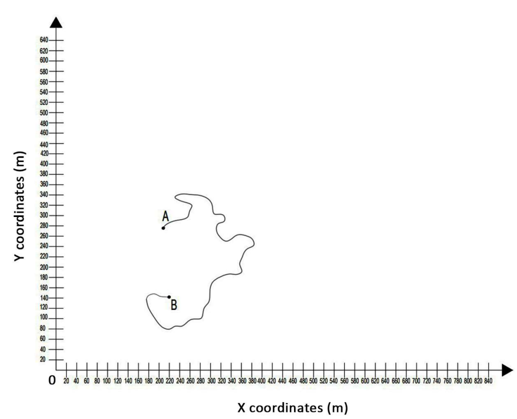
Edge of the Pa2 ecological patch's that faces the Pa1 and Pa3 patches has changed to the extent that it fragmented into 2 separate patches; Pa2a and Pa2b during the study period.

3.2.1.3. Pa3 Ecological Patch

(1)



(2)



(3) (4)

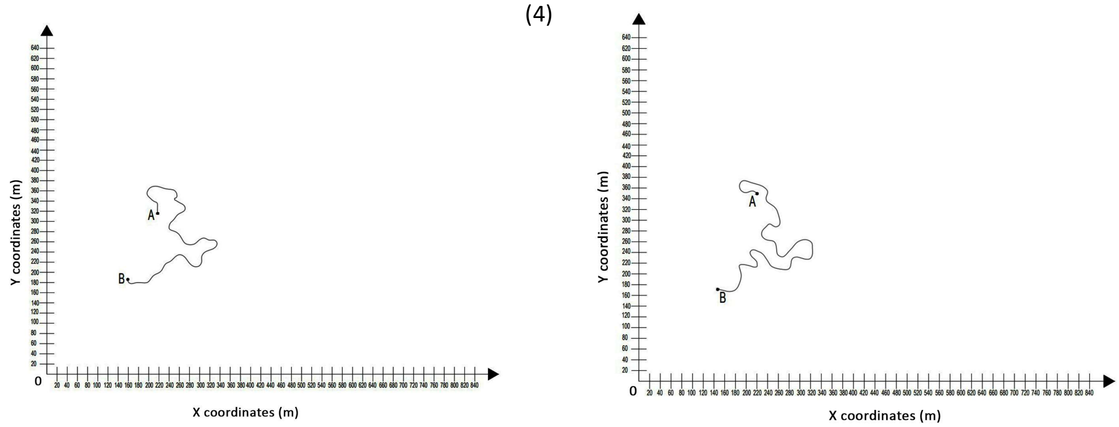


Figure 8: From (1) 2000 to 2005, (2) 2005 to 2010, (3) 2010 to 2015 and (4) 2015 to 2020 these graphs indicate the change in the shape of the Pa3 ecological patch's edge that faces the Pa1 and Pa2 patches. (Source: Remote sensing and GIS data through, compiled by author)

The change in the shape of the Pa3 ecological patch's edge that faces the Pa1 and Pa2 patches can be seen in figure 8 (Data set no 1 & 2) from 2000 to 2010. Between 2000 and 2010, the Pa3 form changed significantly from point A to point B. However, the patch's corners (points A and B) did not change significantly.

Point A $_{2000}$ (205,260) → Point A $_{2010}$ (208,278)

Point B $_{2000}$ (223,141) → Point B $_{2010}$ (220,141)

Considering figure 8 (Data set no 3 & 4) from 2010 to 2020, it can be seen that the coordinates at the corner (point A and B) of the Pa3 patch did not change significantly,

Point A $_{2010}$ (208,278) → Point A $_{2020}$ (220,350)

Point B $_{2010}$ (220,141) → Point B $_{2020}$ (147,170)

But the coordinates between points A and B are changed significantly. Due to that, the shape of the Pa3 ecological patch's edge that faces the Pa1 and Pa2 patches changed significantly increasing the perimeter while decreasing in the total area.

3.2.2. DEPTH

Edge-effect depth can be characterized in a variety of ways, but it generally refers to the physical distance at which one patch's effects penetrate an adjacent patch(Porensky and Young, 2013). As a landscape architect, using the remote sensing field, let's analyse how the edge-effect depths of the three major patches in Bhairawakanda's chosen area have changed over the study period.

3.2.2.1. Pa1 Ecological Patch

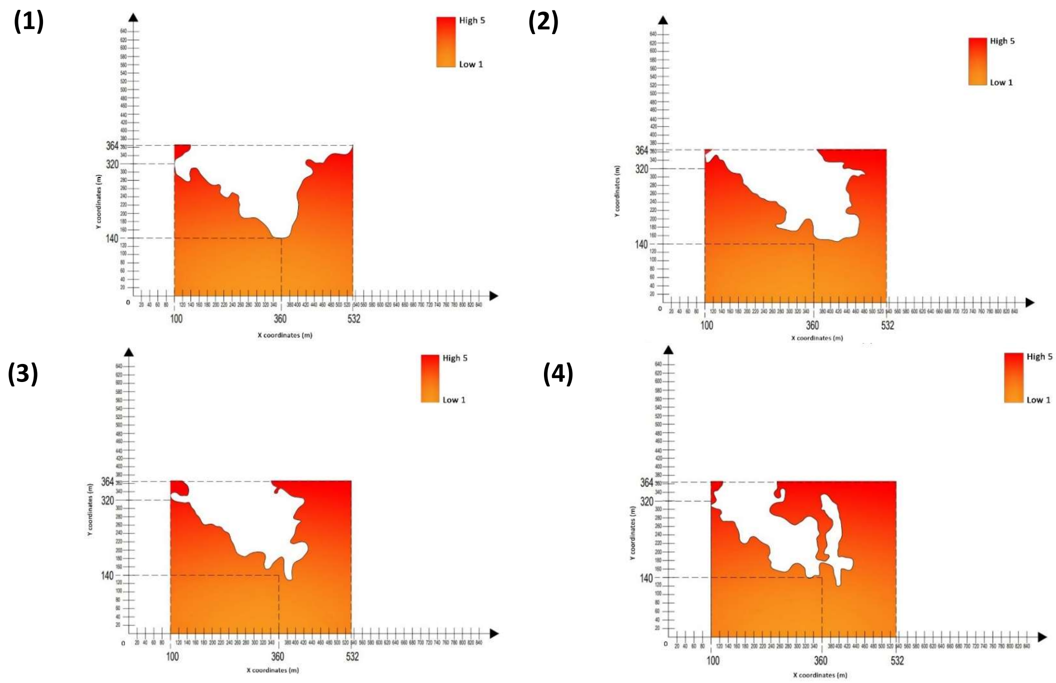


Figure 9: The chart shows locations where the Pa1 ecological patch depth of the edge may increase from (1) 2000 to 2005,(2) 2005 to 2010, (3) 2010 to 2015 and (4) 2015 to 2020
(Source: Remote sensing & GIS data, edited by author*)*

Considering figures 8 can identify the orange-colored area has to high impact, whereas the yellow-colored area has to lesser impact. Based on those two colored areas can be predict the impact areas in future.

From 2000 to 2010 considering the figure 9: (1) and (2), Pa1 ecological patch edge effect depth change and from 2005 to 2010 it higher than the before years 2005.

After 2010 considering figure 9: (3) and (4), can be identified impact was higher than the previous years due to rapid urbanization. Furthermore, the edge effect depth was also can be identified higher than from 2000 to 2010.

As a result, the Pa1 ecological patch edge has gone into the patch while examining the X and Y coordinates from 2000 to 2020.

3.2.2.2. Pa2 Ecological Patch

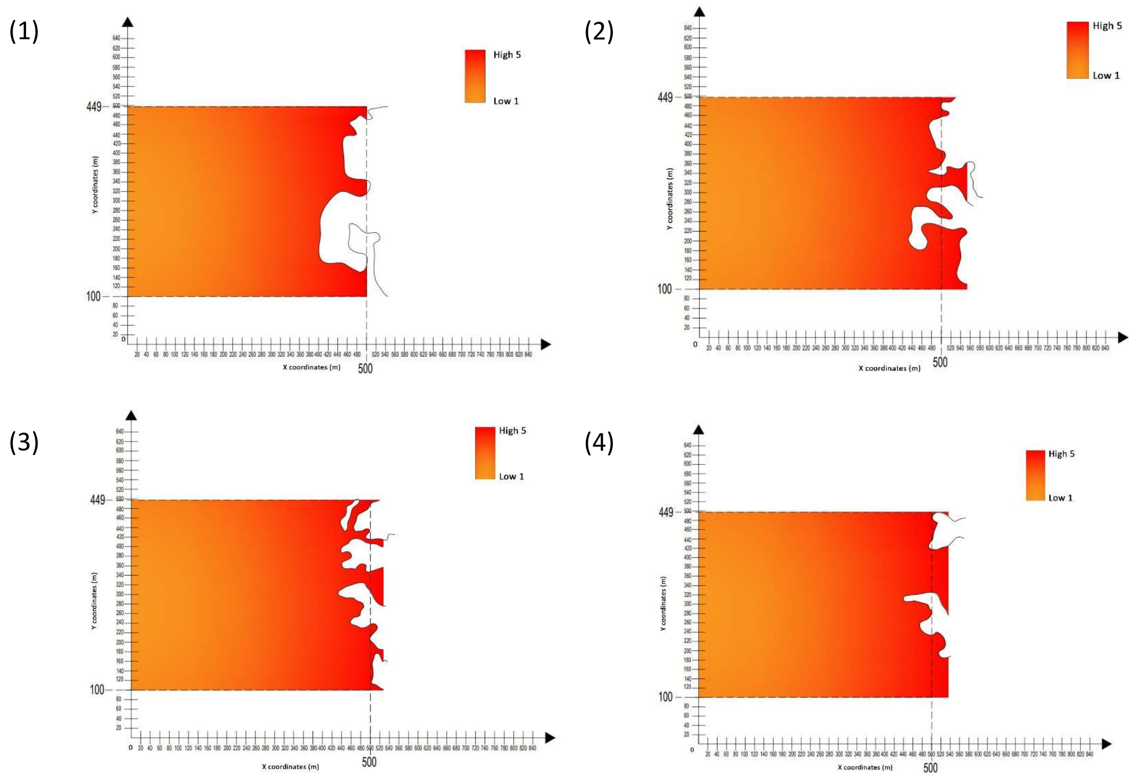


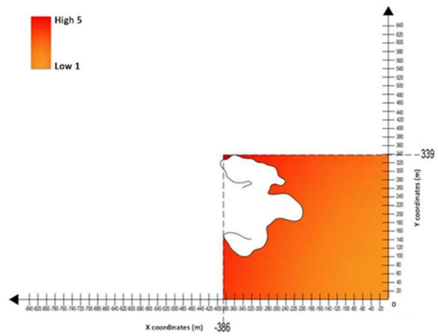
Figure 10: The chart shows locations where the Pa2 ecological patch depth of the edge may increase from (1) 2000 to 2005,(2) 2005 to 2010, (3) 2010 to 2015 and (4) 2015 to 2020
(Source: Remote sensing & GIS data, edited by author*)*

Considering figure 10 can identify the X coordinates from 0 to 500 from 2000 to 2005 before the (500,100) and (500,449) line the Pa2 ecological patch amount was higher than in other years. After 2005, can identify the patch edge impact depth has grown by 2010. As a result, the patch's middle area depth impact was greater than the other areas, and it has gone into the patch.

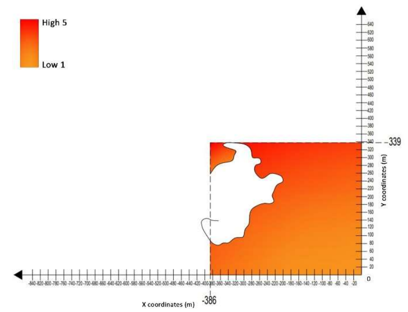
The plot area ratio increased than other years from 2010 to 2020, As a result, the edge effect depth has been steadily growing since 2010(Fig: 10). In this case from 2010 to 2020, considering figure 10: no. (3) And (4), it can be seen that the edge effect depth into the Pa2 ecological patch is greater than in previous years.

3.2.2.3. Pa3 Ecological Patch

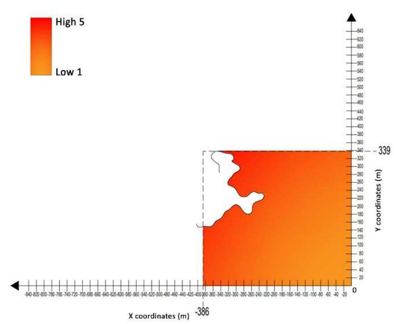
(1)



(2)



(3)



(4)

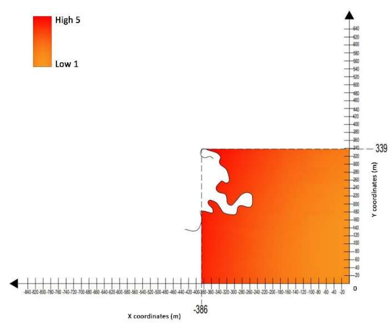


Figure 11: The chart shows locations where the Pa3 ecological patch depth of the edge may increase from (1) 2000 to 2005,(2) 2005 to 2010, (3) 2010 to 2015 and (4) 2015 to 2020
(Source: Remote sensing & GIS data, edited by author*)*

According to the figure 11: no. (1), the Pa3 amount was high from 2000 to 2005. However, considering the orange colour areas can predict the impact edge effect depth increase after 2005.

Considering figure 11: no. (2), can be identified that, the prior prediction is right. It can be observed that from 2005 to 2010, the patch edge began to go into the patch.

The depth of the edge effect rapidly increased after 2010. As a result, between 2010 and 2020, the Pa3 ecological patch reduced and changed shape dramatically. (Fig: 11: no.3 and 4)

3.2.3. MAGNITUDE

The landscape is organized into sets of patches, each with a distinct pattern of borders that allow patches to interact. Landscape change includes two aspects: a quantitative one that refers to the places where changes occur, and a qualitative one that refers to the degree of resemblance among the patches that are replacing one another.(De Pablo, Roldán-Martín and De Agar, 2012)

The quantitative component provides information on the magnitude of the change: the total area affected by landscape patches. According to that, this part examines the magnitude of change in the study area's selected main patches in last two decades.

(1) **(2)**

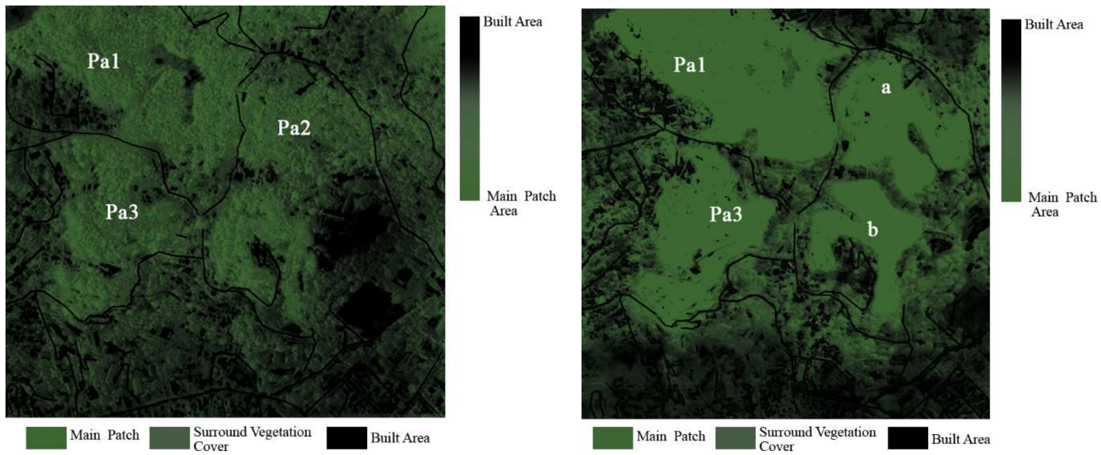


Figure 12- The maps show, the visual pattern of the main patch changing from (1) 2000 to 2005 and (2) 2005 to 2010.
(Source: Remote sensing data through, compiled and edited by author)

(3) **(4)**

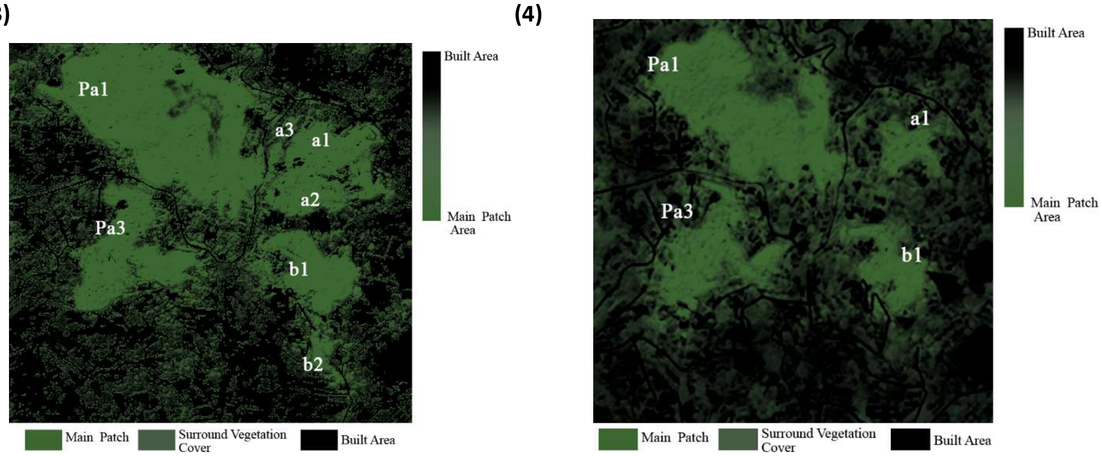


Figure 13: The maps show, the visual pattern of the main patch changing from (3) 2010 to 2015 and (4) 2015 to 2020.
(Source: Remote sensing data through, compiled and edited by author)

Table 1: The table show, the changes of magnitude in main patches from 2000 to 2020. (Source: Remote sensing data through, compiled and edited by author)

Name of the Patch	Magnitude			
	From Year 2000 to 2005	From Year 2005 to 2010	From Year 2010 to 2015	From Year 2015 to 2020
Pa1	49502.80 m^2	48143.20 m^2	44234.90 m^2	37646.40 m^2
Pa2	31179.00 m^2	30180.20 m^2	22057.00 m^2	12901.00 m^2
Pa3	23250.70 m^2	22305.20 m^2	15598.20 m^2	15035.10 m^2

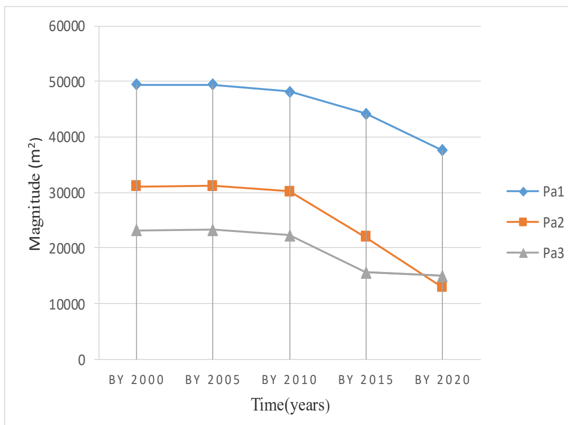


Chart 1: The chart shows a comparison of the magnitude differences of the main patches from 2000 to 2020.
(Source: Above data through, compiled by author)

Figure 12 and 13 RS data shows how the visual pattern of main patches has changed over the previous two decades. As a result, the data in table 1 may be calculated, and after charting those data, a chart of type chart 1 can be generated.

Considering chart 1 can identify Pa1 patch magnitude is all-time higher than the other two main patches. Furthermore, the magnitude of the Pa2 patch did not change significantly from 2000 to 2010, but it dramatically reduced after 2010. As a result, it had the lowest magnitude in 2020.

The Pa3 main patch magnitude is lower than the Pa2 main patch magnitude for the first fifteen years, but it does not noticeably decrease beyond 2015. As a result, that is higher than the Pa2 main patch magnitude by 2020. It can be identified through the results in chart 1.

Furthermore via chart 1 can identify magnitudes of the main three patches were rapidly decreased after 2010.

In addition considering chart 1, Pa2 and Pa3 graphs from 2005 to around 2013 the slope of the graphs are equal. That is within that eight years their rate of decrease are the same.

4. Results

This section considers the findings of the three major aspects of analytical data gathered in section 3.2.

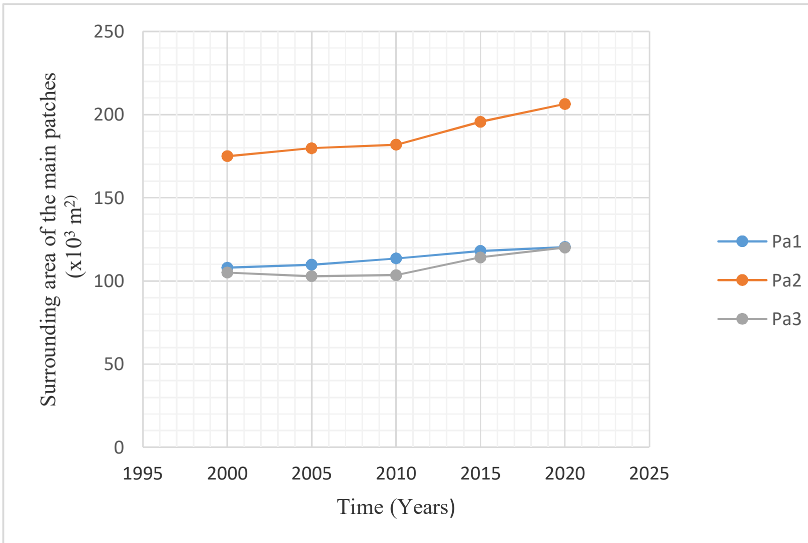


Chart 2: The chart shows how the overall surrounding area of the main patches changed into the selected area over the study period.
(Source: section 3.2 Analytical remote sensing data through, compiled by author)

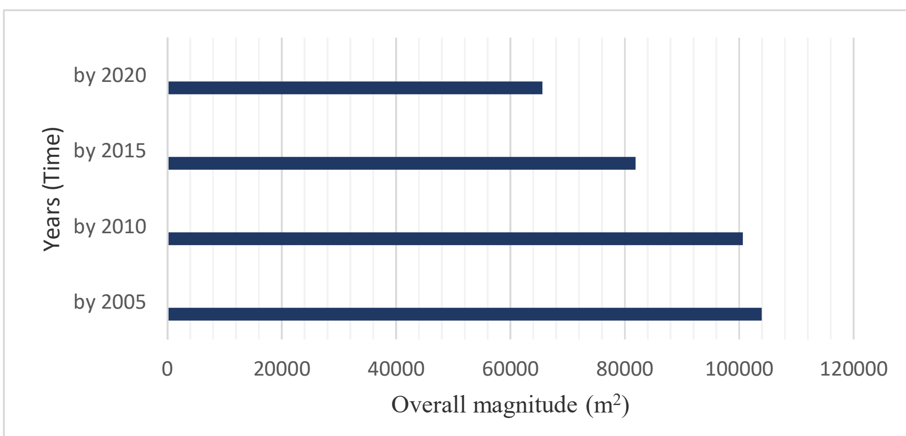


Chart 3 : The chart shows how the overall magnitude changing of the main patches in the selected area over the past two decades.
(Source: Section 3.2 Analytical remote sensing data through, compiled by author)

As a result, chart 2 can be created, considering the total reduction in the surrounding area of the selected main patches. It's the same as the depth effect getting deeper. In that instance, the slope of the graphs can be used to determine the surrounding decline rate. That rate equals the depths rate of the patch edge.

Comparing the chart 2 and 3 can found, the increase in the depth effect of the ecological patch over a given period of time is proportional to the decrease in the magnitude of the patch.

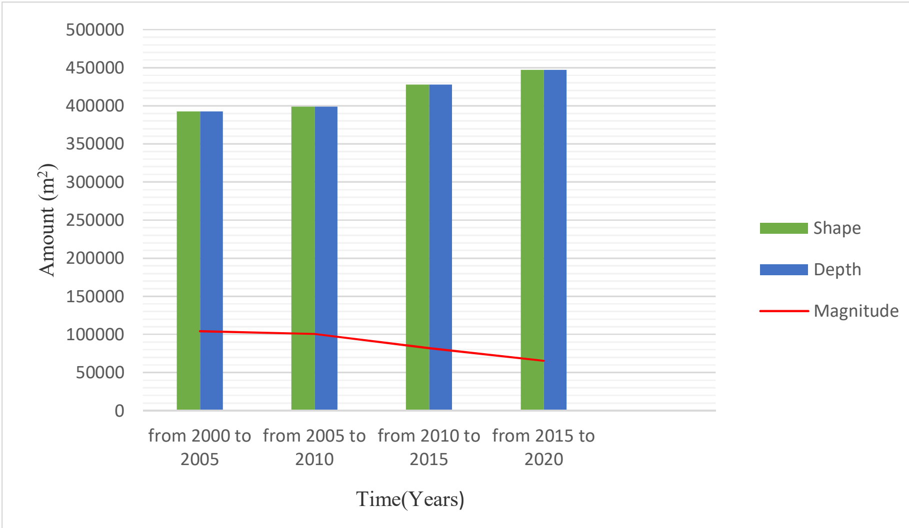


Chart 4: The chart shows comparison of the three aspects above mentioned.
(Source: Author)

Considering the chart no 4, it can be seen that the change in overall depth and shape of the patch amount are equal. It can be concluded that the magnitude is declining as the influence of shape and depth increases in any selected area. That is, the change in the magnitude of the ecological patch is inversely proportional to the change in depth and shape. In addition, the impact of the edge effect was increased and based on the above finding can predict in the future it can be increase more.

5. Conclusion

This study provides evidence as indicated by the significant changes in the edge effect that the peri-urban natural ecosystems has deteriorated significantly during the study period (2000 to 2020). All three measured matrixes of edge effect show a negative impact. This will have a significant effect on the ecosystems in the area as well as the ecology, flora and fauna and the soil quality of the region. As this is also a hilly terrain fragmentation of the ecology may lead to additional effects such as landslides.

This research also shows how the remote sensing field can be effectively used for analysing issues in urban studies which is not extensively practiced in Sir Lanka. In future, this method can be used to analyse for places that are inaccessible and difficult like dense forests, montane forests, urban wetlands, glacier ecosystems etc... This is very much pertinent to current Sri Lankan context as peri-urban developments, especially new residential developments and subdivisions are carried out with little regard to ecological integrity in the area. While there is some protection for government identified ecological reserves there is practically no identification or protection for general integrity and health of broader ecological network of an area.
Combining this type of remote sensing techniques with current land resurvey programs such as "Bim Saviya" can lead better land and eco system management in the habitable areas of the country.

Considering the analyzed 3 subcategories of the edge effect; shape, depth and magnitude, it can be prove that the edge effect is the starting point of the ecological impact process. Edge effect is influenced by the shape, depth, and magnitude of the patch. As the patch's depth increased, the patch's shape began to deteriorate.

Not only that, it also shows that the patch's magnitude shrinks as the shape and depth of the edge change. As discussed in the investigation, after starting the edge effect then patch isolation starts to increase.

While this paper was limited to analysing only the edge effect of the case study area, a more comprehensive knowledge of the impact on the ecology can be obtained by carrying out further research with other Ecological Indices in combination with edge effect on a much larger scale.

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