RAIS RESEARCH ASSOCIATION for INTERDISCIPLINARY STUDIES
August 3-4, 2023

DOI:10.5281/zenodo.8310061

Understanding the Relationship Between Natural Habitat Loss and Urban Development in Irbid Governorate

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ABSTRACT: The global population has grown rapidly, causing urbanization and rural habitat loss. Current research investigates the causes for habitat loss and fragmentation in the Bani-Kinanah County, Irbid, Jordan. It defines loss and fragmentation as natural or anthropogenic separation of green land. It also examines decision-makers' challenges and proposes greenways to reduce habitat loss and fragmentation. The study utilized snowball sampling to interview decision-makers and ArcGIS software to digitize aerial photographs. A literature review and criteria analysis determined greenway and green corridor locations. The study compared digitized aerial photos from 2005 and 2021 for several villages to assess built-up areas, street construction, and ecological natural corridors. Agricultural footprints were also examined. Interviewing the decision-makers revealed that habitat loss and fragmentation are attributed to physical and non-physical factors. they suggested modifications to natural habitat regulations and laws, public awareness of their importance and the causes of fragmentation, and physical interventions to minimize negative effects to prevent habitat fragmentation and loss. This study provides a foundation for understanding habitat fragmentation and loss and proposing solutions. The study recommends community involvement and collaboration with nature/environmental associations to monitor and prevent changes. It also proposes greenways and green corridors to sustain natural habitats.

KEYWORDS: Habitat loss, fragmentation, greenway planning, rural development, Jordan

Introduction

The primary threats to Earth's biological diversity are habitat loss and fragmentation, which are closely associated with land conversion for human activities and land degradation (Collinge 1996). The loss and fragmentation of habitats pose significant challenges to the preservation of biological diversity (Bennett 1999). Habitat fragmentation is a process that divides a large continuous habitat into multiple smaller patches with a smaller overall area. Addressing habitat loss is critical across multiple scientific disciplines. Urban planners believe that reducing the impact of habitat loss and fragmentation on quality of life is critical. The literature in urban planning has focused on raising biodiversity conservation awareness, implementing policy and strategy changes, and managing land use and infrastructure as key approaches to addressing habitat loss (Di Giulio, Holderegger, and Tobias 2009).

Extensive research has been conducted to investigate the causes of habitat loss and fragmentation, including both natural (Collinge 1996) and human factors (Al-Kofahi et al. 2018). While numerous factors contribute to this problem, researchers have identified effective techniques for mitigating habitat loss (Di Giulio, Holderegger, and Tobias 2009). Globally, these techniques have been implemented to improve connectivity in fragmented areas, involving policy and strategy changes, community engagement, and the development of green infrastructure (Bennett 1999).

In Jordan, several natural areas, particularly in the north, face the imminent threat of habitat loss and fragmentation (Khresat, Rawajfih, and Mohammad 1998). Furthermore, there

is a lack of understanding of the methodologies available to address this issue. As a result, the research seeks to accomplish the following goals:

- Investigate the factors that contribute to habitat loss and fragmentation in the Irbid governorate.
- Examine the role of urban planning practices and activities in facilitating habitat loss and fragmentation within the governorate.
- Determine decision-makers' awareness of habitat loss.
- Emphasis on green infrastructure as a technique for mitigating the effects of habitat loss and fragmentation, particularly in the Bani-Kinanah County of the Irbid governorate. This method includes the creation of natural corridors, buffers, species-specific connections, and steppingstones.
- Identify the factors influencing the selection of suitable locations for the creation of a green corridor in Bani-Kinanah County.

Loss of habitat and fragmentation

When natural or human actions damage and degrade the habitat, it can no longer support the animals and biological systems that live there. Animal extinction and biodiversity loss result (Stuart, Raven, and Raven 2000). 'Fragmentation' occurs when a large area of flora layers is partially cleared, leaving smaller parts that are separated from each other (Bennett 1999, Fahrig 2003). It is an active process that changes the habitat pattern over time (Bennett 1999).

Natural or anthropogenic factors cause habitat loss and fragmentation (Collinge 1996). Earthquakes isolate and reduce wildlife populations. On May 12, 2008, an 8-degree earthquake hit Wenchuan County, Sichuan Province, China, affecting the environment (Zhang et al. 2011). This earthquake destroyed 5.9% (656 km2) of giant panda habitat, including 19 nature reserves (Ouyang 2008).

Human factors arise from global population growth, which drives demand for commercial, residential, and agricultural development (Al-Kofahi et al. 2018). Natural ecosystems have suffered from global urbanization (Brown et al. 2014). Rapid economic development and population growth in China have caused unprecedented urban expansion (Normile 2008). Between 1981 and 2011, China's built-up area nearly fivefold increased from 7.44*103 km2 to 4.36*104 km2 (He et al. 2014). Rapid urbanization in China has destroyed habitat (Xie and Ng 2013). Wuhan, Hubei, China lost 85.3 km2 of water coverage and forest between 1987 and 1999 (Li et al. 2006).

Cleared farmland fragments forest patches; streets, houses, and roads divide urban forests; old forests are replaced by regenerating wood; and green spaces are replaced by intensive human activity (Bennett 1999). Isolation can be measured by the distance to the nearest larger habitat fragment, the number of suitable habitats within a radius, and the presence of linking habitats (Forman and Godron 1986).

Measurements of remaining natural habitat total area, fragment shapes, fragment size-frequency distribution, fragment average distance, and level of dissimilarity between adjacent land uses and habitats can reveal fragmentation-induced landscape changes (Fahrig 1997; Fahrig 2003).

Three main factors cause wildlife habitat fragmentation and loss (Schmiegelow and Mönkkönen 2002).

- Habitat fragmentation breaks up large patches, reducing habitat. This reduces the number of species in a habitat by reducing shelter land.
- Habitat fragmentation also reduces the number of edges suitable for species because they threaten their lives.
- Habitat fragmentation limits species’ mobility and isolates them from other habitats.

Accelerated urbanization, economic development, agricultural industrialization, land use restructuring, and transportation network expansion through natural areas have caused

natural area fragmentation, ecosystem deterioration, species extinction, and natural habitat and structure loss (Baris et al. 2010). In countries with low environmental development and planning, urbanization will threaten over 70% of species by 2030 (Huang, McDonald, and Seto 2018).

As ecosystems change due to urbanization, biodiversity conservation becomes a major issue (Antrop 2004). Urbanization, sprawl, and conurbations have major impacts on biodiversity and ecosystems. In recent decades, habitat loss and fragmentation have caused biodiversity loss (Maxwell et al. 2016). The second half of the 20th century saw unprecedented advances in speed, frequency, and magnitude (Antrop 2000). Existing, fragmented ecosystems have many new features and systems. New ecosystems are functionally homogeneous. New issues arise in landscape science due to its complexity and lack of understanding (Brandt, Holmes, and Skriver 2001). Planners and decision-makers seek new research and scientific expertise. Urbanization, road networks, and globalization drive these developments and new ecosystems (Antrop 2004).

Green infrastructure, policies, and regulations have reduced habitat loss and fragmentation worldwide (Jeusset et al. 2016, Orth et al. 2002). National and subnational governance is needed to mitigate urbanization and other habitat loss and fragmentation (Huang, McDonald, and Seto 2018). Land policies and regulations reduce environmental risks in key biodiversity areas, mitigating the effects of urban habitat depletion on biodiversity (Halleux, Marcinczak, and van der Krabben 2012).

Proper land use planning and policy enforcement are essential for managing environmental risks in biodiversity hotspots (Halleux, Marcinczak, and van der Krabben 2012). Land administration involves discussing land-use policy decisions, implementing appropriate legislation, and collaborating with stakeholders and official bodies at various strategic decision-making stages (Jepson et al. 2001). Land-management laws, regulations, and organizations are fostered by good land governance (Smith et al. 2003).

Green infrastructure balances protection and development best (Benedict and McMahon 2006, Guneroglu et al. 2013, Tarabon et al. 2019). Green corridors—a type of green infrastructure—meet human needs for environmental protection, recreation, and historic and cultural preservation (Baris et al. 2010). Green corridor networks connect rural and urban areas and offer open space (Fabos 1995). Green corridor planning aims to reconnect landscape fragments. Green corridors improve road safety and site value (Viles and Rosier 2001). Based on fragment size, vegetated corridors allow wildlife to move between habitat fragments, allowing more species and/or populations to survive (Collinge 1996).

Many studies have used suitability analysis to locate green corridors. Green corridor locations are determined by parcel size, soil type, future land use, floodplains, and ownership (Conine et al. 2004). Green corridor suitability analysis have included land use or cover factors (Conine et al. 2004; do Carmo Giordano and Riedel 2008; Miller et al. 1998; Steiner, McSherry, and Cohen 2000; Uy and Nakagoshi 2008). Green corridor planning papers often mention slope (do Carmo Giordano and Riedel 2008; Miller et al. 1998; Steiner, McSherry, and Cohen 2000). Green corridors consider the distance to water, streams, or ecological sites (Miller et al. 1998; Steiner, McSherry, and Cohen 2000). The study site must define these factors.

Jordan's Habitat Destruction

Jordan is known for its diverse ecosystems and abundant plant and animal species. Jordan has ecosystems thousands of miles apart despite its 400-kilometer length. Jordanian wildlife populations have declined and several species have gone extinct due to environmental threats. Lack of information, habitat degradation, wildlife persecution, climate change, and ineffective law enforcement are threats (Tellawi 2001).

Al Karadsheh, Akroush, and Mazahreh (2013), Al-Bilbisi (2012), and Khresat (1998) have studied "land degradation" in Jordan. Although some researchers have defined land degradation, Jordan appears to lack the strategies and technologies to effectively combat this issue due to a lack of socioeconomic context, inaccurate identification of arid land problems, and ineffective natural resource management (Al Karadsheh, Akroush, and Mazahreh 2013). Soil fertility loss, wind and water erosion, and overgrazing cause North-Western Jordan's land degradation (Khresat, Rawajfih, and Mohammad 1998). Jordanian land degradation is caused by urbanization, unplanned agricultural activities, and overuse of vegetative cover. Poor farmers and herders use unsustainable methods to increase food production (Al Karadsheh, Akroush, and Mazahreh 2013). Off-roading and plant uprooting threaten Jordan's rangelands (MOE, 2001). Jordan's land degradation is caused by ineffective land use planning policies (Al Karadsheh, Akroush, and Mazahreh 2013).

Community participation is crucial to any land degradation plan, policy, or strategy. Decision-makers, planners, and users at all levels should actively participate in planning to ensure initiative effectiveness and sustainability (Al Karadsheh, Akroush, and Mazahreh 2013). Many habitat fragmentation studies have examined natural and human factors. Glaciation, fires, floods, hurricanes, and volcanic eruptions fragment habitats (Collinge 1996, Al-Kofahi et al. 2018). Glaciation destroys landscapes and habitats. Landforms and vegetation change over time (Collinge 1996). Fires—natural and manmade—damage habitats. In ecosystems with natural fire regimes that renew plant species and preserve habitat diversity, uncontrolled or frequent fires can cause habitat loss and fragmentation (Al-Kofahi et al. 2018). Floods can alter landscapes and destroy habitat. Floodwaters destroy land, vegetation, and ecosystems (Collinge 1996). Tropical storms like hurricanes can damage ecosystems. Hurricane winds and storm surges can uproot trees, destroy vegetation, and reshape coastal areas, fragmenting habitat (Al-Kofahi et al. 2018). Molten lava, toxic gases, and volcanic ash can destroy ecosystems. Eruptions can bury habitats under lava or ash, destroy vegetation, and alter soil fertility, causing habitat loss and fragmentation (Collinge 1996).

These natural factors can cause habitat loss and fragmentation, affecting biodiversity and ecosystem functioning. Effective conservation and management require understanding and mitigating these phenomena. Urban development is Jordan's biggest environmental problem, according to research. Rapid urbanization, driven by waves of immigrants and a growing population, has caused critical conditions nationwide (Abdeljawad and Nagy 2021). Some researchers blamed glaciation, fires, floods, hurricanes, and volcanic eruptions for habitat loss and fragmentation (Collinge 1996). Others (Al-Kofahi et al. 2018) have discussed how population growth affects natural habitats. Many researchers discussed ways to reduce habitat loss and fragmentation, such as regulating urban expansion. Much research in Jordan has focused on land degradation solutions, but "insufficient knowledge of the socio-economic contexts, incorrect identification of the causes of arid land problems, and ineffective management of natural resources" (Al Karadsheh, Akroush, and Mazahreh 2013) prevents effective strategies and technologies from being implemented. Thus, Jordanian decision-makers' habitat fragmentation and loss strategies are unknown.

Green corridors are another option. Green corridors reduce habitat loss and fragmentation. Jordan has only one study (Al Masri, Özden, and Kara 2019). Green corridor criteria were summarized, but habitat fragmentation and loss were not investigated. Urban observation, not aerial photos, was used to prove habitat fragmentation and loss. Thus, decision-makers' experiences define habitat fragmentation and loss, filling a gap in the literature. Green corridors could link these habitats. Jordanian organizations are addressing land degradation through policy interventions. In limited research, green corridors may reduce habitat fragmentation (Gharaibeh 2010, Gharaibeh and Sawalqah 2016, Gharaibeh et al. 2019, Al Masri, Özden, and Kara 2019). Gharaibeh's research stressed the importance of greenways for urban revitalization and pedestrian safety. Green corridors were also stressed for urban

character preservation. Al Masri, Özden, and Kara (2019) suggested green corridors to reduce habitat fragmentation and connect fragmented patches. Urban observations showed habitat fragmentation and loss in Ajloun Forest Reserve, Dibben Forest Reserve, Zay Forest, and Al-Hummar Forest.

Study area

The North-Western Jordanian county of Bani-Kinanah was chosen for this study. Bani-Kinanah County is one of nine Irbid Governorate departments. The county has 149,190 residents and 252 square kilometres, according to the Department of Statistics (2020). Sama Al-Rousan is the county seat (Department of Statistics 2020). Bani-Kinanah County is known for its fertile agricultural lands and diverse farming activities. The county's moderate climate boosts agricultural productivity and contributes to this research. Bani-Kinanah County's ecological sites make it an ideal case study. These ecological sites include springs, streams, valleys, lakes, dams, and beautiful natural parks. These sites are beautiful and support unique ecosystems, increasing the county's ecological diversity (Department of Statistics 2020).

The authors overlap aerial photographs from the past two decades to show habitat fragmentation and loss in Bani-Kinanah County. In 2005, Google Maps took an aerial photo of Kufr-Soum, a county village. The 2005 map shows urban and agricultural areas. Figure 1 shows the area 16 years later. The map shows that the built-up area has expanded into agricultural land. New road construction divided the large agricultural patch into smaller patches. This suggests that urbanization and road construction have fragmented Bani-Kinanah's habitat. To understand habitat loss and fragmentation's causes, more research is needed.

Figure 1: Kufr-Soum 2005 and 2021. *Source: Google maps*

Methodology

This study examines how urban growth, decision-makers, and stakeholders affect green corridor and green space habitat loss and gain. Thus, it assessed conditions and attitudes toward natural habitat preservation and loss using several methods.

Aerial photographs from the past 20 years are used to assess temporal changes. Each aerial photo will have green valleys, urban areas, agriculture lands, and green spaces. Polygons will define green spaces, valleys, and agricultural land. Urban areas and roads will form a second layer with polygon tool parameters. The maps will be combined to calculate green and urban territory addition and subtraction. Given this, only two maps are needed: one for current conditions and one for the earliest aerial to document change. GIS digitization of elapsed aerial photographs will assess spatial fragmentation. The assessment usually compares

maps and aerial photos using GIS maps. After documenting losses/gains, human factors like urban or agricultural expansion can be investigated. Many factors cause habitat losses/gains. Some are due to planning regulations and others to local citizen practices. Thus, this study will poll decision-makers and locals. Interviews provide detailed answers to identify the causes of habitat fragmentation, the decision-makers' awareness of habitat loss, and the challenges they face in addressing it.

Qualitative snowball sampling was used to select interviewees. When finding specialized interviewees is difficult, use the snowball technique. The authors interviewed a UNDP expert, who suggested the other interviewees, using the snowball sampling technique.

Qualitative research stops when data saturation occurs. Five people are interviewed to advise on local practices and policies affecting habitat loss and fragmentation. Municipal planners, Ministry of Environment, UNDP, and natural reserves make decisions.

Decision-makers are asked to assess the reasons for habitat loss, the challenges of preserving these habitats, the policies or strategies they use to legitimize land seize for urban purposes, and their expected respect and value of such habitats. Green infrastructures reduce habitat loss and discontinuity, and green corridors and areas connect Bani-Kinanah's fragmented green cover. This step defines government and stakeholder green corridor implementation barriers. The authors interviewed local residents and farmers to assess their awareness of habitat fragmentation and loss to support the idea that decision-makers should define the role of community in reducing its impact.

Finally, the authors summarized the main variables considered in suitability analysis for green corridors from previous studies and presented them to the interviewees to evaluate, rearrange, and score. It is expected to define factors that affect Bani-Kinanah County green corridor suitability analysis and explore barriers to green corridor connectivity.

Results

In the first step, top view maps of some areas in Bani-Kinanah County were created using aerial photographs and GIS tools to show habitat fragmentation that occurred over the last decade. These areas were chosen because they demonstrate the fragmentation that occurred between 2005 and 2021. Al-Sero, Sama Al-Rousan, and Aqraba villages were specifically chosen because they demonstrated the growth of built-up areas and streets towards natural lands. In addition, an example of new street constructions in natural valleys (natural corridors) in Kufr Soom village was chosen. The figures below (Figure 2) depict the changes in agricultural lands, roads, and built-up areas (footprints) in AL-Sero over the last two decades. The data show that built-up areas are shifting away from agricultural lands between 2005 and 2021. In particular, built-up areas increased by 30,795 square meters over a 16-year period, resulting in a decrease in agricultural lands. While new road construction increased from 8741 meters in 2005 to 11817 meters in 2021.

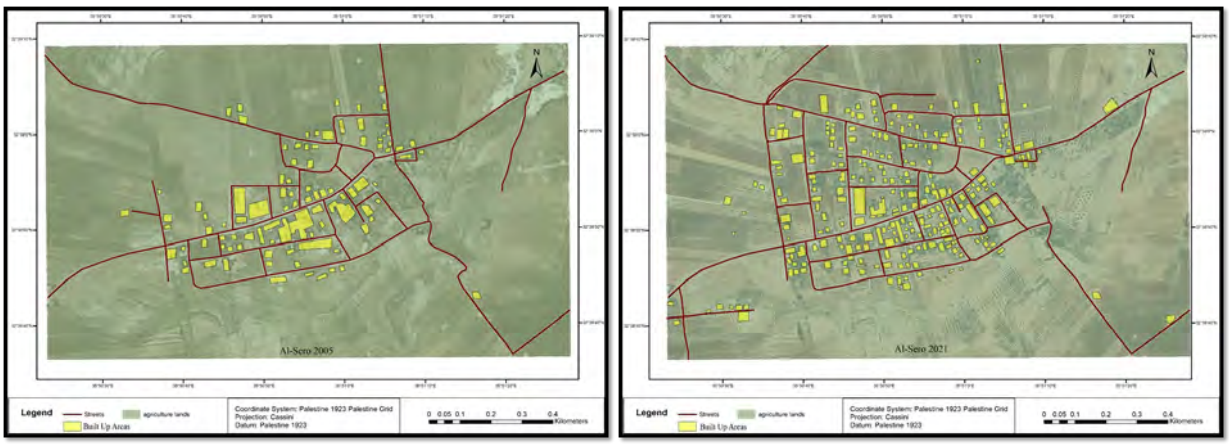

Figure 2: AL-Sero 2005, 2021. *Source: Google maps/ Edited by: Authors*

Aqraba village, on the other hand, undergoes a transformation in built-up areas and road construction between 2005 and 2021. In 2005, as shown in figure 5, the built-up area was 84616 square meters, the length of the roads was 6796 meters, and the agricultural lands area was 1516140 square meters. In 2021, the built-up areas increased to 111087 square meters, the length of the roads increased to 8575 meters, and the agricultural land area decreased to 1489669 square meters, as shown in figure 3.

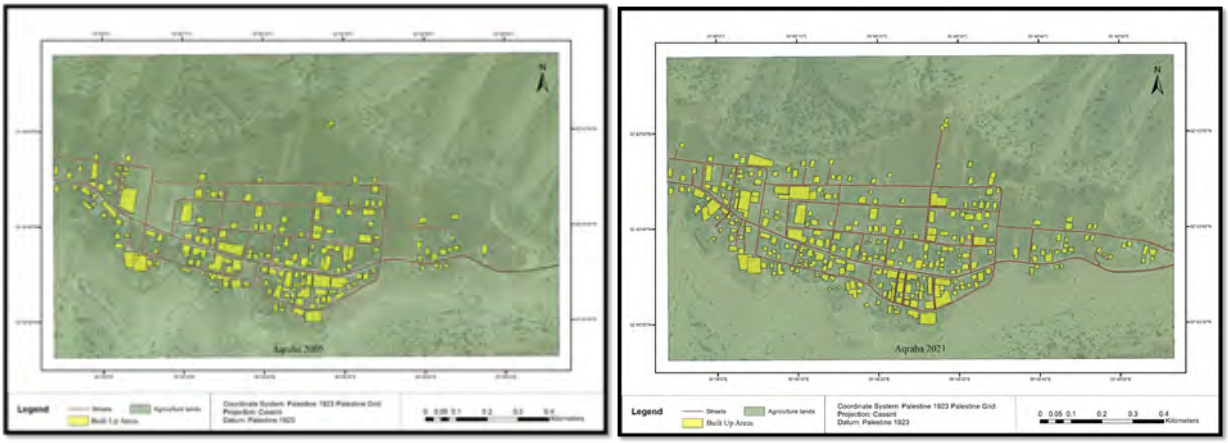

Figure 3: Aqraba 2005, 2021. Source: Google maps/ Edited by: Authors

Kufr-Soum village (Figure 4) depicts the changes in green corridors, agricultural lands, roads, and built-up areas (footprints) in Kufr-Soum over the last two decades. The data show that built-up areas are shifting away from agricultural lands and green corridors between 2005 and 2021. In particular, built-up areas increased by 37,080 square meters over a 16-year period, resulting in a decrease in agricultural lands. While road construction increased from 16110 meters in 2005 to 20747 meters in 2021. Figure 4 shows that the natural green corridor was exposed to street construction, which is considered evidence of habitat fragmentation and loss.

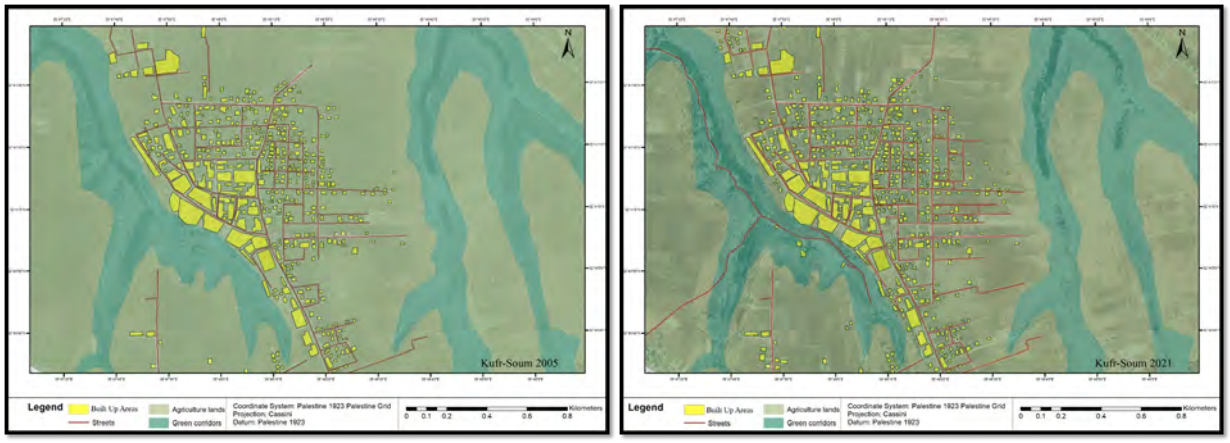

Figure 4: Kufr-Soum, 2005 to 2021. Source: Google maps/Edited by: Authors

Finally, as shown in Figure 5, the agricultural land area in Sama AL-Rousan village decreased from 2771248 square meters in 2005 to 2676141 square meters in 2021. This is due to an increase in built-up areas from 63884 square meters in 2005 to 158991 square meters in 2021, as well as the construction of new roads from 15159 meters in 2005 to 25480 meters in 2021.

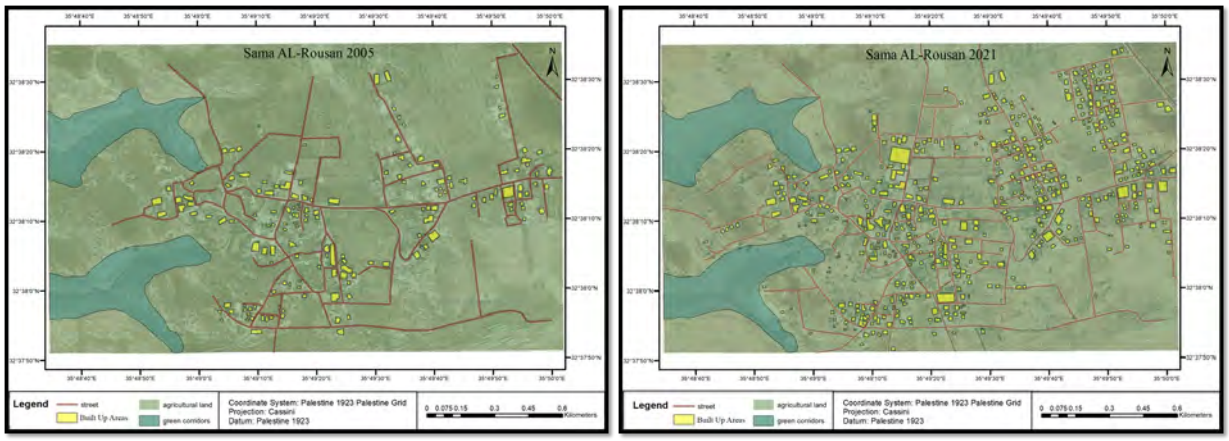

Figure 5: Sama Al-Rousan, 2005 to 2021. *Source: Google maps/Edited by: Authors*

Second, the authors conducted interviews with decision-makers in Bani-Kinanah to determine the causes of habitat fragmentation. The findings revealed that habitat fragmentation in Bani-Kinanah was caused by a decline in agricultural activities, unplanned agricultural activities, logging activities, a lack of environmental laws and regulations, a lack of awareness among residents about the importance of natural environments, climate change, global warming, and desertification.

Furthermore, decision-makers defined the effects of habitat fragmentation and loss. The decision-makers stated that habitat loss and fragmentation caused by urban expansion causes air pollution and increases CO2 emissions, negatively impacting the lives of wildlife. Habitat loss and fragmentation also have a negative impact on natural environments, resulting in a decline in biodiversity values and land degradation. Similarly, urbanization has an impact on the lives of wildlife by disrupting their communities and habitats. Building roads, for example, causes land fragmentation, endangering the lives of wildlife living in these habitats.

Policy and Strategy Development: Decision-Makers

After that, decision-makers were asked about their habitat loss and fragmentation mitigation policies. Decision-makers restrict urban expansion into forests, reserves, and natural areas to prevent habitat loss and human intervention. The climate action plan, green growth plan, and resilience strategy all aim to increase the number of green buildings in Amman, reduce climate change, use new technologies to reduce CO2 emissions, preserve natural areas, increase walkability, and incentivize green buildings and green areas.

Policymakers tried many methods to mitigate habitat loss and fragmentation, but they faced many obstacles. First, funding limits their ability to develop new habitat loss and fragmentation technologies. Municipalities, institutions, and environmental organizations also lacked habitat loss and fragmentation experts. Acquisition costs made private land ownership difficult. Limited institutional collaboration hinders habitat loss and fragmentation projects. Current policies and institutional discord can harm natural areas. For example, if an investment project is proposed in a forest, construction is not permitted under the Forestry Law, but under the Land Regulation Law, the project is presented to the Supreme Organizing Council and a general environmental study is required, confirming that. Because natural environments are not a top priority in all institutions, some condone laws and make exceptions for some citizens in exchange for fine payments, resulting in habitat loss and fragmentation. Finally, community awareness of natural areas and awareness workshops were issues for decision-makers.

Reducing Habitat Loss and Fragmentation

Interviews showed that buffering zones prevent urban sprawl into natural areas, but Bani-Kinanah County does not use them. The Yarmouk natural reserve in Bani-Kinanah County, which protects

wildlife, can also mitigate habitat loss and fragmentation. Jordanian municipalities also create new regulations to protect natural areas and agricultural lands and increase green spaces, open spaces, and parks to protect wildlife and natural heritage.

No decision-makers mentioned green infrastructure in their physical interventions to address habitat loss and fragmentation. They were familiar with green infrastructure and agreed that it can help mitigate habitat damage, but not alone. Green infrastructure, effective policies and regulations, strong institutional collaborations, and community participation and awareness can reduce habitat fragmentation and loss.

This study found green corridors effective, but Bani-Kinanah County decision-makers identified several obstacles to their implementation. First, Jordan's narrow roads were difficult. Due to poor public transportation, more people drove. Another barrier to county green corridors was expansion control. Illegal expansions into agricultural and natural areas exacerbated habitat loss and fragmentation. Green corridors require land acquisition, but private land ownership was the biggest obstacle. The steep slopes of Bani-Kinanah County made creating animal walkable corridors difficult. Without public-private cooperation, green corridors cannot be created.

The decision makers agreed that residents focused on their priorities, selling their land at high prices without regard for wildlife, unaware of habitat fragmentation and loss and its effects on natural areas. Policies also encourage land sales and investment. Workshops raise community awareness. Social media, schools, and community involvement can raise habitat awareness. As in Jordan, community-based protected areas gave local communities ownership and responsibility for wildlife habitat. To raise awareness, the Yarmouk natural reserve employs county residents.

Finally, regular community workshops can help. Bani-Kinanah County green corridor factors were identified. Slope, distance to streets, distance to water, land cover, land ownership factor, land ownership, and land use were these factors.

Discussion

This study demonstrated that the Bani-Kinanah County had experienced habitat loss and fragmentation by comparing aerial photographs of some towns in Bani-Kinanah from the previous decade to current aerial photographs of the same towns. The aerial photographs revealed the county's two main causes of habitat fragmentation and loss. The maps revealed that urban expansion is the primary cause of habitat fragmentation (Figure 6). Specifically, the maps revealed that the increase in built-up areas in some towns caused encroachments on natural lands and habitats, as well as the construction of roads, which resulted in the division of these habitats into smaller patches. These causes are similar to those described in the literature. This study validated the findings of the first step by conducting in-depth interviews with decision-makers to identify the causes of habitat loss and fragmentation. The decision-makers mentioned both physical and non-physical causes, which supports previous research (Collinge 1996, Mullu 2016).

Policies and regulations were mentioned as effective tools to reduce habitat fragmentation and loss in some previous literature (Lewis, Plantinga, and Wu 2009) and as a cause that shapes the landscape and causes habitat fragmentation and loss in other studies (Jongman 2002). As stated by decision-makers in the previous chapter, policies and regulations are the primary cause of habitat loss and fragmentation in Jordan in general, and in Bani-Kinanah in particular. Because Bani-Kinanah's policies and regulations allow residents and landowners to build new structures without considering the effects on wildlife habitats. This supports the findings of Jongman's study (Jongman 2002). However, in the literature, little attention is paid to lack of awareness as a cause of habitat loss and fragmentation. According to decision-makers, if residents or landowners are unaware of the natural value of their lands in Bani-Kinanah, habitat loss and fragmentation will worsen,

because landowners will either sell their lands to investors or keep them for the next generation to build their own houses in the town, resulting in urban expansion.

According to the findings of the interviews, urbanization as a physical cause of habitat fragmentation was caused primarily by a lack of policies, regulations, and community awareness (Figure 7). Urbanization also causes habitat fragmentation and loss through a variety of activities. These activities include unplanned agricultural activities, logging, desertification, road construction, and new building construction. Unlike the findings of this study, previous research has identified human activity as the primary cause of habitat fragmentation and loss (Fahrig 2003, Mullu 2016).

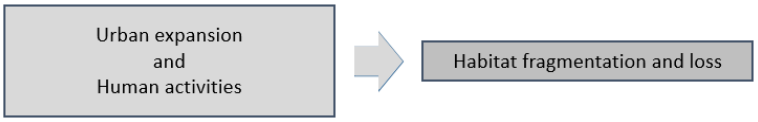

Figure 6: The main cause of habitat fragmentation and loss depending on the literature

Figure 7: The main cause of habitat fragmentation and loss depending on the results of the interviews with the decision-makers

According to the findings of this study, urbanization causes air pollution and increases CO2 emissions, both of which have an impact on the lives of wildlife. Air, noise, and vision pollution may be caused by urbanization. Similarly, it is discussed in the literature that habitat fragmentation and loss cause large patches of natural areas to be broken up, resulting in a decrease in the habitats available for wild species and, as a result, the extinction of these species. Furthermore, fragmentation and loss may result in the formation of edges, which act as unsafe habitats for species. Furthermore, habitat fragmentation and loss isolate habitats, limiting species mobility (Mullu 2016). In summary, habitat fragmentation and loss have direct and indirect effects on wildlife lives, as illustrated in figure (8) below.

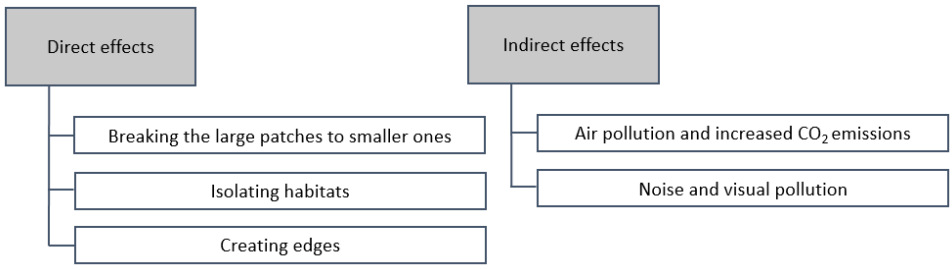

Figure 8: The direct and indirect effects of habitat loss and fragmentation /*Source: Authors*

Decision-makers use the climate action plan, green growth plan, and resilience strategy to control urban expansion into forests, reserves, and natural areas to prevent habitat loss. However, incentive-based conservation policies have been studied (Plantinga and Ahn 2002, Lewis, Plantinga, and Wu 2009). Private landowners are targeted to increase natural, reserve, and forest areas. This policy specifically subsidizes landowners who plant forests (Plantinga and Ahn 2002). This policy does not account for spatial variation in expected benefits, but it reduces habitat loss and fragmentation (Lewis, Plantinga, and Wu 2009). Decision-makers

also recommend prioritizing policies and regulations to reduce habitat fragmentation and loss, but there are few effective natural policies and regulations. Thus, current regulations and policies cannot solve this issue. The decision-makers also mentioned buffering zones (Meffe and Carroll 1997; Martino 2001), natural reserves, green open spaces, the protection of agricultural lands, and the creation of green corridors as physical methods to reduce habitat fragmentation and loss. Green corridors can facilitate species migration and movement between patches (Meffe and Carroll 1997) and affect species diversity (Meffe and Carroll 1997; Martino 2001). In interviews, decision-makers did not mention green corridors, which many literatures recommend for habitat fragmentation and loss.

The community and farmers in Bani-Kinanah's awareness of their lands and habitats is crucial because urbanization's negative effects on wildlife increase without it. Depending on the results, Bani-Kinanah landowners are generally unaware of habitat loss and fragmentation, even though they refuse to sell their land for land investments. They keep their land for future generations to build new houses, which means more urban expansion. Thus, effective policies and regulations, physical methods like green corridors, and community awareness and participation must be combined to solve habitat fragmentation and loss.

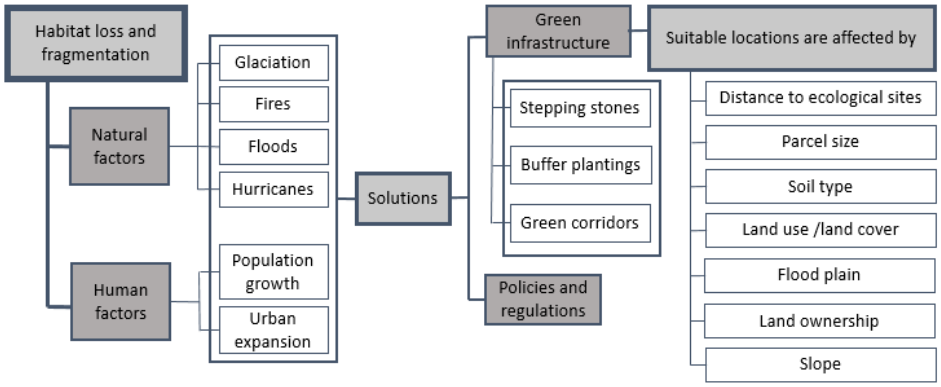

Figure 9: Habitat fragmentation and loss framework depending on the literature

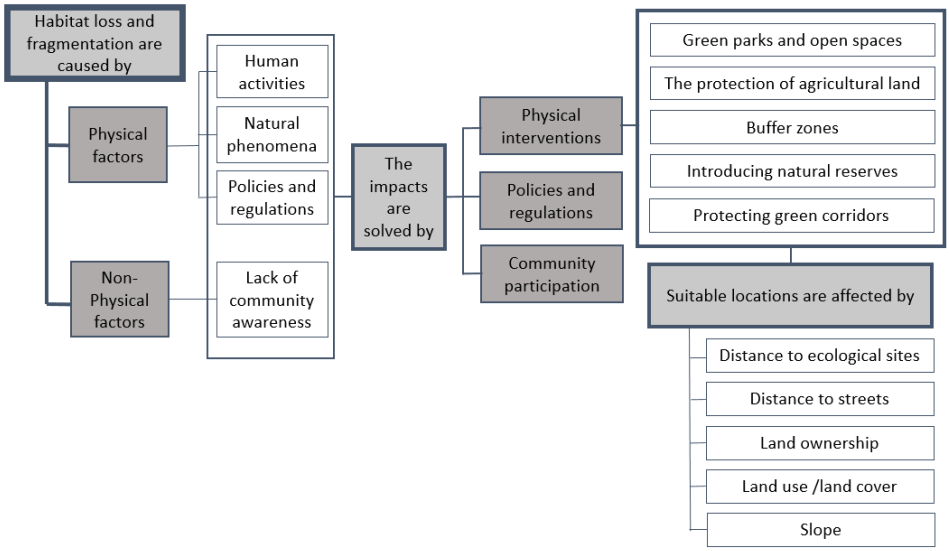

Figure 10: Habitat fragmentation and loss framework depending on the results of this study

The figures (9 and 10) above show the difference between information gathered from the literature review and information gathered in this study. The new framework can serve as a starting point for reducing habitat fragmentation and loss. It demonstrates how to use the

proper physical methods, policies, and community participation strategies to reduce habitat fragmentation and loss. It also illustrates the factors that should be considered when implementing green corridors to connect fragmented natural habitats using ArcGIS suitability analysis.

Conclusion

This study defined habitat fragmentation and loss in Bani-Kinanah County, Irbid, Jordan, identified key causes, evaluated how county decision-makers address these issues and the challenges they face. It also assessed community habitat and wildlife awareness. Additionally, green corridors were explored to mitigate habitat fragmentation and loss. This involved using aerial photographs from the past two decades and GIS to track changes in the study area. Interviews with decision-makers and local residents provided insights into reasons for habitat loss, preservation challenges, urban land acquisition policies, and their expected respect and value of these habitats.

Green corridors can solve habitat loss and fragmentation, but Bani-Kinanah County faces challenges in implementing them. After reviewing literature and interviewing decision-makers, the study presented the factors that may affect green corridor locations in the county. This research is the first to discuss habitat loss and fragmentation, not land degradation, in Jordan, Irbid, Bani-Kinanah. It also adds to urban planning literature by identifying factors to consider when implementing green corridors to mitigate habitat loss and fragmentation in Bani-Kinanah. Although important for urban planning and ecology, this research has many limitations. Many Bani-Kinanah municipal decision-makers didn't help answer the interview because they didn't understand habitat loss and fragmentation. The authors had trouble finding authorities on habitat loss and fragmentation because decision-makers in different associations did not cooperate. They also had to make their own maps since digital ecological maps and information were scarce.

This study suggests workshops should help decision-makers raise community awareness of habitat loss and fragmentation. Natural habitat associations should prioritize community involvement.

- Jordanian natural habitat associations should digitize land covers for research base maps.
- Experienced natural habitat decision-makers should prioritize physical interventions, especially green corridors, to reduce habitat fragmentation.

This research paves the way for future Bani-Kinanah ecological and urban planning studies, which could include the defined factors affecting green corridor locations.

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