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From Theories to Practice: A Landscape Ecological Approach and Sandwich Elephant Ecological Barrier for Sustainable Human-Elephant Coexistence in Southern Sri Lanka

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Abstract: ***Human-elephant conflict remains one of the most significant conservation and socio-ecological challenges in Sri Lanka. This study proposes a Landscape Ecological Approach integrated with a Sandwich Elephant Ecological Barrier (SEEB) to promote sustainable human-elephant coexistence while maintaining ecological connectivity. Qualitative research was conducted along the eastern boundary of Udawalawe National Park using participant observation, focus group discussions, key informant interviews, and secondary data analysis. The findings indicate that habitat fragmentation, declining habitat quality, degraded biological corridors, and inadequate maintenance of electric fences intensify human-elephant conflict by encouraging elephants to enter human-dominated landscapes. The proposed SEEB integrates vegetation buffers, engineered barriers, and protected ecological corridors to reduce elephant incursions while preserving seasonal movement and habitat connectivity. The study demonstrates that combining landscape ecology, ecosystem-based in situ conservation, and metapopulation principles provides a practical framework for long-term human-elephant coexistence in the Southern Wildlife Region of Sri Lanka.***

Keywords: Human-Elephant Conflict; Landscape Ecology; Ecological Connectivity; Elephant Corridors; In Situ Conservation; Sustainable Conservation; Udawalawe National Park; Sri Lanka

1. Introduction

The impacts of wild elephants on human environs are the most challenging issues in the wildlife conservation and management in Sri Lanka, and one of the main impacts is Human Elephant Conflict (HEC) (Isthikar, 2021; Santiapillai et al., 2010) [14], [21]. On one hand, destroying crops and damaging properties, as well as occasional human deaths, are common features of HEC. On the other hand, killing and wounding of elephants is also a frequent event due to the HEC in the wildlife regions of the country (Gunawansa et al., 2023; Fernando, 2015; DWC, 2011; Santiapillai et al., 2010) [10], [4], [3], [21]. The main reasons for the impacts of elephants on the human environment are elephants' invasions into human environments; the elephants' invasions are high, especially over the last 15 - 20 years. However, in Sri Lanka, the HEC is not a new issue; it has existed for more than 40 years with various conservation and management measures (Isthikar, 2025) [15]. According to Santiapillai et al. (2010) [21], increasing new settlements and the expansion of farming lands in the neighbouring areas of National Parks (NPs) at the expense of forests are considerable threats to elephants' habitats, their ecological niche and free movement. On one hand, elephant habitats are declining and becoming isolated habitat patches[1]. On the other hand, biological corridors[2] are vanishing. As a result, elephants' habitats are being scattered and isolated in several wildlife regions, including the Southern Wildlife Region (SWR). According to Fernando (2015) [4], it is expected by neighbouring people that elephants should be sustained in the NPs and Protected Areas (PAs). However, many adult wild elephants roam outside the system of PAs as well as NPs despite millions of rupees spent on elephant barriers for years (Isthikar, 2021; Fernando et al., 2021; Santiapillai et al., 2010, p.21) [14], [5], [21]. Consequently, HEC occurs across the entire range of wild elephants in Sri Lanka (Prakash et al., 2020; Fernando, 2015; Santiapillai et al., 2010; Jayawardene, 1994) [20], [4], [21], [16]. Managing and controlling the HEC not only conserves wild elephants and makes temporary arrangements to restrict elephants in their habitats, but also provides socio-economic, cultural, psychological, environmental, aesthetic, and political remedies. Especially human well-being and safeguarding are very crucial in the bordering areas of the PAs.

The Department of Wildlife Conservation (DWC) has been implementing quite a lot of management methods[3] aimed at safeguarding humans and elephants from the HEC, mitigating the conflict, promoting human development, conserving the wild elephant population, maintaining the Protected Area system and encouraging eco-tourism[4] (Gnanapala, Bunltjens, and Rathnayake, 2017; DWC, 2011; Senevirathna and Perera, 2013) [9], [3], [22]. The most popular methods are establishment of new National Parks and increasing the size of conservation areas, Habitat enrichment of elephant areas to enhance carrying capacity, distribution of Elephant Thunder Crackers (ETCs) to the bordering people, elephant deterrence,

[1]Isolated Habitat Patches and its consequences have been highly emphasized in 1967 by Robert McArthur and E.O. Wilson in the 'Theory of Island Biogeography' and also explained in the theory of 'Meta-population' by Richard Levins in 1969.

[2]It has been used as 'Elephant Corridors' in Sri Lanka but 'Habitat Corridors', 'Green Corridors', 'Ecological Corridors', 'Wildlife Corridors', Green Linkages'. 'Ecological Networks' as well as 'Green Ways' are also used by authors.

[3] Methods were based on 'In-Situ' and 'Ex-Situ' conservation Methods.

[4] 'Elephant Viewing Tourism' and 'Close Viewing Tourism' has been highly focused under wildlife tourism.

elephant drives, translocation of elephants to less populated areas by capturing and transporting, construction of Electric Fences (EFs), control of poaching, enforcement of law and compensation scheme, and breeding programme. However, the intentions of management of HEC are meant to be long-term and multi-dimensional, including stable livelihood and safety of the people in bordering areas of the NPs and ensuring natural and normal life of elephants in their home ranges and corridors too. Nevertheless, most of the above prolonged temporary management measures are still in operation but have failed to achieve their set targets, and the conflict is still going on at an alarming rate; in addition, these measures have led to creating ruder elephants and worsened the HEC (Isthikar, 2018a; Fernando, 2015) [12], [4]. Among the wildlife regions, the SWR has been identified as one of the major elephant ranges in the country (Isthikar, 2018b; DWC, 2011) [13], [3]. HEC in the SWR, particularly in the bordering areas of Yala, Udawalawe, Lunugamvehera and Bundala National Parks, is a chronic issue. For many years, despite several research and management measures, HEC has been causing injuries and occasional human deaths, property damage, destruction of crops and farmlands, and farmers' vulnerability. Besides, the killing and wounding of elephants by people in the bordering areas of NPs in the SWR prompted the current research based on the Landscape Ecological Approach (LEA) and elephant ecological barrier for sustainable Human–Elephant Coexistence (HECo). Numerous studies have examined the HEC in the SWR, focusing on the effectiveness of EFs, elephants' behaviours, and crop raiding from different perspectives. However, limited attention has been given to developing a combined landscape ecological framework that promotes long-term Human-Elephant Co-Existence (HECo). Therefore, it is highly crucial to introduce a theoretically based practical management approach especially the concept of LEA and 'Sandwich Elephant Ecological Barrier (SEEB)' for sharing landscapes. Accordingly, this study aims to propose SEEB based on LEA as a sustainable strategy for enhancing HEC-E in the SWR. This research emphasises the importance of implementing LEA as a holistic ecosystem-based approach for mitigating HEC while maintaining ecological connectivity. This includes to propose a LEA and a SEEB for promoting sustainable human-elephant coexistence in the Southern Wildlife Region of Sri Lanka through ecosystem-based *in situ* conservation, landscape connectivity, and the maintenance of elephants' seasonal ecological niches.

2. Theoretical Foundation

Landscape Ecological Approach

The 'Landscape Ecological Approach' is a combined planning, conserving and management approach that applies the principles of landscape ecology to conserve ecological processes and conservation of biodiversity with human land uses (Turner and Gardner, 2015) [24]. It highly emphasises conserving and managing species and habitat diversity and also landscape connectivity from geographical and ecological perspectives. Besides, it focuses on the interactions among them and the interactions between living and non-living components. The 'Ecosystem Approach' also refers almost the same as an integrated strategy for managing land, water, and biotic resources that encourages biodiversity conservation while safeguarding their sustainable use holistically (Miller, 2005; Barrow, 2005; Convention on Biological Diversity, 2004) [18], [1], [2]. The in-Situ Conservation approach also highlights the conservation of species within their natural habitats through the protection and management of ecosystems, allowing species populations to persevere and evolve under natural ecological processes (Barrow, 2005) [1]. In the context of HEC, the approach emphasises managing landscapes as interconnected social-ecological systems rather than isolated PAs, thereby facilitating sustainable coexistence between elephants and people (Turner and Gardner, 2015; Turner, 2005; Forman and Godron, 1986) [24], [23], [8]. LEA also gives more focus on landscape connectivity as well as on geographical factors such as landforms, water availability, seasonal climatic variations and their functions. Biological corridors, or bio-linkages connecting habitats and landscapes fragmented by human activity, are geared to protect and improve the habitat of species and facilitate free movement of species for various resources. According to Miththapala (2015) [19], the lack of focus on a landscape approach to conservation is important, and ecosystems are not isolated and exist as mosaics of interconnected biological patches across a heterogeneous landscape (Turner, 2005) [23]. Besides, elephants interact with other animals and all other non-living components, including water bodies, land forms and soil. In this regard, LEA facilitates the conservation and management of landscapes where people and elephants share the landscape. Fernando categorically states that the conservation of elephants requires a landscape approach (Fernando, 2015b as cited in Miththapala, 2015) [19].

In Sri Lanka, most of the present HEC-prone areas were ideal elephant habitats without any human disturbances until the 1970s. However, with multipurpose Government Development Projects including irrigation and settlement programmes, elephants' habitats have shrunk and fragmented, and most of the biological corridors have been disconnected (Fernando, 2021; Jayawardene, 1994) [5], [16]. In the SWR, after the declaration of the Yala NP in 1938, the entire SWR, including the present Yala, Udawalawe, Bundala, Lunugamvehera NPs and the entire forest areas, including the present settlements and developed areas, were elephant habitats except for a very few settlements. Udawalawe, Lunugamvehera and other dry zone development projects had impacts on elephants' habitats, causing them to become fragmented patches as NPs and other forest patches. Most of the bordering areas of the elephants' habitats have been transformed into settlement and farming areas, where most of the people who settled there were farmers.

Accordingly, proposing LEA as a mosaic method is highly important for both humans and elephants to live by sharing the landscape co-existentially. Accordingly, elephants can find their ecological niche in their home range, as well as travelling via corridors to various habitats, would be possible. In the same time, it is important to consider elephants' ecological niche and their home ranges. An elephant's ecological niche states its functional role within an

ecosystem, including its use of resources, habitats[5], feeding ecology, and interactions with biotic and abiotic environment (Forman, 1995) [7]. Besides, an elephant's home range refers an area that an individual or herd regularly uses to obtain food, water, shelter, mates, and other resources during its normal activities in a climatic season, without necessarily caring it as a region. These ideologies have been mentioned in the theory of 'Island Biogeography' by Robert McArthur and E.O. Wilson (1967), and also in 'Meta-population' theory by Richard Levins (1969) and highly encourages the connectivity among habitats to facilitate moving species as a meta -population to travel from continental landmass to biological island and also one habitat patch to another. According to Miththapala (2015) [19], the importance of this fact in conservation is twofold. Firstly, an individual species can exist as sub-populations in isolated habitats as a Meta-Population (Hanski, 1999) [11], and if habitat conditions permit, these sub-populations can be linked to support immigration and emigration; and secondly, ecosystems are affected by actions taken both within and without their boundaries (Meffe et al., 1997) [17]. However, since 2007, several national documents have highlighted the need for establishing linkages between fragmented habitats (MoENR, 2007, 2009, 2010; MoERE, 2014, as cited in Miththapala, 2015) [19]. Yet, the practice continues of largely establishing isolated PAs with little effort to connect them. Besides, in theory, allowing human settlements and other livelihood activities outside the home range, as well as natural habitats and conserving wild animals in the same landscape with the support of corridors has been highlighted.

3. Methodology

The Methodology for this research consists of an explanation of the study site, data collection methods and analysis methods. According to the DWC (2011) [3], among six Wildlife Regions of the country, SWR is identified as one of the regions where HEC has become a serious problem. Impacts of wild elephants on human environments are one of the most important factors around UNP in the SWR. In this study, the Eastern side of the Udawalawe National Park (EUNP) in the SWR has been taken as the study site. The following figure1 shows the study sites in the SWR.

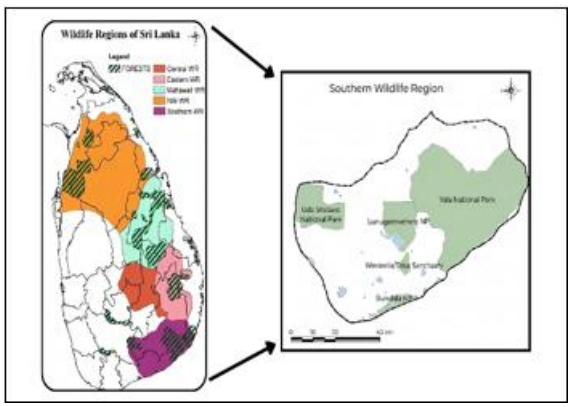
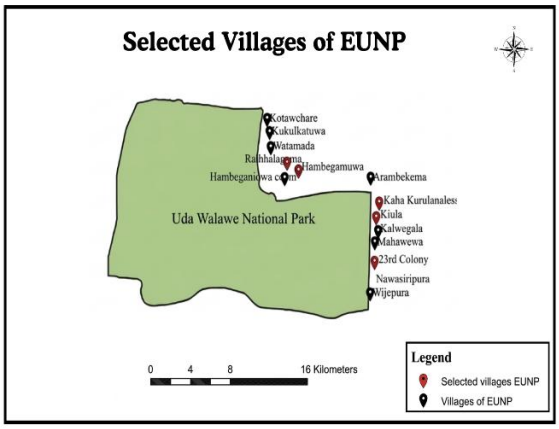


Figure 1: Study area in the Southern Wildlife Region
Source: Author, Based on the Department of Wildlife Conservation

HEC around the UNP is common, but its status varies among the borders. Almost all the villages are remote and depend on farming, especially Chena cultivation. HEC in EUNP is more critical and severe. Besides, Lunugamvehera NP is situated along the eastern side of EUNP, just 12 KMs in distance and connected with the Hambangamuwa and Kula elephant corridors. In the EUNP, elephant invasions and HEC are very high because of theses corridors, Lunugamvehera NP, and attraction of crops. Therefore, EUNP has been selected as the study site. Of the 15 villages, eight are situated along the southern side of the eastern boundary, extending from Thanamalvila. The HEC and the impacts of elephants are high in the villages in the middle and the Southern part of the EUNP. The main purpose of selecting 5 severely affected villages with HEC out of 15 villages in the EUNP is the movement of elephants, the severity of the conflict, and the impacts of the conflict are high, and to mitigate the conflict with the use of LEA. Figure 2 shows the selected villages in the EUNP as study sites.



Source: Author, Field Survey 2024 and 2025
Figure 2, Selected Villages in the Eastern Udawalawe National Parks

The study focuses on a comparison of different groups of people: the officials of the park, safari jeep drivers and the people in the selected villages. Participant observations, focus group discussions with the victims by HEC and key informant interviews with officials of the park and jeep drivers. Purposive Sampling, criterion purposive sampling and snowball sampling techniques have been used to collect data from targeted respondents. The opinions of the officials, jeep drivers and the locals were gathered based on views, opinions and narrations. Besides, selected secondary data have also been used in the analysis. In addition to the secondary data, theoretical based literature was incorporated in relation to LEA, ecosystem approach, in-situ conservation approach, elephant barriers and biological corridors.

Field survey: The field survey was conducted in four stages in 2025 and 2026. Four different seasons, especially April, August and December in 2025 and February in 2026, were chosen for the field. Particularly, February is one of the driest months in the study sites, and it is the inter-monsoonal season in April. August and September are dry and drought months in the sites and get most of their rainfall during December every year. Participant observations provide a detailed picture

[5] Including fundamental niche and realized niche.

to the researchers, and it provides a live literature of a study site. Participant observation and survey were conducted at selected locations in all five villages and especially in the corridor area using purposive site selection. Observation and survey sites were chosen based on the frequency of human and elephant interactions and conflict-prone locations. Key informant interviews with officials working in the park at various levels, including rangers, wildlife guards, labourers and the park entrance officials. Besides, Safari Jeep drivers of UNP were interviewed. Seven key informants' interviews were conducted in UNP and information provided by officials was most important in different ways; first to understand the impacts of the government policies, projects and programs on HEC, second to clarify the existing corridors, elephants' home range, seasonal ecological niche, effectiveness of existing barriers including electric fences, community fences, crops which are avoided by the elephants and the elephants' attacks, and their movement patterns. Six focus group discussions in EUNP were conducted with victims of HEC on their attitudes and views regarding the park's boundaries, existing corridors, elephant's movement patterns, electric fences and other type of barriers, elephant's entry to villages and farmlands, seasonal crop raiding, damages by elephant's attack, recommendations to mitigate and solve the conflict as well as the relationship with park officers. This research depends entirely on qualitative data; the findings could reflect the participants' personal perceptions as a limitation. However, the credibility of the findings was improved over the triangulation of data collected from multiple sources. Analysis: Data were analysed using content analysis methods. Qualitative information, such as experiences, feelings, narratives, and views, was mainly analysed through content analysis. The analysed qualitative results were presented by main headings and subheadings.

4. Results and Discussion

4.1 Justification for implementing the LEA and the SEEB along the EUNP

The analysis presented in this study is based on a synthesis of the relevant literature, established theoretical and conceptual frameworks, especially collected data from the field survey. The findings are interpreted through the theoretical perspectives of the ecosystem approach as in situ method, carrying capacity, ecological niche, the LEA, and the proposed Sandwich Elephant Ecological Barrier (SEEB) framework. The SEEB is introduced as a pilot intervention along the EUNP to evaluate its potential as a landscape-based strategy for mitigating HEC while enhancing habitat connectivity and promoting sustainable human-elephant coexistence. According to the analysis, in the SWR, four national parks and one wildlife sanctuary function as relatively isolated habitat patches surrounded by expanding human settlements and diverse land-use activities. The biological corridors connecting the EUNP are increasingly affected by human disturbances, resulting in habitat fragmentation, reduced landscape connectivity, and restricted elephant movement. Consequently, elephants are mostly restricted to the park, where the available carrying capacity is controlled by seasonal fluctuations in food and water availability, particularly during the dry season, as well as by human-induced pressures such as poaching, illegal hunting, and over-tourism.

Although the DWC has established electric fences around UNP, inadequate maintenance has reduced their effectiveness, enabling elephants to break the fences and enter surrounding human-dominated landscapes. As a result, elephants frequently raid and trample agricultural fields, damage warehouses containing stored grain, and forage on food waste near hotels and restaurants, thereby increasing the frequency and severity of HEC. Local communities often respond by employing hazardous chasing methods, which not only threaten elephant welfare but also further exaggerate HEC. Accordingly, the conflict is comparatively high in the EUNP. The Eastern boundary of the UNP is in the shape of a simple 'b' of the English alphabet. Beyond the boundary, most of the villages are very rural, and the villagers are poor. The main livelihood of the people in the area is seasonal chena cultivation. The southern part of the Eastern boundary is flat, and the Northern part of the boundary is hilly. Two elephant corridors are maintained by the DWC in Hambangamuwa and Kiula villages of the Eastern boundary, which experience a lot of elephant movement. In the Eastern boundary, there is a continuous forest cover from South to North. Among the management measures, one of the most important measures is physical barriers. Within the physical barriers, electric fencing methods play the most dominant role. Among other physical barriers, comparatively, EFs have been accepted by locals and officials as an operational barrier both physically and psychologically to sustain elephants in the park as well as to stop and control invasions of them into the farmlands, villages, and warehouses. Through analysis, these EFs are erected to perform two purposes: the first one is to be an administrative boundary of the Government Departments, and the second one is to be an elephant barrier. The following incident reflects as evidence that the EF acts as a psychological barrier. In Hambangamuwa, one of the villages bordering the eastern boundary of UNP, the researcher approached the agricultural land in front of a house. An elderly female resident responded by shouting the following:

> *"Hello Sir, don't be anxious of the wire; there is no voltage in it. We preserve the fence to discourage elephants because they have learned to distress electric fences, whether or not voltage is actually flowing through the wire."* (Unanimous, aged 58, Eastern boundary village of UNP).

Virtually, it is a very obvious feature that the elephants are often found to be roaming on both sides of the EFs[6]. However, it is worth mentioning a fact that comparatively breaking EFs near the farmlands and villages is higher than breaking the EFs near the forests outside the parks to target the ready source of food in the farming fields. Through analysis, including field observations revealed that elephants spend most of their time outside the UNP, especially in the EUNP and make limited use of the designated biological corridors. Usage of both Hambangamuwa and Kula corridor are minimal during daylight hours up to 3:00 p.m., whereas only

[6]They don't have any fear and disturbance in breaking the EFs in the middle of the forests.

a small number of elephants utilise these corridors after dark, suggesting that human disturbances discourage daytime movement. Furthermore, the limited availability of modern monitoring technologies and inadequate human resources within the DWC reduce the effectiveness of HEC mitigation and corridor management. The abundance of palatable crops, fruits and grains in the chena farming fields regarded as high-risk crops, attracts elephants into human-dominated landscapes, increasing crop raiding and property damage.

These findings indicate that enhancing the carrying capacity of UNP throughout the year, particularly during the dry season, is essential to enable elephants to satisfy their ecological niche requirements within the park. At the same time, biological corridors should be restored, protected, and managed to minimize human encroachment and other anthropogenic pressures, thereby facilitating safe and uninterrupted elephant movement between NPs and habitat patches. Improving habitat quality within NPs while restoring functional landscape connectivity would reduce the need for elephants to move into surrounding human settlements, ultimately promoting long-term human-elephant coexistence. In this context, an ecosystem approach should be adopted for the management of natural habitats, as in situ conservation method, while a LEA should guide planning and management across both NPs and adjacent human-dominated landscapes. A Proper, human-elephant-friendly, unbreakable fence should be regularly maintained, strengthened using elephant-friendly designs and technologies, and strategically integrated with biological corridors to direct elephant movements without causing injury.

It was also observed and learnt that there are gaps as corridors in the fences of the Eastern boundary of UNP villages without EFs to facilitate elephants to move to the Lunugamvehera NP. Maintaining such corridors is more viable to sustain elephants' movements towards other areas based on seasonal variation as well as mating purposes. Accordingly, except the corridors, in the boundaries, the ecological barriers should be a 'Sandwich Elephant Ecological Barrier' (SEEB). If so, the ecological barrier will play a part of Human- Elephant Co-Existence Model. To the utmost dismay, there were no such arrangements in the study sites.

4.2 Sandwich Elephant Ecological Barrier

A 'SEEB' is proposed to maintain human-elephant co-existence based on LEA. The SEEB is a different combined fence system proposed in this study, comprising successive layers[7] of vegetation belts and engineered barriers designed to sustain elephants inside the park, reduce elephants' invasions into human environs, as well as to control HEC while maintaining ecological integrity and landscape connectivity. This barrier is permanent and multi-layered in a horizontal manner. This multi-layered SEEB will definitely impact elephants as a physical and mental barrier. Erecting SEEB at the eastern boundary of the UNP, except Hambangamuwa and Kiula areas, where the corridors are connecting to the Lunugamvehera NP, would have a positive impact on villagers/farmers as well as elephants rather than erecting barriers which are continuously breakable and incur a lot of expenditure. Moreover, this method would allow elephants to roam naturally in their home ranges, avoiding the trapping of elephants inside the park and in the forest patches. Further, this method can contribute to HECo. Particularly along the eastern boundary of UNP, where agricultural lands directly adjoin the elephants' home range, the proposed SEEB should be established as a multi-layered ecological buffer. On the elephant home-range side, the first layer should consist of a bio-layer planted with thorny, coarse, and unpalatable plant species that elephants generally avoid. Suitable species include Bougainvillaea, Palmyra palm, and Neem. This bio-layer would serve as a natural deterrent while enhancing the barrier's ecological integrity.

The First layer of the sandwich barrier, which is called the bio-layer, should be maintained with a dense plant layer from 6 to 10 feet[8]. The second layer should be a sloped ditch with a 6 to 7 feet slope on both sides; following the ditch, EF should be erected. Getting into the ditch and emerging out of it is a difficult task for large-bodied elephants, and it is difficult for them to break the EFs[9] coming out of the deep ditch. Commonly used dimensions of trenches are 3m wide at the top, 1m wide at the bottom, and 2m deep. However, the dimensions could vary from place to place. Then, there should be an EF as the third layer. Again, as the final layer in the SEEB, there should be a linear bio-fence including neem. The purpose of the bio-fence is that, when the elephants look from their home range towards the farmlands and villages, they visualise an image out of their home range that nothing is available for them. Planting neem with other plants which are avoided by elephants in the dense bio-layer would be viewed by elephants from their habitats as a dense neem belt outside the parks. Moreover, through neem, the locals can also get economic benefits. Sri Lanka is very famous for Ayurvedic medicine; neem is well known for its leaves, bark, and roots, which play a vital role in Ayurvedic Medicine. Therefore, in EUNP, encouraging neem-based Ayurvedic medicine among tourists would be ideal. In UNP and surroundings, narrow-viewing tourism and elephant-viewing tourism are very popular among tourists. Therefore, a neem-based Centre for Ayurvedic medicine would be attractive among narrow-viewing tourists, and some villagers would get a very attractive livelihood.

The SEEB will divert the HEC to HECo by sharing landscapes based on LEA. Therefore, the proposed multi-layered sandwich elephants' ecological barrier would provide multiple benefits for villagers, farmers, as well as the elephants. The following Figure 3 and 4 shows a model of the sandwich elephants' ecological barrier.

[7] Tree belt, then a ditch, electric fence, then a tree belt again.

[8] Bio fence alone won't work by any mean but multiple applications would be effective, one such is a row of agave planted along the electric fence at Udawalawe and Yala national parks, which has been ineffective. Similarly, a cactus fence tried out along the Weerawila farm perimeter failed completely (Fernando *et al*. 2008).

[9] Breaking EFs from a ditch is not such easy as they break in the flat surface.

Figure 3: Model of Sandwich Elephants' Ecological Barrier (A)
Source: Author, prepared based on Field Survey, 2025 and 2026.

Figure 4: Model of Sandwich Elephants' Ecological Barrier (B)
Source: Author, prepared based on Field Survey, 2025 and 2026.

4.3. Ecosystem Approach as In-Situ Holistic Method

Based on the Ecosystem Approach, elephants must live in the UNP as their home range, enjoying their entire ecological niche. This would be practicable if the SEEB were erected in the EUNP. The ecosystem would be highly functional when the interactions among organisms and living and non-living components are very complex. Conservationists adopt an ecosystem approach to conserve biodiversity, especially because it highly emphasises conserving the entire system in its original and natural conditions (Miller, 2005) [18]. To eradicate and control HEC, the focus should be given to the entire elephant ecosystem rather than focusing only on elephants and trying to trap them inside the parks with hard physical barriers. The concept of the ecosystem approach is much more similar to the In-Situ Conservation method (Miller, 2005; Barrow, 2005) [18], [1]. Both emphasise conserving species naturally in their own habitats to enjoy their ecological niche. Accordingly, to achieve the above, erecting a SEEB within the park boundary, considering elephant corridors, would be the most suitable option. This would lead to landscape sharing among humans and elephants in a friendly manner without disturbing each other for a long time.

4.4 Managing 'Landscape Connectivity' Among "Meta Population" as a Mosaic Method.

Accordingly, present spatial arrangements of NPs in the SWR are much more suitable to apply Meta-population theory. Therefore, conservation and management of wildlife, especially elephants in the SWR, explained in the theory of meta-population, is ideal for the present scenario. Based on the Meta-Population model, elephants could share all the NPs in the SWR, including Yala, Udawalawe, Bundala and Lunugamvehera, according to the seasons to fulfil their needs. The long-term resilience of such species may be dependent on establishing connectivity[10] between fragmented habitats (Seidensticker, 2002 as cited in Miththapala, 2015) [19]. This model highly matches with SWR, demarcating the ecological boundaries with the use of SEEB between home ranges and developing areas, which would be highly potential for HECo in a sustainable manner.

4.5 Elephants' Seasonal Ecological Niche and Home Range

Elephants move within and beyond their home ranges primarily to meet their seasonal ecological niche. Large-bodied highly migratory species such as elephants often have home ranges that extend partially or entirely outside PAs (Fernando et al., 2011) [6]. Within their ecological niche, the availability of food, water, space, shade, mating opportunities, breeding sites, and a secure environment are essential. In the SWR, the UNP and the surrounding forest cover have the potential to fulfil these seasonal ecological requirements. For example, elephants consume teak bark in the southern part of the park and red soil in the southeastern area to supplement their mineral requirements. Therefore, the seasonal ecological niche is a key factor determining the extent and boundaries of elephants' seasonal home ranges. Elephants inhabiting human-dominated landscapes generally have larger home ranges, largely influenced by food availability, and use fixed crossing points between habitat patches (Weerakoon et al., 2004, as cited in Miththapala, 2015) [19]. During and after the rainy season, however, they tend to restrict their movements to smaller home ranges.

The analysis indicates that the reservoir surroundings of UNP serve as a sustainable home range for several elephants because of the availability of water. During the dry season, many elephants from Yala move to UNP via Lunugamvehera NP, through the biological corridors along the eastern boundary. These movements enable elephants to utilise surrounding forest habitats and satisfy their ecological niche requirements. However, effective management is required to encourage elephants to use designated biological corridors rather than moving randomly through human-dominated landscapes.

[10] Also known as corridors, linkages, ecological networks.

4.6 Landscape Ecological Approach in HEC Management.

Modern conservation concepts focus on landscapes rather than isolated PAs. In particular, in Yala, Udawalawe, Lnugamvehera NPs and the surrounding natural landscapes of SWR, it is urgent and most important to control HEC based on a landscape ecological approach, including landscape connectivity to establish HECo. This would be practicable if the SEEBs are erected in the elephants' ecological boundaries sharing natural landscapes by both humans and elephants without disturbing each other.

4.7 Villagers' Hostility towards Elephants and Human-Elephant Coexistence

As a result of HEC, both humans and elephants have suffered considerably over a prolonged period in the SWR. Suffering, economic losses, and psychological distress are among the most significant consequences experienced in the study area. Consequently, many local people live with fear and hostility towards elephants, largely due to the frequent raiding of crops. The situation would be friendly and co-existent if we followed the mentioned multiple HECo measures by sustainably sharing the natural landscapes and collaborating with the authorities and the locals.

5. Conclusion

The findings demonstrate that persistent HEC in the SWR is closely associated with habitat fragmentation, declining ecological connectivity, and limitations in existing mitigation measures. The proposed integration of the LEA with the SEEB provides a practical framework for reducing conflict while maintaining elephant movement through protected biological corridors. By combining ecosystem-based in situ conservation, landscape connectivity, and ecological barrier design, the proposed framework has the potential to improve long-term coexistence between humans and elephants. Future field implementation and quantitative evaluation of the proposed barrier system would further validate its effectiveness under different ecological and socio-economic conditions.

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