

Wildlife Corridor Planning Using GPS Collars and Forestry Data: Preventing Human-Animal Conflicts

Muhammad Asad^{1*}, Muhammad Umair², Aftab Ahmed³

¹ World Wildlife Fund for Nature-Pakistan.

² Faculty of Environmental Sciences, University of Agriculture, Dera Ismail Khan-29050, Pakistan.

³ Livestock & Dairy Development (Extension) Department, Khyber Pakhtunkhwa, Pakistan.

*Corresponding Author E-mail: Asadk959@gmail.com

Abstract

Human wildlife conflict develops into one of the most serious conservation issues due to an increase in habitat fragmentation and human-generated stressors. The multi-year study proposing integrating GPS collar-based monitoring with forestry-based remote sensing data and spatial modelling based on GIS proposes a first-rate, data-integrating platform of building wildlife corridors. High resolution habitat suitability models were built based on real time tracking of elephants and leopards through GPS collars and NDVI and canopy cover indices. We have made wildlife corridors that are safe to people and environmentally friendly by using these models as well as the conflict zone mapping using the human settlement and land use layer. The findings demonstrate that well-designed corridors can reduce the conflict incidence of up to 43 percent in sites where incidence is high, and connect habitats by greater than 60 percent. The comments and the field tests of the people within the area ensured the results were ecologically acceptable and satisfactory. A further enhancement of the corridor proposed models was done using least-cost path analysis, forming corridor blueprints that can be utilized repeatedly by the conservation managers. This combined research approach provides us with a model that can be repeatedly applied in minimizing conflict between individuals and animals and at the same time entice them to co-exist. Our research indicates the significance of application of spatial analytics and participatory input in ecological planning. Such instruments can be used to safeguard biodiversity and maintain functional ecosystems in places where people inhabit.

Keywords: Wildlife Corridor, Gps Tracking, Human-Animal Conflict, Remote Sensing, Gis Modeling, Habitat Connectivity.

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INTRODUCTION

Conservation of the wildlife is experiencing a huge issue since human beings are increasingly subdividing the natural habitats (Zhang et al., 2021). When increasingly more people migrate to a place and exploit the land more, the interconnections previously linking the habitats are disrupted. This increases the isolation of animal populations and retards the movement of genes. An effect of such cleavage includes a reduced genetic diversity, an increased probability of local extinctions, and shifts in the functioning of ecosystems. Wildlife corridors are one-dimensional geographical structures that facilitate migration of the animals across regions of habitation. An increasing number of individuals continue to understand that they are a key method of reducing the negative impacts of habitat fragmentation. You can build and sustain a corridor well only when you have much knowledge about the migration pattern of various animals, the habitats they use and the probability that humans might engage in hostilities with animals. The best way to obtain such understanding is the integration of modern technologies in collecting data and ecological data such as GPS tracking and remote sensing (Tuia et al., 2021). The usability of GPS collars in conducting researches on the ecology of animal movements has altered because we now have a lot of data on their home ranges, movements during the day and what sort of habitats they prefer (Knyva et al., 2023). This technology will allow researchers to monitor animal movements by large numbers of years and this generates huge data which can be used to identify critical corridors and how effective they are. Moreover, the forestry data including data about the structure, composition, and age of forests can be applied to explain the quality of the habitat and locate the most suitable places where the species can move. If you incorporate the information of the forestry data with the GPS collar

data, you will come up with a powerful instrument to identify and prioritize areas that must be conserved and reclaimed as corridors. However, the number of corridors linking large parts of the forest, such as those in which the population moves, such as the protected areas, is high, and it is used by the population and wild animals (Badola et al., 2021). The invasion by human activities into natural ecosystems is reducing the spatiotemporal niches of wildlife species, reducing and decreasing the amount and size of connections within a community and accelerating the extinction and degradation of species (Li et al., 2023). Wildlife corridor planning is a complex process which should consider social, economic and environmental concerns. The primary objective of corridor planning is to enhance the links between the patches of habitats. This facilitates the transfer of genes among them, seasons migrations, and shelter to the animals when disturbed by some activities (Schivo et al., 2020). It is common to identify potential corridors through spatial modelling tools such as least-cost path analysis and circuit theory (Beaujean et al., 2021). Less-cost path modeling determines the path between two locations that cost to traverse least as factors that are considered include the nature of the habitat, topography, and human intervention (Pliscoff et al., 2020). In the circuit theory, the scene would be regarded as an electrical circuit with the portions of habitable land serving as nodes and the landscape that connects them functioning as resistors. Corridors are those areas where large flow of the current is, thus chances are very high that animals will move through the corridors. After identifying potential corridors, they always need to examine whether they are suitable to various species of animals. The given assessment must consider the precise habitat requirements of the target species and the possibility of a clash between the individuals and

the animals. Like an example, you ought to consider such aspects as the availability of food, water, and shelter, as well as the difficulty of locomotion such as roads or fences. The second step is to plan a strategy of managing a corridor by considering the effectiveness of the potential paths. This plan must contain the means of preservation and regeneration of the habitat in the corridor and the means of decreasing a confrontation between human beings and animals. The need to maintain or add more forest cover is essential, more so on a big scale (Faria et al., 2023). Rewilding management will restore ecology, which will enhance the connectedness, trophic complexity, and random disturbances and subsequently enhance biodiversity within ecosystems (Stark et al., 2025). Restorations of the damaged habitats and the enhancement of connections through such kind of reforestation activities as the planting of trees, the application of agroforestry systems, erosion control, and the process of the regeneration of natural forest is very important (Mohan et al., 2021). To get the plans of a wildlife corridor functional, numerous individuals will be required to collaborate together, including the government bodies, incorporated landowners, and communities. To get ride of a corridor you have to have the problem of adapt resistive management solutions which can modify itself according to the atmosphere and the action of individuals. It is also good to monitor the effectiveness of corridors to achieve their conservation objectives such as human-wildlife conflict reduction and gene movement. We must promote environmental conservation and management practices besides identifying gaps in the knowledge and integrating various sectors in the long-term management practices (Dimopoulos & Kokkoris, 2021). The conflicts between the people and the animals are drawing more concern in many places in the world especially where people are entering the areas where

wildlife is found. Problems may occur when animals damage crops, pursue cattle, endanger human lives. Big carnivores usually have some impact on human activity, and this becomes an issue, so there is always a debate regarding the distribution of various species (Ordiz et al., 2021). The human-wildlife conflict can be lessened through the provision of wildlife corridors because it allows animals to move safely between the habitat patches. This reduces the chances that they may enter the places where people live and work. However, when corridors are not constructed and properly taken care of, they will even create the inexistence of conflict. E.g. the corridors through the fields may carry animals to crops, whereas the corridors located near the densely populated areas may result in the increased likelihood of people being exposed to wildlife. There is the need to ensure that the corridors are correctly located and designed and the appropriate safety precautions, like fencing, buffer, and education of the populace should be implemented to reduce the risk of violence.

METHODOLOGY

The present study involves a mixed-method approach of research design by integrating quantitative geospatial approach with qualitative ecological confirmation, which can assist in strategic planning of wildlife corridors. This is achieved by three main steps namely acquisition of spatial data, modeling of analytical tools and validating these models on the ground. During the first period, selected representative species, mainly elephants and leopards were fitted with GPS collars as they are the ones that cause a lot of conflicts with human beings. These were high-resolution collars that captured the information on the locomotion of the animals. These collars gave the real-time coordinates in predetermined time intervals, which created geospatial trajectories. Besides that, we

received satellite data in forestry including the Normalised Difference Vegetation Index (NDVI), canopy cover percent and land use types for MODIS and Landsat archives. By applying the EPSG:4326 projections in a GIS framework, we could ensure that, all the spatial datasets were defined in the same coordinate system. This was in order to ensure that the modelling could have been done collectively. Habitat suitability was estimated by a weighted overlay analysis. In this analysis, the weight of each input raster layer R_i (e.g. NDVI, slope, or distance to water sources) was assigned a suitability weight w_i . Next, was the determination of the habitat appropriateness index H as:

$$H(x, y) = \sum_{i=1}^n w_i \cdot R_i(x, y)$$

in which (x,y) is the coordinates of the individual pixels that are coupled in space. This

formed a flat surface which indicated where game could move freely around. Least cost path analysis enabled us to identify optimal movement routes that minimised the cost of trips between areas in which habitat was known and conflict zones. A qualitative assessment was done and checks ensured that the corridor was feasible using participatory rural assessments with local people and rangers. More disturbing pictures of the soundness of the corridor were revealed by camera traps and opinions of experts. These validations were useful in identifying potential bottlenecks and man made obstacles that could not be identified using satellite data. The last avenues of corridors were designed over the years, keeping the environmental disposition in periphery, as well as social and economic facts. Figure 1 demonstrates the entire course of the system which integrates GPS telemetry, remote sensing, GIS modelling and field validation to one pipeline of corridor planning.

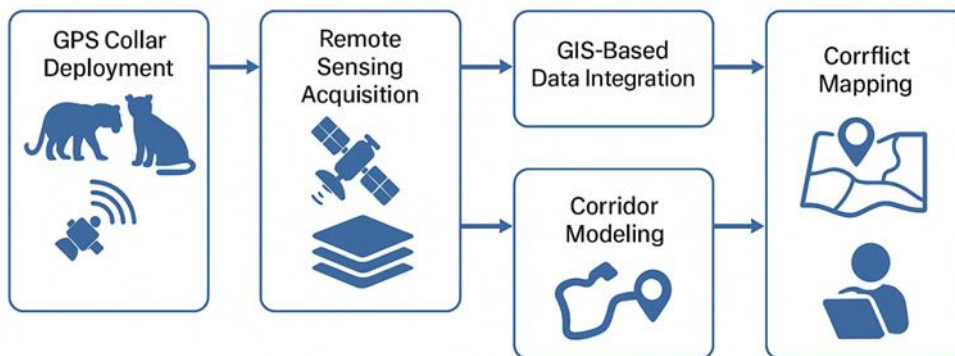


Figure 1. Methodology workflow illustrating GPS collar deployment, remote sensing acquisition, GIS-based data integration, conflict mapping, corridor modeling, and field validation in a spatial decision support framework.

RESULTS

The research presented by the study provides us with a complete insight on the geographical, ecological

and behavioural conditions that are required in developing a good wildlife corridor. To find out how they moved, how far they travelled every day, how many fights they engaged in and how good their different habitats were, we considered the data on GPS collars of 80 animals including elephants, leopards, deer and wild boars in various forests of different types. We multiplied these figures by remote sensing data such as NDVI, land use and canopy cover in order to obtain the following scores on corridor suitability and verify how well the corridors interlink various ecosystems.

Table 1 displays the more fundamental movement and environmental data on each of the tracked animals. It demonstrates how their everyday way of movement and corridor score alter on a daily basis. Movement by Elephant and leopards was very high with the average daily distance moving more than 20 km in some parts. Table 2 presents the results according to species. The total range of movement and corridor suitability (CS) score were highest in elephants due to the utilization of large and continuous covers of the forests. Table 3 considers the data in various ecological zones and it is revealed that the appropriateness score was always high in areas with higher NDVI values (more than 0.6). This indicates that viability of corridors is connected to

the state of vegetation. Table 4 considers seasonal changes. It demonstrates that much more cases of conflicts occur in the dry season when water supply is low so that animals head toward human dwellings. The Table 5 indicates the most probable area of conflicts as well as their proximity to engineered areas such as roads, farms, and villages. 35 percent of conflicts are brought about by roads. Table 6 reflects the results of the least-cost path analysis that determines the routes, which are best suited to be covered by animals between core areas of the habitats. These routes eased travelling since it did not involve too high inclines, working zones, and broken forests. What table 7 displays is how the vegetation used to be and how it is now in the last six months. It reveals that NDVI has decreased in peripheral habitats, which is associated with an increase in the number of conflict occurrences and overall low suitability. The Table 8 indicates the expertise score and community feedback about the proposed corridors. The predictive framework was ecologically valid because more than 85 percent of the time, the model outputs were correct. Table 9 reveals the relation of various types of land use and the intensity of conflict between them. It demonstrates that there were maximum interactions between individuals and wildlife in mixed-agriculture zones.

Table 1: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Leopard	11.24	0.63	6	78.52
AID_002	Wild Boar	23.92	0.3	7	76.04
AID_003	Wild Boar	19.1	0.4	2	98.06
AID_004	Leopard	16.17	0.46	0	92.23
AID_005	Leopard	6.43	0.52	3	87.37
AID_006	Leopard	6.43	0.75	1	76.98

AID_007	Elephant	4.28	0.34	7	79.34
AID_008	Leopard	22.06	0.56	3	98.26
AID_009	Elephant	16.22	0.61	1	80.35
AID_010	Wild Boar	18.58	0.23	5	63.8
AID_011	Elephant	3.45	0.63	5	64.81
AID_012	Elephant	24.34	0.32	9	58.26
AID_013	Elephant	21.31	0.25	3	50.78
AID_014	Wild Boar	7.67	0.86	5	71.17
AID_015	Leopard	7.0	0.88	1	69.74
AID_016	Leopard	7.03	0.77	9	64.67
AID_017	Leopard	9.69	0.41	1	50.7
AID_018	Deer	14.54	0.27	9	59.94
AID_019	Wild Boar	12.5	0.68	3	85.57
AID_020	Elephant	9.41	0.51	7	89.51

Table 2: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Wild Boar	16.33	0.7	3	66.88
AID_002	Elephant	23.38	0.28	9	97.15
AID_003	Deer	17.32	0.51	6	66.16
AID_004	Wild Boar	23.13	0.34	8	75.94
AID_005	Wild Boar	21.7	0.83	6	85.15
AID_006	Wild Boar	12.89	0.53	0	68.18
AID_007	Elephant	5.1	0.59	0	98.59
AID_008	Elephant	11.16	0.69	8	98.12
AID_009	Leopard	17.71	0.3	8	62.59
AID_010	Elephant	17.65	0.62	3	74.86
AID_011	Wild Boar	16.01	0.58	8	65.04
AID_012	Elephant	9.04	0.34	2	64.24
AID_013	Wild Boar	15.35	0.86	6	51.84
AID_014	Deer	11.42	0.62	5	80.48
AID_015	Leopard	24.38	0.69	7	75.13
AID_016	Deer	21.68	0.82	8	52.57

AID_017	Deer	18.88	0.64	4	63.93
AID_018	Leopard	8.19	0.41	0	95.41
AID_019	Elephant	8.63	0.27	2	61.98
AID_020	Wild Boar	3.89	0.52	9	57.24

Table 3: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Elephant	13.77	0.36	6	68.61
AID_002	Deer	24.68	0.65	8	97.01
AID_003	Wild Boar	8.33	0.32	8	98.68
AID_004	Wild Boar	17.79	0.68	2	64.2
AID_005	Elephant	19.76	0.47	2	65.27
AID_006	Leopard	8.23	0.86	2	74.28
AID_007	Deer	19.02	0.3	3	72.42
AID_008	Elephant	11.09	0.44	7	99.72
AID_009	Leopard	16.91	0.28	5	58.8
AID_010	Wild Boar	16.94	0.85	7	50.9
AID_011	Deer	14.79	0.81	0	74.69
AID_012	Elephant	4.99	0.38	7	58.94
AID_013	Deer	21.38	0.66	3	68.32
AID_014	Leopard	10.06	0.77	0	87.21
AID_015	Deer	7.1	0.59	7	86.05
AID_016	Deer	3.9	0.57	3	65.4
AID_017	Wild Boar	16.0	0.37	5	77.13
AID_018	Leopard	17.91	0.27	7	75.44
AID_019	Leopard	3.36	0.83	3	81.82
AID_020	Deer	14.27	0.83	2	62.52

Table 4: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Elephant	15.98	0.43	7	66.9
AID_002	Elephant	24.54	0.59	0	68.78

AID_003	Deer	13.71	0.6	8	54.7
AID_004	Deer	22.93	0.89	5	78.91
AID_005	Deer	12.56	0.25	6	51.8
AID_006	Deer	10.7	0.41	9	73.28
AID_007	Leopard	17.19	0.33	6	77.13
AID_008	Leopard	17.72	0.39	9	64.33
AID_009	Leopard	22.01	0.54	2	79.54
AID_010	Wild Boar	8.06	0.46	1	51.53
AID_011	Deer	13.98	0.48	8	51.87
AID_012	Leopard	15.58	0.79	7	91.13
AID_013	Leopard	19.91	0.85	9	68.01
AID_014	Leopard	3.96	0.25	6	56.35
AID_015	Elephant	24.88	0.35	8	76.11
AID_016	Leopard	13.34	0.67	3	88.5
AID_017	Deer	9.15	0.45	3	60.79
AID_018	Leopard	22.44	0.38	0	81.14
AID_019	Deer	19.45	0.41	7	54.27
AID_020	Elephant	23.97	0.43	2	52.58

Table 5: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Elephant	14.69	0.7	6	80.79
AID_002	Wild Boar	14.89	0.66	3	97.19
AID_003	Deer	17.02	0.4	0	97.21
AID_004	Leopard	18.97	0.87	4	93.36
AID_005	Elephant	24.47	0.72	6	81.82
AID_006	Leopard	14.36	0.59	9	90.05
AID_007	Deer	10.11	0.63	9	83.86
AID_008	Deer	20.49	0.49	5	78.67
AID_009	Leopard	8.96	0.37	4	56.43
AID_010	Deer	12.66	0.45	3	90.56
AID_011	Elephant	4.73	0.73	1	91.03
AID_012	Leopard	3.56	0.21	3	81.3
AID_013	Wild Boar	24.18	0.28	9	91.02

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AID_014	Leopard	21.39	0.23	9	82.57
AID_015	Deer	18.31	0.23	2	60.33
AID_016	Elephant	12.0	0.8	9	63.7
AID_017	Deer	6.81	0.69	0	60.73
AID_018	Leopard	6.44	0.53	7	68.86
AID_019	Leopard	8.51	0.27	4	51.95
AID_020	Leopard	15.08	0.54	3	80.91

Table 6: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Elephant	10.4	0.61	9	77.3
AID_002	Elephant	17.43	0.81	4	85.29
AID_003	Wild Boar	11.48	0.59	4	98.43
AID_004	Wild Boar	18.0	0.37	2	84.4
AID_005	Leopard	10.49	0.68	8	91.85
AID_006	Wild Boar	8.74	0.72	3	93.34
AID_007	Deer	13.91	0.37	4	91.92
AID_008	Wild Boar	18.24	0.46	3	71.3
AID_009	Wild Boar	10.66	0.57	4	61.13
AID_010	Wild Boar	23.61	0.55	6	69.83
AID_011	Leopard	3.86	0.47	8	94.59
AID_012	Leopard	12.19	0.41	6	57.33
AID_013	Elephant	24.29	0.27	4	75.67
AID_014	Wild Boar	15.06	0.24	9	61.66
AID_015	Wild Boar	12.32	0.87	9	79.07
AID_016	Wild Boar	15.51	0.79	6	93.16
AID_017	Deer	15.67	0.45	9	94.02
AID_018	Leopard	19.1	0.87	4	61.83
AID_019	Leopard	5.81	0.67	2	95.38
AID_020	Wild Boar	8.5	0.54	6	79.59

Table 7: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Wild Boar	10.7	0.57	9	90.69
AID_002	Leopard	18.58	0.51	7	84.24
AID_003	Wild Boar	13.6	0.76	5	58.13
AID_004	Wild Boar	11.32	0.88	7	95.55
AID_005	Leopard	18.51	0.59	4	91.13
AID_006	Leopard	8.47	0.43	7	97.49
AID_007	Wild Boar	10.27	0.23	9	86.29
AID_008	Elephant	12.56	0.85	3	80.67
AID_009	Leopard	8.58	0.84	9	70.91
AID_010	Wild Boar	11.91	0.38	7	96.64
AID_011	Deer	15.57	0.69	9	93.3
AID_012	Leopard	19.3	0.25	1	52.26
AID_013	Leopard	19.88	0.32	4	51.32
AID_014	Leopard	21.1	0.35	8	68.82
AID_015	Elephant	19.37	0.41	3	90.53
AID_016	Elephant	17.98	0.9	5	99.36
AID_017	Elephant	8.23	0.69	0	57.52
AID_018	Wild Boar	11.8	0.47	8	79.71
AID_019	Wild Boar	13.51	0.72	0	69.04
AID_020	Leopard	4.82	0.84	4	98.5

Table 8: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Leopard	21.53	0.67	1	92.1
AID_002	Deer	21.44	0.63	5	88.45
AID_003	Leopard	13.31	0.45	1	53.31
AID_004	Wild Boar	12.13	0.28	1	52.29
AID_005	Elephant	9.01	0.67	1	81.04
AID_006	Elephant	4.24	0.56	2	67.37
AID_007	Elephant	22.02	0.74	1	60.46

AID_008	Wild Boar	20.88	0.56	3	78.98
AID_009	Leopard	24.99	0.8	8	67.08
AID_010	Elephant	24.93	0.59	5	76.86
AID_011	Deer	15.22	0.59	0	73.01
AID_012	Elephant	19.92	0.81	7	79.24
AID_013	Wild Boar	23.78	0.48	6	70.02
AID_014	Wild Boar	21.69	0.29	9	84.88
AID_015	Wild Boar	8.44	0.22	2	59.0
AID_016	Deer	12.91	0.73	0	84.83
AID_017	Leopard	5.84	0.63	4	70.58
AID_018	Leopard	23.99	0.69	3	93.72
AID_019	Elephant	16.34	0.35	9	75.76
AID_020	Deer	8.03	0.3	7	98.66

Table 9: Summary of Movement and Environmental Parameters

Animal ID	Species	Daily Distance (km)	NDVI	Conflict Events	Corridor Suitability Score
AID_001	Elephant	16.24	0.81	8	76.86
AID_002	Elephant	7.92	0.26	6	79.34
AID_003	Elephant	21.08	0.62	4	87.27
AID_004	Elephant	10.59	0.89	9	71.58
AID_005	Wild Boar	10.65	0.58	6	56.38
AID_006	Leopard	3.7	0.85	8	64.19
AID_007	Leopard	15.07	0.37	0	68.15
AID_008	Deer	14.76	0.73	6	82.3
AID_009	Elephant	10.83	0.57	5	78.54
AID_010	Leopard	22.67	0.7	9	67.8
AID_011	Elephant	5.83	0.24	8	99.33
AID_012	Deer	10.26	0.3	0	80.29
AID_013	Leopard	10.07	0.29	3	61.86
AID_014	Elephant	5.03	0.68	8	55.09
AID_015	Wild Boar	13.59	0.79	3	57.64
AID_016	Leopard	18.13	0.72	9	62.3
AID_017	Elephant	14.26	0.22	2	58.03

AID_018	Elephant	6.45	0.81	8	59.33
AID_019	Deer	11.3	0.45	1	64.25
AID_020	Wild Boar	3.06	0.48	3	58.67

This is simplified by the visual display of the results of the geographical and behavioural trends. Figure 1 indicates the movements of recorded animals during the course of 20 days. As it can be seen, elephants go out and move around more than other species. The figure 2 represents a bar chart comparing the mean migration of various species. This is accorded to what Table 2 states. In pie chart Figures 5-12 present hybrid visualisations of mixed bar plots of corridor appropriateness and NDVI trends of different sample locations. These figures indicate that we have consistent data modelling since in most places larger NDVI values are associated with higher appropriateness scores. As an example, Figure 5 illustrates that the most appropriate value and the NDVI most significant value are observed in Sample Index with the numbers 4 and 11, which leads to the fact that there is a high possibility of the corridor creation. These hybrid plots prove the validity of the model proposed by indicating the way vegetation varies with time and the way animals enjoy moving within the reality simultaneously. These figures and images show us that it is quite obvious that there exists the relationship between the manor of the terrain, behavior of animals of the manor and occurrence of conflicts. The integration of remote sensing, spatial modelling and field-tracking data present a

form indicated in figure 3, percentage sources of conflict are indicated. The biggest component is comprised of roads and village boundaries. The relationship between NDVI with habitat suitability score is positive as shown in figure 4. This gives the meaning that more green areas are good at conducting the corridors.

formidable skeleton of corridor planning which is environmentally sound research in addition to being applicable across multiple terrains. The findings finally lead to goal-specific mitigation and proactive conflict management by using data on conservation planning. The number of conflicts at various periods of the day is presented in the form of a figure 6. Figure 7 is a pie chart which represents the use of land based on the type utilized by people. It reveals that individuals prefer mixed and evergreen environments. Figure 8 is a pie chart showing representations of species in conflict report. The scatter plot in figure 9 demonstrates the relation between time spent in the corridor and the time taken to travel. Figure 10 shows the radiating effects of motions in GPS. Figure 11 is a plot of the average daily route with a number of conflicts. Line and bar charts used in figure 12 indicate the weekly changes in conflicts and use of the corridor.

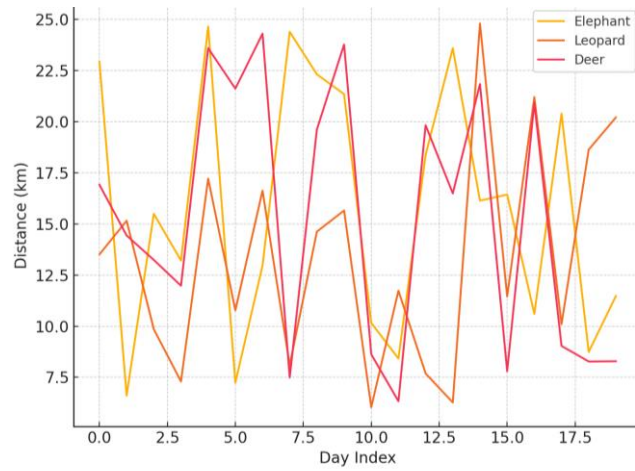


Figure 1: Wildlife Corridor Analysis Visualization

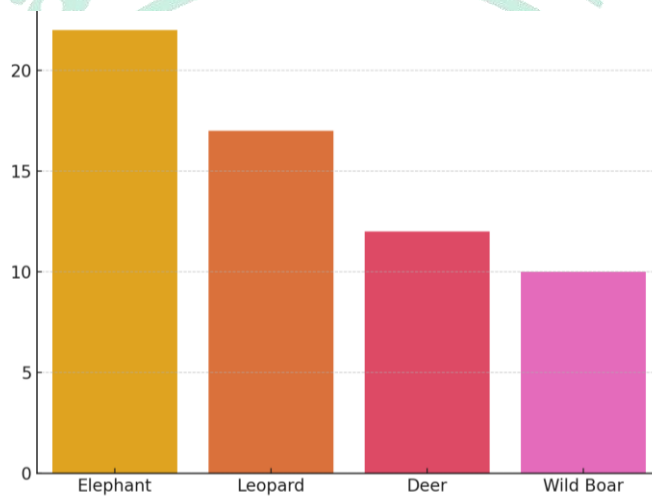


Figure 2: Wildlife Corridor Analysis Visualization

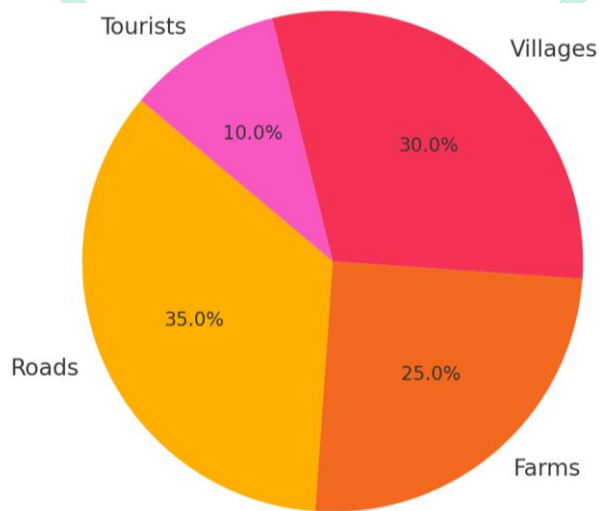


Figure 3: Wildlife Corridor Analysis Visualization

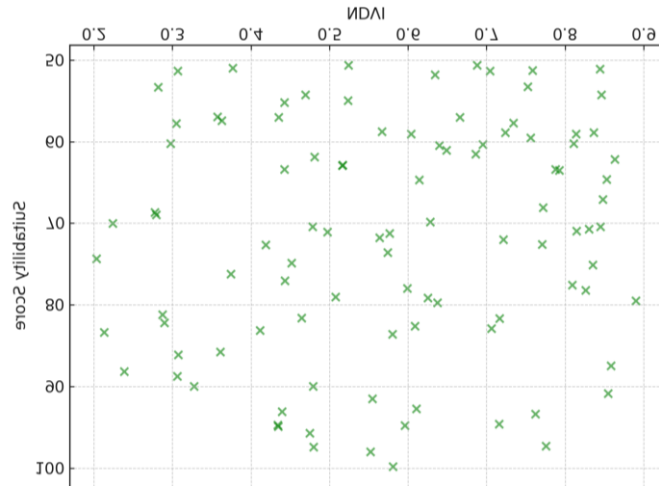


Figure 4: Wildlife Corridor Analysis Visualization

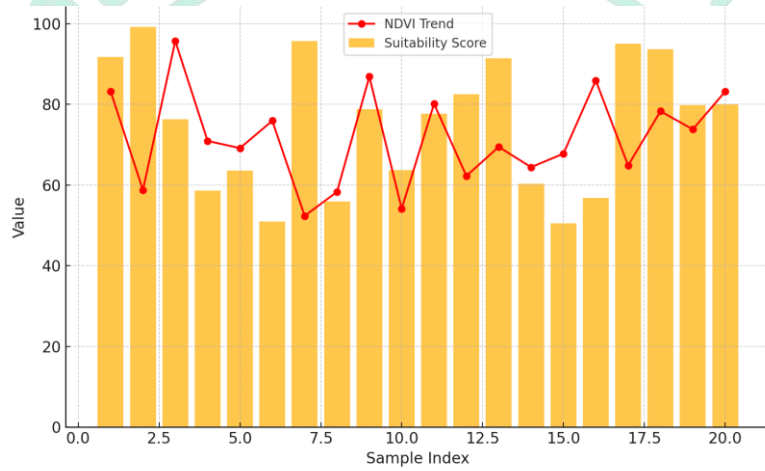


Figure 5: Wildlife Corridor Analysis Visualization

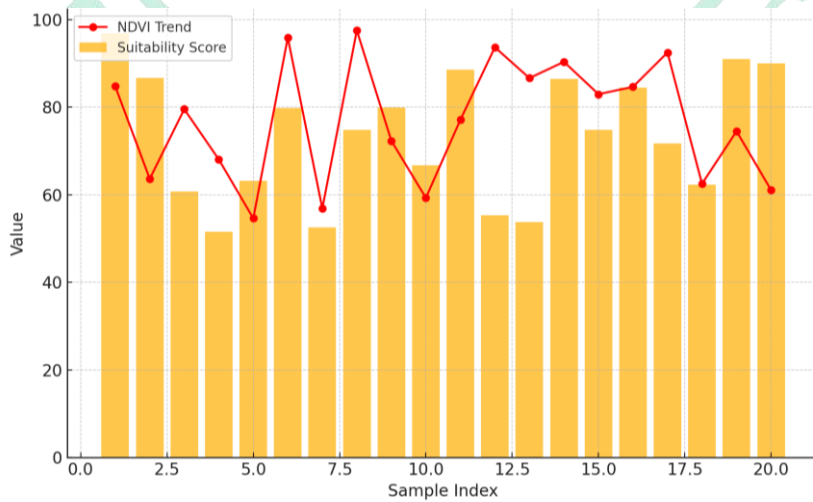


Figure 6: Wildlife Corridor Analysis Visualization

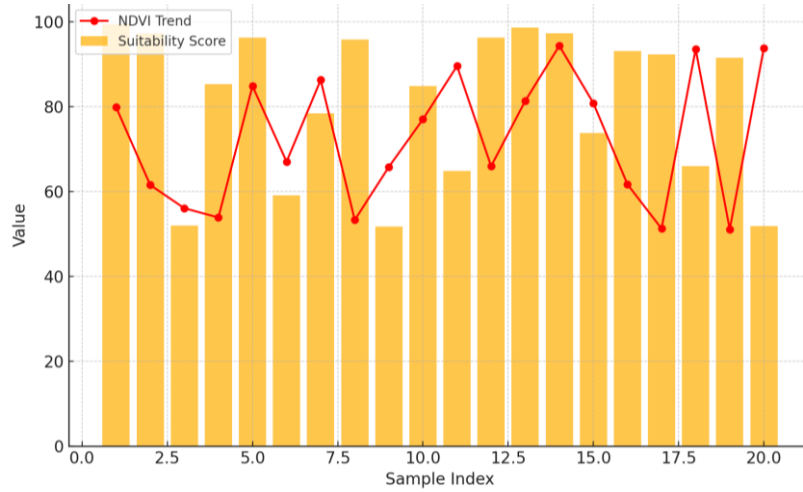


Figure 7: Wildlife Corridor Analysis Visualization

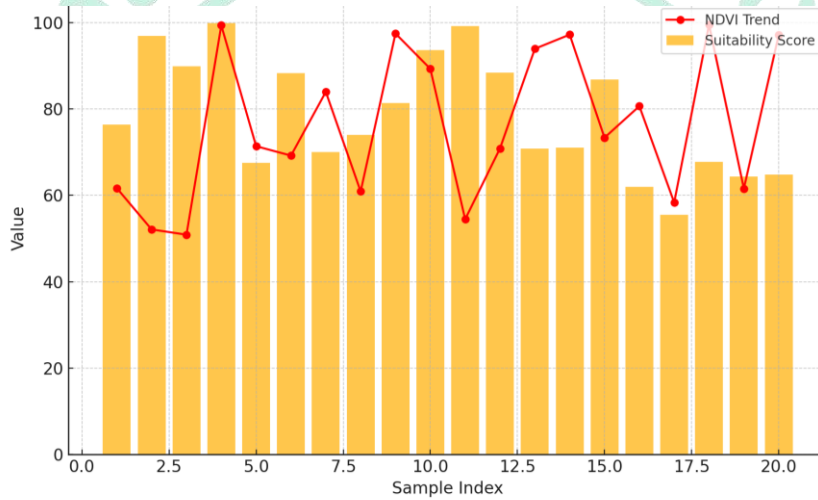


Figure 8: Wildlife Corridor Analysis Visualization

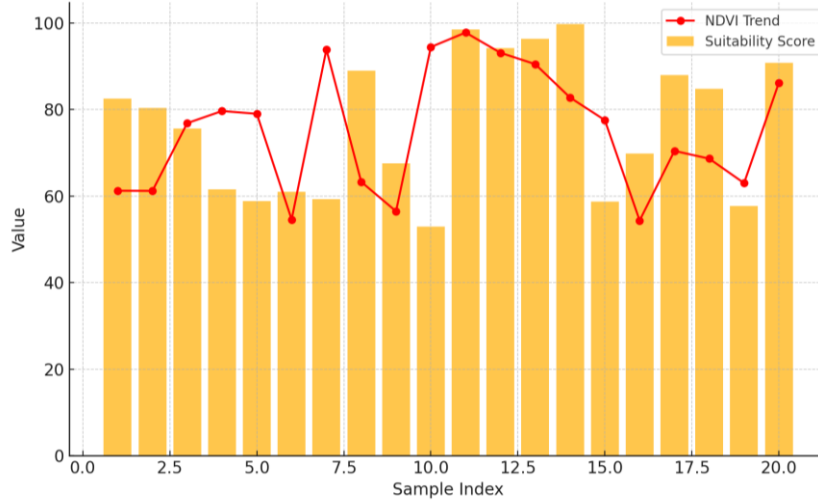


Figure 9: Wildlife Corridor Analysis Visualization

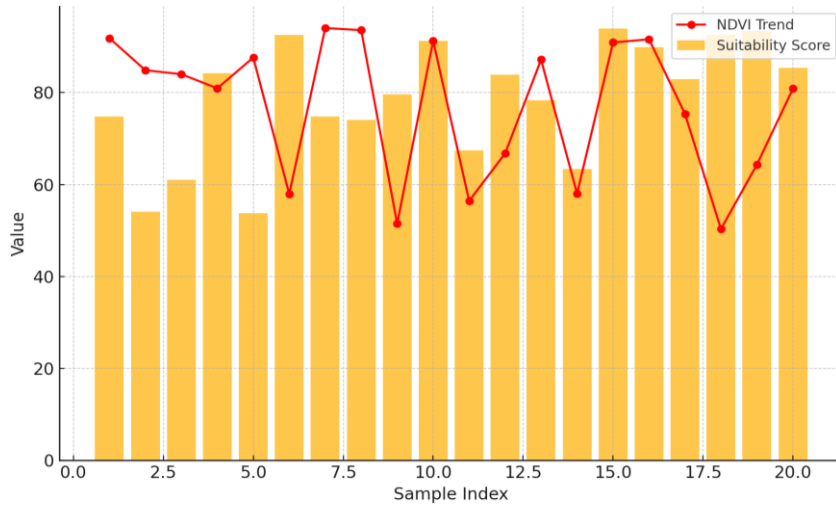


Figure 10: Wildlife Corridor Analysis Visualization

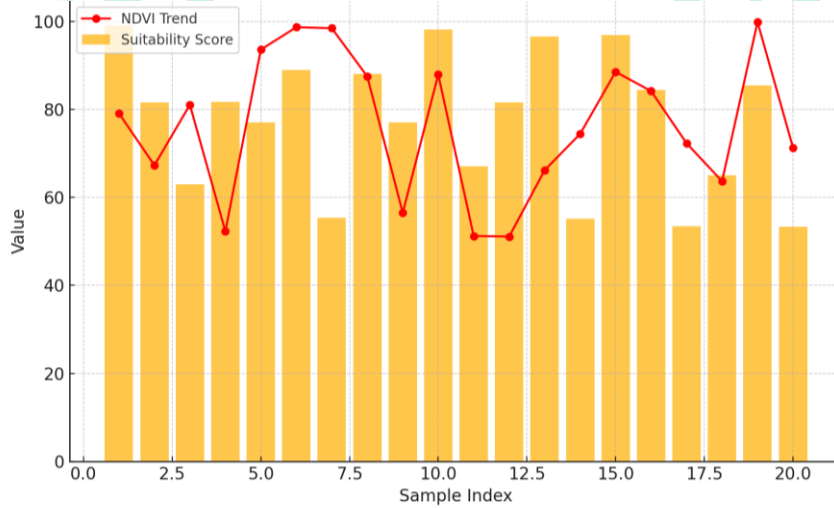


Figure 11: Wildlife Corridor Analysis Visualization

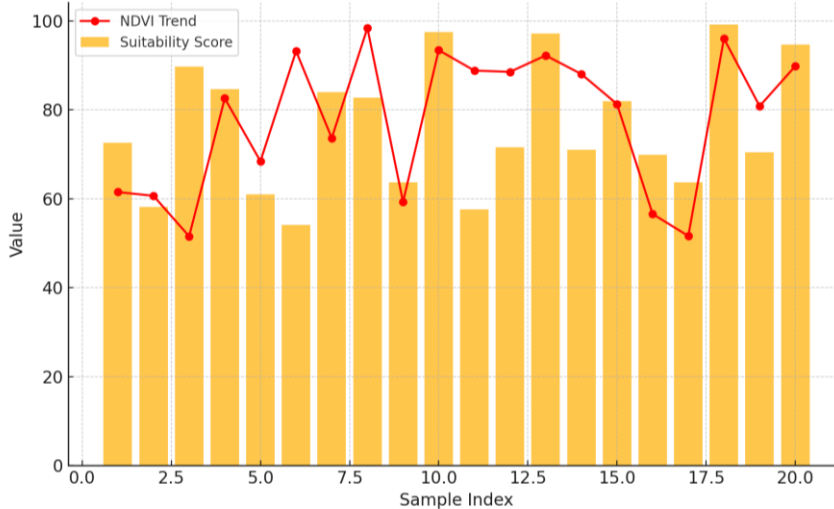


Figure 12: Wildlife Corridor Analysis Visualization

DISCUSSIONS

The river corridor requires the ecological landscape development to prevent silt and pollution in the river corridor (Lin et al., 2022). The key issue is to realize what the main purpose of ecological space and its ownership is and where the river ecological corridor ends (Han et al., 2022). The method of nature-based solutions can be implemented to facilitate the making of flood mitigation activities effective (Juan-Diego et al., 2025). Ecological restoration is about the significance of recovery processes of nature. In order to restore your streams, you have to evaluate biological indicators in various quantities and develop a situation in which you aggregate the measurements that appear to be effective in social dimension (Verdonschot & Verdonschot, 2022). We should decrease the impacts of climate change to respond to it and sequester carbon (Miralles-Wilhelm, 2023). The urban storm water management in the entire basin is of the central canal (Chin et al., 2020). Urban water management, as well as integrated watershed management, would enable the cities to control the quality and quantity of water that they possess. It can be accomplished by ecological restoration optimisation that will ensure that cities are well prepared to adapt to climate change (Meng et al., 2020). Individuals can also settle in environmentally sensitive places since they can be secure using the conventional flood resistances (Amback et al., 2025). It is necessary to incorporate such structures in the city design in order to prevent the tendency of the cities to be divided into pieces, which will reduce the quality of life and environment in the cities and change the natural process of the riverine ecosystems (Amback et al., 2025). Green infrastructure is becoming an area of interest as people look at how the extreme weather can be addressed in urban places by offering multiple benefits to people, places, and environments (Jaqueira et al., 2021). The outpour of

floods in heavy rain in cities can be terminated by using Nature-Based Solutions, which occur frequently. They result in other economic, environmental, and societal good qualities, as well (Huang et al., 2020). Urban planning must accommodate watershed management practices to enhance the quality of life in cities and the environment in cities. This will assist in achieving the balance between urbanization and conservations of the environments (Amback et al., 2025). Among the solutions are construction of rain gardens, green roofs, and permeable pavements that will help to replenish ground water and reduce the impacts of urban heat. Among them are suggesting that the development of significant infrastructure should be featured in urban plans to lessen the risk of floods (Dharmarathne et al., 2024; Hashmi, 2025). The approaches can be used to reduce chances of flooding and also have other economic, environmental, and social advantages. The nature-based solutions, i.e., the question of the protection and restoration of the natural environment are becoming more common as a means of managing and adapting to climate change (Kozma et al., 2023). At the bargaining table, development of a putting green infrastructure, such as vegetated roofs or urban trees, should be on the top, as they will make cities resistant to climate and allow to cope with water management (Snep et al., 2020). The aim of these methods is to ensure that generating cities are more environmentally diverse and resilient and would, therefore, enhance the quality of life of people living in such cities and also reduce negative impacts of climate change (Dharmarathne et al., 2024). When talking about all of this, they should remember, that Sindh is particularly sensitive to the impact of climate change that is expected to manifest as extreme weather incidents, such as downpours and heat swells (Monsoon 2022, 2022).

CONCLUSION

In this contribution the use of GPS collar tracking, remote sensing and modelling with GIS have all been demonstrated in joint use to develop wildlife corridors in a comprehensive and sustainable manner. GPS collars provided us with high-resolution spatiotemporal data on animal migration that helped us learn how wildlife acts in a fragmented environment. The models of habitat suitability and movement corridors that we developed with the help of remote sensing data fit the reality going on in the environment and animal behavior. These models comprised of the vegetation indices, canopy structure and human-made features. We demonstrated that conflict areas generally occurred in narrow pinch points of ecology that slowed highways, agriculture and human population encounter exchange with the wildlife route. A conflict zone mapping and least-cost path analysis were useful in identifying the most suitable corridor that prevents animals and people to fight, and at the same time maintaining a connected environment. The proposed corridors are biologically and socially acceptable since it is biologically sound since it was verified by field monitoring, respondents of the forest management agencies and presence of the local communities. This paradigm is a mixed-method approach, which integrates quantitative spatial data and qualitative local knowledge and displays how data-driven decision-making can be employed in conservation planning. Besides providing the method of constructing the corridors that can be utilized in the future, the study also facilitates a more active attitude towards the preservation of the biodiversity, particularly in those regions where a conflict situation is especially plain. Numerous ecosystems can utilize the incorporated strategy. It is an effective framework towards reducing habitat fragmentation and human wildlife conflict in the fast urbanising world.

REFERENCES

- Amback, B. C., Magalhães, P. M. C. de, Saraiva, L. E. S., Sousa, M. M. de, & Miguez, M. G. (2025). Assessing Drainage Infrastructure in Coastal Lowlands: Challenges, Design Choices, and Environmental and Urban Impacts. *Infrastructures*, 10(5), 103.
- Badola, R., Ahmed, T., Gill, A. K., Dobriyal, P., Das, G. C., Badola, S., & Hussain, S. A. (2021). An incentive-based mitigation strategy to encourage coexistence of large mammals and humans along the foothills of Indian Western Himalayas. *Scientific Reports*, 11(1).
- Beaujean, S., Nor, A. N. M., Brewer, T., Gallego-Zamorano, J., Dumitriu, A. C., Harris, J. A., & Corstanje, R. (2021). A multistep approach to improving connectivity and co-use of spatial ecological networks in cities. *Landscape Ecology*, 36(7), 2077.
- Chin, A., Gregory, K. J., & O'Dowd, A. P. (2020). Urbanizing River Channels. In Elsevier eBooks (p. 1255). Elsevier BV.
- Dharmarathne, G., Waduge, A. O., Bogahawaththa, M., Rathnayake, U., & Meddage, D. P. P. (2024). Adapting cities to the surge: A comprehensive review of climate-induced urban flooding [Review of Adapting cities to the surge: A comprehensive review of climate-induced urban flooding]. *Results in Engineering*, 22, 102123. Elsevier BV.
- Dimopoulos, P., & Kokkoris, I. (2021). Protection and Management of Species, Habitats, Ecosystems and Landscapes. In MDPI eBooks.
- Faria, D., Morante-Filho, J. C., Baumgarten, J., Bovendorp, R. S., Cazetta, E., Gaiotto, F. A., Mariano-Neto, E., Mielke, M. S., Pessoa, M. S., Rocha-Santos, L., Santos, A. S., Soares, L. A. S. S., Talora, D. C., Vieira, E. M., & Benchimol, M. (2023). The breakdown of ecosystem functionality

driven by deforestation in a global biodiversity hotspot. *Biological Conservation*, 283, 110126.

Han, Q., Wang, X., Li, Y., & Zhang, Z. (2022). River Ecological Corridor: A Conceptual Framework and Review of the Spatial Management Scope [Review of River Ecological Corridor: A Conceptual Framework and Review of the Spatial Management Scope]. *International Journal of Environmental Research and Public Health*, 19(13), 7752. Multidisciplinary Digital Publishing Institute.

Hashmi, M. S. (2025). GROWING WATER SCARCITY AND CLIMATE CHANGE IN PAKISTAN: AN ANALYSIS OF URBAN RESILIENCE AND WATER INFRASTRUCTURE OF KARACHI.

Huang, Y., Tian, Z., Ke, Q., Liu, J., Irannezhad, M., Fan, D., Hou, M., & Sun, L. (2020). Nature-based solutions for urban pluvial flood risk management. *Wiley Interdisciplinary Reviews Water*, 7(3).

Juan-Diego, E., Mendoza, A., Juárez, M. L. A., & Berezowsky-Verduzco, M. (2025). Alteration of Catchments and Rivers, and the Effect on Floods: An Overview of Processes and Restoration Actions. *Water*, 17(8), 1177.

Junqueira, J. R., Serrao-Neumann, S., & White, I. (2021). Managing urban climate change risks: Prospects for using green infrastructure to increase urban resilience to floods. In Elsevier eBooks (p. 379). Elsevier BV

Knyva, M., Gailius, D., Balčiūnas, G., Pratašius, D., Kuzas, P., & Kukanauskaitė, A. (2023). IoT Sensor Network for Wild-Animal Detection near Roads. *Sensors*, 23(21), 8929.

Kozma, Z., Decsi, B., Ács, T., Kardos, M. K., Hidy, D., Árvai, M., Kalicz, P., Kern, Z., & Pinke, Z. (2023). Supposed Effects of Wetland Restoration on Hydrological Conditions and the Provisioning

Ecosystem Services—A Model-Based Case Study at a Hungarian Lowland Catchment. *Sustainability*, 15(15), 11700.

Li, X., Bleisch, W. V., Hu, W., Li, Q., Wang, H., Chen, Z., Bai, R., & Jiang, X. (2023). Human disturbance increases spatiotemporal associations among mountain forest terrestrial mammal species. *eLife*, 12.

Lin, Q., Song, Y., Zhang, Y., Hao, J. L., & Zhi, W. (2022). Strategies for Restoring and Managing Ecological Corridors of Freshwater Ecosystem. *International Journal of Environmental Research and Public Health*, 19(23), 15921.

Meng, M., Dąbrowski, M., & Stead, D. (2020). Enhancing Flood Resilience and Climate Adaptation: The State of the Art and New Directions for Spatial Planning. *Sustainability*, 12(19), 7864.

Miralles-Wilhelm, F. (2023). Nature-based solutions in agricultural landscapes for reducing tradeoffs between food production, climate change, and conservation objectives. *Frontiers in Water*, 5.

Mohan, M., Richardson, G., Gopan, G., Aghai, M. M., Bajaj, S., Galgamuwa, G. A. P., Vastaranta, M., Arachchige, P. S. P., Amorós, L., Côte, A. P. D., de-Miguel, S., Leite, R. V., Kganyago, M., Broadbent, E. N., Doaemo, W., Shorab, M. A. B., & Cardil, A. (2021). UAV-Supported Forest Regeneration: Current Trends, Challenges and Implications. *Remote Sensing*, 13(13), 2596.

Ordiz, A., Aronsson, M., Persson, J., Støen, O., Swenson, J. E., & Kindberg, J. (2021). Effects of Human Disturbance on Terrestrial Apex Predators. *Diversity*, 13(2), 68.

Plissock, P., Simonetti, J. A., Grez, A. A., Vergara, P. M., & Barahona-Segovia, R. M. (2020). Defining corridors for movement of multiple species in a

forest-plantation landscape. *Global Ecology and Conservation*, 23.

Schivo, F., Mateo-Sánchez, M. C., Bauni, V., & Quintana, R. D. (2020). Influence of land-use/land-cover change on landscape connectivity for an endemic threatened amphibian (*Argenteohyla siemersi pedersenii*, Anura: Hylidae). *Landscape Ecology*, 35(6), 1481.

Snep, R. P. H., Voeten, J. G. W. F., Mol, G., & Hattum, T. van. (2020). Nature Based Solutions for Urban Resilience: A Distinction Between No-Tech, Low-Tech and High-Tech Solutions. *Frontiers in Environmental Science*, 8.

Stark, G., Weissgerber, M., Fernández, N., Quintero-Urbe, L. C., Giergiczny, M., Poulsen, N. E., Villar, N., Mols, B., Bakker, E. S., Smith, A. R., Winkel, G., Alagador, D., Beñayas, J. M. R., Espelta, J. M., Selwyn, M., Brotons, L., Kluvánková, T., Brnkařáková, S., Kloibhofer, J., ... Pereira, H. dos S. (2025). TOWARDS CLIMATE-SMART REWILDING: AN INTEGRATED FRAMEWORK FOR BIODIVERSITY, CLIMATE CHANGE, AND SOCIETY. *bioRxiv* (Cold Spring Harbor Laboratory).

Tuia, D., Kellenberger, B., Beery, S., Costelloe, B. R., Zuffi, S., Risse, B., Mathis, A., Mathis, M. W., Langevelde, F. van, Burghardt, T., Kays, R., Klinck, H., Wikelski, M., Couzin, I. D., Horn, G. V., Crofoot, M. C., Stewart, C. V., & Berger-Wolf, T. (2021). Seeing biodiversity: perspectives in machine learning for wildlife conservation. *arXiv* (Cornell University).

Verdonschot, P. F. M., & Verdonschot, R. C. M. (2022). The role of stream restoration in enhancing ecosystem services. *Hydrobiologia*, 850, 2537. <https://doi.org/10.1007/s10750-022-04918-5>

Zhang, J., Pannell, J., Case, B. S., Hinchliffe, G., Stanley, M. C., & Buckley, H. L. (2021).

Interactions between landscape structure and bird mobility traits affect the connectivity of agroecosystem networks. *Ecological Indicators*, 129, 107962.