Developing an Urban Framework to Rehabilitate the Russeifa Watercourse as a Blue-Green Corridor in Jordan

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Abstract— Watercourses are one of the most vital elements in cities, which are essentially the core of city formation. Over time, with increased urbanization and industrialization, many watercourses faced difficulties in preserving their natural form, resulting in the loss of many of their characteristics. This transformation has led to a clear degradation of ecosystems and increased pollution and health risks. Many countries tend to undertake projects to rehabilitate watercourses that have degraded, aiming to achieve environmental, as well as socio-economic benefits. Russeifa city is one of the most densely populated cities in Jordan and the Arab world. The watercourse passing through it is also a source of pollution that poses risks to the city and its residents. However, the study aims to present a suggested plan to rehabilitate the watercourse as a blue-green corridor to enhance the water and greenery in the city. Thus, the study relied on previous studies, in addition to interviews with officials and residents, to understand their connection to the river and the problems they suffer from. It turned out that the watercourse is currently used only as a landfill. Furthermore, the study relies on a study of successful case studies to extract suitable mechanisms that fit the Russeifa watercourse rehabilitation. In the end, the study shows that it is necessary to set logical and achievable goals for adopting the rehabilitation strategy. In addition to activating the role of citizens in development and rehabilitation projects, they are an essential element in the long-term success. Moreover, this study contributes by proposing an urban framework for transforming degraded watercourses into blue-green corridors, offering both theoretical insights and practical guidelines applicable to similar urban contexts in Jordan and beyond.

Keywords— Blue-Green Corridor; Blue-Green Infrastructure; Watercourse Rehabilitation, Sustainable Development; Urban Ecology; Flood Risk

I. Introduction

Water features are important elements in cities as a result of the possibility of their use in many economic and environmental development projects. One of the key projects concerned with water elements is the rehabilitation of watercourses [1]. As watercourses are the basis around which the cities were formed, with the aim of obtaining water, irrigation of land, transportation, and other uses [2]. However, with the industrial renaissance witnessed by the countries, most attention has turned to industries and the economic aspects, which have generated problems in environmental elements, including watercourses. Currently, some of these watercourses are known as "dead" or "neglected" elements in the city, as they create an area of unexploited lands [3]. Moreover, watercourses became a source of pollution and danger to the city. These transformations in watercourses drew many environmental and sustainability agencies to pay attention to rehabilitating these watercourses and recovering their lost environmental value [4]. One of these trends that has increased in popularity recently is the provision of blue-green corridors. These corridors aim to restore water to normal as well as habitats on the watercourse riparian to achieve environmental benefits, as well as social and economic benefits represented by providing spaces for gathering, interaction, and recreation [5]. Jordan has three rivers, including the Russeifa watercourse, a major source of pollution and environmental hazards in the cities it crosses. This study examines its current conditions in Russeifa—the most densely populated area and most affected—while proposing rehabilitation mechanisms to convert it into a blue-green corridor. The study comprises five sections: literature on rehabilitation and blue-green corridors, study area, research problem, methodology, results and findings, and discussion with conclusions.

II. Literature Review

Watercourses are considered vital and valuable natural resources, whether for the landholders, the wider community, or even the environment. According to [3], watercourses often play a significant role in shaping cities and people's lives while contributing to biodiversity and food security. Furthermore, watercourses provide habitat for the aquatic and terrestrial species, such as plants and animals. Historically, cities have been constructed close to watercourses in order to achieve water accessibility, provide a navigational route, and dispose of sewage [4]. Most watercourses—especially river corridors—not only have many important ecological roles, but also have important socio-economic and cultural values [6]. [7] illustrated that many watercourses have been affected by the construction of dams and channels, besides the erosion and water extraction, which led to the loss of habitats. She also mentioned that some watercourses are still in excellent condition, supporting ecosystems such as the ecological community of fauna and flora. However, many watercourses are currently suffering from degradation and in need of active management to rehabilitate them.

A. Challenges facing watercourses

a. Threats to sustainable ecosystems and the environment.

According to the statistics, by the early 20th century, almost no complete natural river existed anymore in the world [8]. They were converted over time into urbanized and industrialized areas, creating many threats to the natural environment [1]. Freshwater systems now challenge sustainable ecosystems, drawing attention from developers, scientists, and professionals. Leading international organizations, such as the UN and IPCC, highlight that river flooding, driven by rapid urbanization and rising water demand, contributes to climate change. Increasing population

density further strains ecosystems and the environment [1]. [8] argued that urban areas of high and increasing population density are vulnerable to climate change consequences, mostly in densely urban watercourse spaces. Thus, watercourse development strategies are being promoted globally in order to ensure sustainable environmental management and flood prevention.

B. Watercourses and urbanization.

Global urbanization shows the need to improve our relationship with nature since nature and the city were known to be conflicting fields, especially in the industrial era. It is obviously noticed through the increased carbon emissions [9]. On the other hand, urbanization and industrialization activities affected urban forms, creating a need for transportation networks, transferring from water to railways and roads, and that led to major changes in the function and structure of rivers. The majority of urban river boundaries were replaced by new infrastructure, and many river canals have been built up and fully separated from their waterfronts; not only did these changes harm the ecological structure, but also isolated rivers from their urban context physically and spiritually [2]. [10] claimed that urbanization and urban development are causing significant changes to the runoff, volume, and quality of flood streams. According to [4], Urbanization increases hard surfaces like roads and pavements, reducing natural areas and preventing water infiltration. This causes watercourses to experience higher flows than normal, leading to erosion, habitat degradation, pollution, and damage to infrastructure, while droughts reduce flow, harming local flora and fauna and drying up channels.

a. Watercourse negligence.

Watercourse negligence can be one of the major reasons resulting in the creation of what is called “dead rivers” or “forgotten rivers”, which is one of the main problems in third-world countries, in particular. Neglected watercourses became sources of disease and pollution, resulting in several negative sequences, such as fractured ecosystems, faded biodiversity, and affecting the healthy environment and degrading the aesthetic values of cities [11].

C. Watercourses and land use.

According to [10], land uses have a significant impact on the quality of watercourses as they are affected by the activities and residuals of these lands. Moreover, it is necessary to assess and quantify the relative impact of various types of land use on water quality. In order to give a historical perspective of land-use change, an assessment of spatial patterns, correlations, trends, and impacts of such change must be studied. Thus, the urban dynamics projects are concerned about land-use changes in the urban environment [12]. Changes in land use are a result of complex interactions involving political, bureaucratic, economic, social, human, and environmental interactions. The industrial and agricultural land uses are heavily related to water pollutant concentrations, whereas the continuous depletion of water resources is driven by the growing population, construction demands, lack of land use planning, and the strong competition for water resources. One of the key sources of pollution is rainfall, which carries sediment, nutrients, and chemical substances coming from the agricultural lands that occupy the larger part of the landscape. Urban areas are changing rapidly, which are often left uncontrolled by local and global forces [10].

D. Concepts Related to Watercourses Treatment

The literature presents many methods for sustaining and replenishing watercourses. According to [1], there are two main methods, as follows:

a. Watercourse restoration.

The restoration seeks to return a degraded ecosystem to its previous, totally recovered situation, which is difficult to achieve.

b. Watercourse rehabilitation.

The rehabilitation refers to a similar return toward natural conditions, but where some elements of the original ecosystem are not fully recovered. However, these methods include watercourse enhancement, improvement, mitigation, and creation of habitats. According to [4], urban watercourse rehabilitation has the potential to provide a number of benefits, such as improving water quality, reducing flood risk, enhancing ecological function, and enriching recreation and social value.

E. Relationship between watercourse rehabilitation and urban regeneration

According to [13], many cities are now focusing on revitalizing their watercourses, recognizing the social, economic, and environmental benefits of healthy ecosystems. In industrialized countries, watercourse rehabilitation projects have expanded rapidly since the late 1980s to improve degraded habitats and ecological health. However, despite significant investment, river restoration often shows limited efficiency, as full ecosystem preservation is rarely achievable. Consequently, watercourse rehabilitation is a more practical approach, often integrated into broader urban regeneration or renewal projects involving water elements. Urban regeneration programs are meant to study the interaction between the city's inner elements by improving the waterfront areas spatially and socially, taking into consideration the water pollution, watercourses sedimentation, and public spaces quality [11].

According to [1], the governments, particularly in developed countries, are challenged to recover watercourses, while it was found that large-scale recovery projects often have much better results than small-scale projects. Even though major efforts require a great deal of time to reach set targets. Without enough data on river rehabilitation and restoration, successful approaches cannot be created.

F. Stages of the watercourse rehabilitation process

According to [4], urban watercourse rehabilitation can be achieved in six stages. Firstly, identifying specific threats and rehabilitation needs requires looking at the whole watershed to determine the largest threats faced by the watercourse—external threats—. Secondly, identifying project goals, whether socio-economic goals, including aesthetics and recreation, or ecological goals, such as reducing pollution and improving habitats. Thirdly, selecting appropriate rehabilitation techniques where different techniques are appropriate to achieve different goals. Fourthly, project prioritization. At this stage, the planning process should be done at the watershed scale by identifying the most important sources of watercourse degradation and the best opportunities for rehabilitation, as explained in stages 1-4. Fifthly, design and implementation to meet project goals.

Sixthly, monitoring and evaluation, where watercourse rehabilitation is an ongoing process, constantly changing, which requires monitoring before, during, and after project implementation.

G. Watercourse rehabilitation goals

According to [1], the implemented rehabilitation projects have varied regarding the aspects covered in the rehabilitation process. These aspects include water aspect to achieve standard water quality, through removing sources of pollution and altering land use within catchment; instream habitats aspect to save fisheries, plants, and rare species, through cleaning up pollutant sources and returning natural productivity; flood mitigation aspect to protect property and lives, through increasing pool volume and reconnecting them to floodplains; riparian zone aspect to maintain natural course of a watercourse and stabilize banks; through revegetation in addition to maintaining urban riparian zones; aesthetics aspect to facilitate recreational facilities through restoring natural flow and channel shape, and manipulating sediment and vegetation.

H. Watercourse rehabilitation axes

[8] mentioned that the significance of the rehabilitation success is project-dependent; it suggests realistic goals for the rehabilitation process, proposes effective rehabilitation methods, and projects the expected rehabilitation results ahead. Realistic goals and expected rehabilitation results must rely on three axes. The first is that investors' performance should reflect human satisfaction with the results of rehabilitation, such as aesthetics, economic benefits, and recreation. The second is Ecological performance, which must ensure that the necessary functions of the ecosystem have been achieved, such as environmental change. The third is learning success, representing an advancement in science and management practices that supports future projects, including scientific contributions, management experience, and enhanced techniques.

I. Examples of implemented watercourse rehabilitation projects

- At the present time, watercourse rehabilitation has become widespread. The USA is one of the leading countries that rehabilitated its watercourses, such as the Missouri, Kissimmee, Chesapeake, Boston Bay, etc. [3]. [4] mentioned other small rehabilitation projects such as:
- Rahway River, New Jersey: Suffering from frequent flooding, it was rehabilitated through collaboration between the local government, the Wetlands Mitigation Council, and other organizations. Measures included lowering the floodplain, constructing wetlands and stormwater ponds, and planting diverse grasses, plants, and trees, providing flood mitigation, improved wildlife habitat, better water quality, and community amenities.
- Strawberry Creek, Berkeley, California: Faced poor water quality and erosion due to inadequate stormwater controls. Rehabilitation involved stabilizing streambanks with logs, vegetation, and natural engineering techniques, improving water quality and habitat.
- Boone Creek, North Carolina: Highlighted the challenge of aligning project objectives with reality, aiming to restore the creek to its original ecosystem but facing practical limitations.

Similarly, sustainable watercourse rehabilitation projects were implemented in Europe, such as in the Mersey River in the United Kingdom, the Rotterdam River in the Netherlands, the Prda River in Poland, and the Tirana River in Albania [3]. Although there are many examples that have been executed in developed countries, watercourse rehabilitation is still a huge challenge for the governments of developing countries.

J. Funding and support agencies

[4] have found that most watercourse rehabilitation projects in the USA, along with Europe, river rehabilitation projects are supported by financially and technically well-off organizations like The World Wildlife Fund (WWF), The International Union for Conservation of Nature (IUCN), The Nature Conservancy (TNC), The Up-scaling Basic Sanitation for the Urban Poor (UBSUP), The Water Sector Trust Fund (WSTF), The Clean Water Fund (CWF), etc. On the other hand, in Japan, such initiatives are mainly launched by small Non-Governmental Organizations (NGOs). However, NGOs can promote large projects by connecting residents with the concerned authorities, even if they are suffering from technical and financial limitations. For example, the Kasumigaura lake rehabilitation project in Japan was initiated by an NGO named "Asaza Project". However, these examples in Japan can be considered as models for the developing countries since the NGOs are moderately small in size and few in number [1].

[4] explained that watercourse rehabilitation in urban areas is especially difficult because of the lack of available land, the complex causes of river degradation, and social, regulatory, and jurisdictional conflicts. They also claimed that it is important to recognize that rehabilitating short sections of watercourses cannot alone repair the damage from watershed-level impairments and may not be sufficient to address the large-scale problems affecting the watercourse corridor. In other words, looking at the entire watershed is essential to identifying the primary threats for a given watercourse.

K. Blue-Green Infrastructure

According to [14], the term Green and Blue Infrastructure (GBI) is used to refer to all strategies seeking to enhance urban resilience regarding climate change and improve the mitigation and adaptation capacity in cities. Furthermore, GBI can reduce soil erosion and provide stormwater runoff cleansing in order to increase water quality [15]. However, Blue-Green infrastructure, when they are well planned and designed, can help resolve urban and climate challenges by providing ecosystem services that enhance the welfare and prosperity of local populations [16]. Studies have shown a number of advantages that Blue-Green infrastructure could offer: Climate change mitigation and adaptation; Integration of sustainable movement for everyone; A distinctive landscape and townscape Promotion; Preservation and enhancement of the quality of ecosystems, water and air; Offer additional sport, recreation, quiet pleasure, and health opportunities; Conservation and enhancement of a quality investment environment through development and the provision of community participation and education opportunities [17].

a. Blue-Green corridor.

In the last decade, there has been a broad establishment of "Blue-Green" corridors in dense urban environments in order to enhance the existing habitats by connecting the fragmented ecosystems[18]. [19] have suggested the need for linking green areas with corridors, such as rivers and watercourses, to enhance the movement of the fauna through urban landscapes. Thus, A blue-green corridor is a sustainable development approach using a river and adjacent lands to create an integrated connection between natural habitats [20]. There is a very clear and important relationship between greening and water management, for example, healthy trees and plants are expected to increase and flourish by improving the soil humidity, while vegetated areas play a key role in absorbing the excess water [21].

b. Blue-Green corridors' components.

The blue-green corridors are known as interconnected and overlapped systems of green, blue, and gray water infrastructure [21]. This infrastructure includes Natural and semi-natural landscapes, including green spaces, forests, scrub, woodlands, wetlands, running and open water, and rocky areas; Green corridors including river banks, river corridors and canals; Outdoor spaces—whether natural or artificial—including sports facilities, parks and garden areas; and Green amenity spaces including recreational spaces [16]. Such systems can decrease pollution, enhance biodiversity, and provide cultural values.

c. Benefits of Blue-Green corridors.

There are multiple benefits for blue-green corridors, which can be divided into environmental benefits and socio-economic benefits, as follows:

I. Environmental benefits.

[5] mentioned that blue-green corridors are created in dense urban environments to enhance and improve existing habitats through the interconnection of fractured, isolated ecosystems. Moreover, they pointed out that blue-green corridors are considered an erosion control strategy for controlling and protecting from torrential watercourse floods, in addition to supporting biodiversity conservation, and mitigating climate change effects. Furthermore, blue-green corridors enhance wildlife habitat, reducing sewer overflows and linking the important ecosystems with each other [20].

II. Socio-economic benefits.

There are many positive impacts of blue-green corridors—besides the environmental benefits—including social and economic benefits. Blue-green corridors make a city more livable, where they are considered the foundation that connects open spaces, providing spaces for people to gather, play, and interact [21]. Moreover, Blue-Green corridors are considered an important economic approach in developing rivers such as the Chicago River system, which generates nearly 200 million dollars annually in the local economy, contributing more than 1,600 jobs each year, while also improving the water quality, mitigating floods, and increasing recreational opportunities [20].

L. Gaps in the literature

There are many studies concerned with assessing water quality in addition to identifying pollutants that contributed to the degradation of the Russeifa watercourse, on its macro scale. However, these studies have considered the whole watercourse and have not given enough attention to provide practical solutions that take into account the needs of every governorate and city that the watercourse passes through. Thus, this study seeks to:

- Bridge the gap by focusing on the watercourse passing through Russeifa city.
- clarifying the problems and pollutants that the watercourse suffers from in Russeifa city.
- Presenting a suggested plan for transforming the Russeifa watercourse into a blue-green corridor in order to gain its multiple benefits—mentioned earlier— to improve the environmental aspect of the watercourse as well as the social and recreational aspects that Jordan needs in general and Russeifa in particular.

III. STUDY AREA

Jordan has three river basins, which are the Jordan River, the Yarmouk River, and the Zarqa River. According to Russeifa's municipality, the Zarqa River is the third-largest river in Jordan and the second-largest tributary of the Jordan River. Zarqa River starts at Wadi Abdoun in Amman, where the main river feeder—Ras El-Ein spring—is located, then passes through Russeifa, Zarqa, Wadi Dhulail, and continues to King Talal Dam (KTD) in the Jordan Valley [22]. Jordan River passes through four governorates, which are Amman, Zarqa, Jerash, and Balqa, with a length of 70km [23] (Figure 1). The part of the Zarqa river which passes through Russeifa city—also known as the Russeifa watercourse—has a unique value to the population in the region. The Russeifa watercourse was an attractive center for many residents and immigrants coming to the country, whether Palestinians, Armenians, Circassians, or Chechens [24]. It had attractive natural characteristics, as it was considered a natural park for residents and a home for many environmental habitats, such as fisheries. Russeifa's municipality officials illustrated that the Russeifa watercourse is a popular destination for Zarqa and Amman residents for a family gathering, fishing, and swimming.

However, the Russeifa watercourse suffers from environmental degradation. [23] explained that watercourse flow has weakened due to the exaggeration of the underlying groundwater. [23] also illustrated that Waste Water Treatment Plants discharge their inefficiently treated effluent into the watercourse, which provides the watercourse with high organic pollution. Moreover, due to the urbanization of the region, the river and its natural features have been neglected, and attention has gone to industries and constructions, which transformed the watercourse from an attractive natural area to a source of pollution and a landfill. This has led to an obvious encroachment on the watercourse area, whether from the use of the lands or the use of its course. All these reasons that have been mentioned above make the Russeifa watercourse an interesting scope to be studied as a case of rehabilitating watercourses as blue-green corridors.

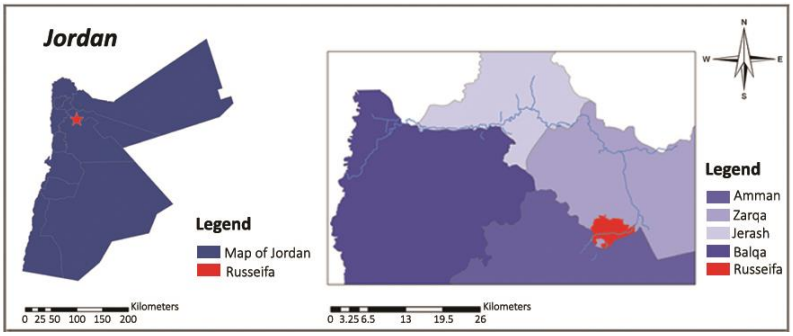

Figure 1: Maps of Jordan and Russeifa

IV. Problem Statement

According to [25], Jordan faces a severe water shortage, with per capita use among the lowest globally (150 m^3/year), creating intense competition for agriculture, industry, and households. Russeifa is a notable area along the Zarqa River, being the most densely populated in Jordan—about 23,500 inhabitants per km^2. The watercourse in Russeifa runs west to east, 8–10 meters wide and 8 km long, dividing the city into north and south. Historically, it was an attractive area with orchards, open spaces, and clean water, but it is now unused and heavily polluted.

This research aims to rehabilitate the Russeifa watercourse, reducing pollution and transforming it into a positive urban element, potentially extendable along the entire watercourse. Given its linear form, the study examines current conditions, identifies strengths and weaknesses, and proposes converting the corridor into a blue-green corridor, addressing environmental and socio-economic challenges while supporting the city's sustainable development.

V. Methodology

As the paper aims to explore the current condition of Russeifa's watercourse and to provide a suggested plan to rehabilitate it as a Blue-Green corridor, several questions were asked that help in achieving these aims, as follows:

- What is the current condition of Russeifa's watercourse?
  - What are the challenges facing the watercourse?
  - What are the strengths and the opportunities that existed in the Russeifa's watercourse?
  - What is the availability and existence of the Blue-Green Infrastructure in the Russeifa's watercourse?
- How can Russeifa's watercourse be rehabilitated to become a Blue-Green corridor?
  - What are the mechanisms used in other similar rehabilitation projects?
- What are the suitable mechanisms that can be adopted in rehabilitating Russeifa's watercourse?
  - What are the criteria to choose mechanisms that suit Russeifa city?

However, the study will be based on both qualitative and quantitative data to achieve its desired goals. Moreover, the study will rely on four stages to answer research questions (Figure 2). The first stage is a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis to clarify the current condition of Russeifa's watercourse. Data for the SWOT analysis will be gathered through three phases, as follows:

- Data obtained from previous studies, in addition to data gathered from the Russeifa municipality and the Jordanian Ministry of the Environment, were obtained from statistics and previous documents or from structured interviews with the officials.
- Field observation, including documenting Russeifa's watercourse with pictures, considering the Blue-Green infrastructure components derived from the literature review, such as natural and semi-natural landscapes, the green corridors, the outdoor spaces, and the green amenity spaces.
- Personal interview survey, also known as a face-to-face survey, with a total of 37 participants, comprising 3 municipal officials and 34 residents, to activate the participation of locals as well as officials in addressing the problems. Participants were selected purposively to ensure representation of both decision-makers and community members directly affected by the watercourse. The study will employ snowball sampling, starting with selected participants who refer others meeting the criteria. Interviews will focus on elderly residents over 70, who can provide insights into the watercourse's history and decline, and on youth to capture their perspectives and needs. Results will be presented through GIS-based diagrams and maps of the study area.

The second stage identifies rehabilitation mechanisms used in similar watercourse conditions through a case study approach, analyzing successful Blue-Green corridor projects to extract adaptable strategies.

The third stage selects the most suitable mechanisms for Russeifa based on criteria relevant to developing countries and local conditions, derived from literature and interviews, eliminating unsuitable options.

The fourth stage integrates the selected mechanisms into a proposed rehabilitation plan for Russeifa's watercourse, illustrated on GIS maps showing threats, potentials, and the desired vision.

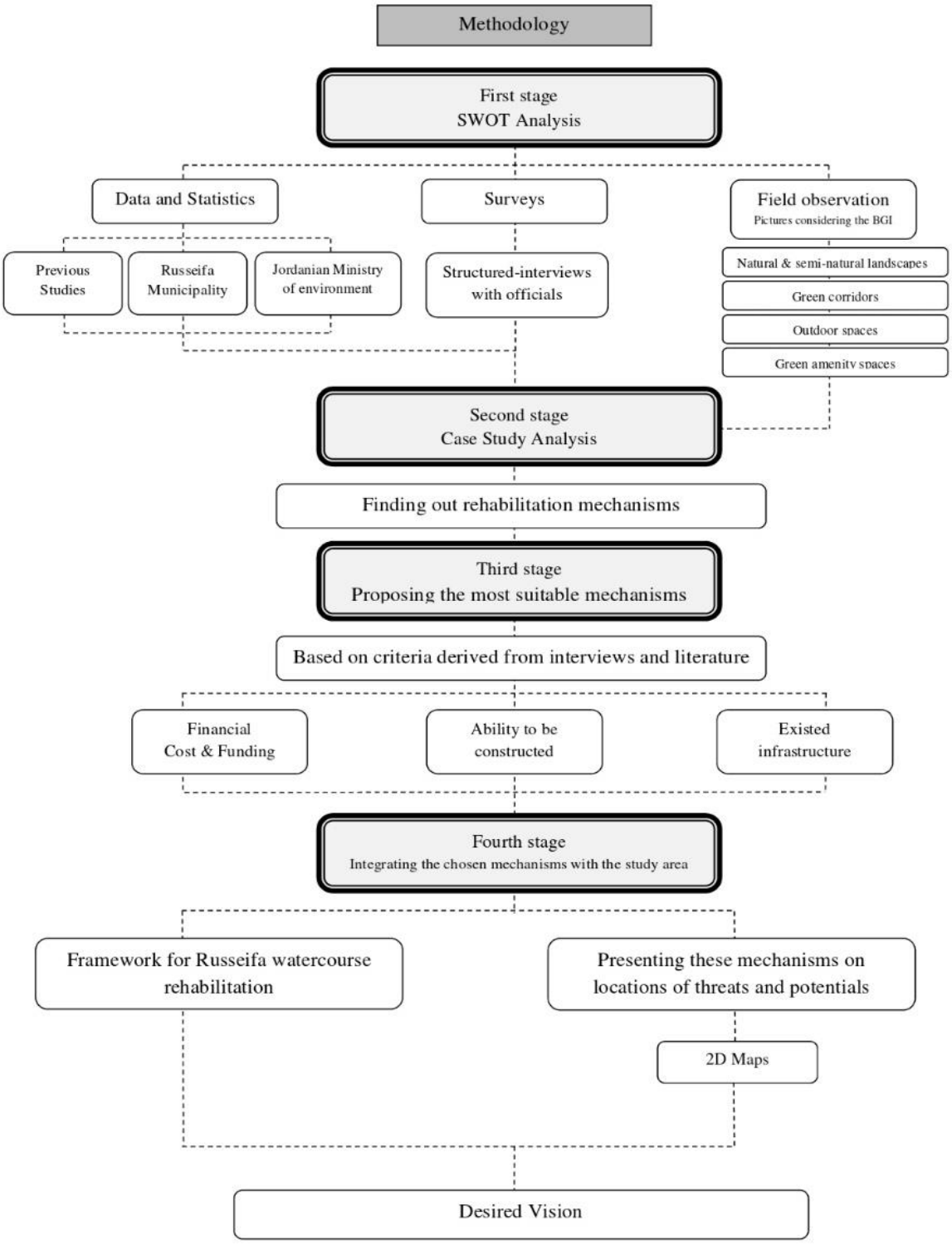

Figure 2: Methodology Chart

A. First Stage: SWOT Analysis

At this stage, the SWOT analysis was conducted to find out the current condition of the Russeifa watercourse and explore its strengths and weaknesses through three phases, as follows:

a. Data and statistics.

In this section, the study relied on previous studies and research—such as the study conducted by [23]—and documents obtained from the Russeifa municipality and Jordanian Ministry of Environment such as the rapid rural appraisal study (2009) which has been done by Jordanian Ministry of Environment in cooperation with the IUCN, Mercy Corps, and other organizations [25]. These data can be divided as follows:

i. Main pollutants are released to the whole watercourse.
The term "whole watercourse" refers to the watercourse in its full length, from Amman to the Jordan Valley. Its main pollutants include:

- **Solid waste and debris** from industries, households, masonry, and car workshops.
- **Organic pollution** from wastewater treatment plant (WWTP) effluents, Greater Amman Municipality (GAM) slaughterhouse overflows, sewer leaks and floods, and agricultural runoff.
- **Nutrients** primarily from WWTP effluents, floods, and agricultural runoff.
- **Heavy metals** (copper, zinc, nickel) from various human activities, including battery factories and industries such as marble, aluminum, tanning, textiles, petroleum, Pepsi, pulp, and detergent production.

ii. Pollution sources to the Russeifa watercourse.
Russeifa, one of the most densely populated cities in Jordan and the Arab world, faces significant pressure on its infrastructure and services. Although city lands are now fully regulated (Figure 3), land use around the watercourse has shifted from agricultural to residential and industrial, directly polluting the watercourse (Figure 4). Additional pollution sources include a distant abandoned landfill, industries such as Pepsi, marble, food, and fabric factories (Figure 5), car workshops, gasoline stations, urban and agricultural runoff, sewer leaks and overflows, farms along the banks, and domestic waste.

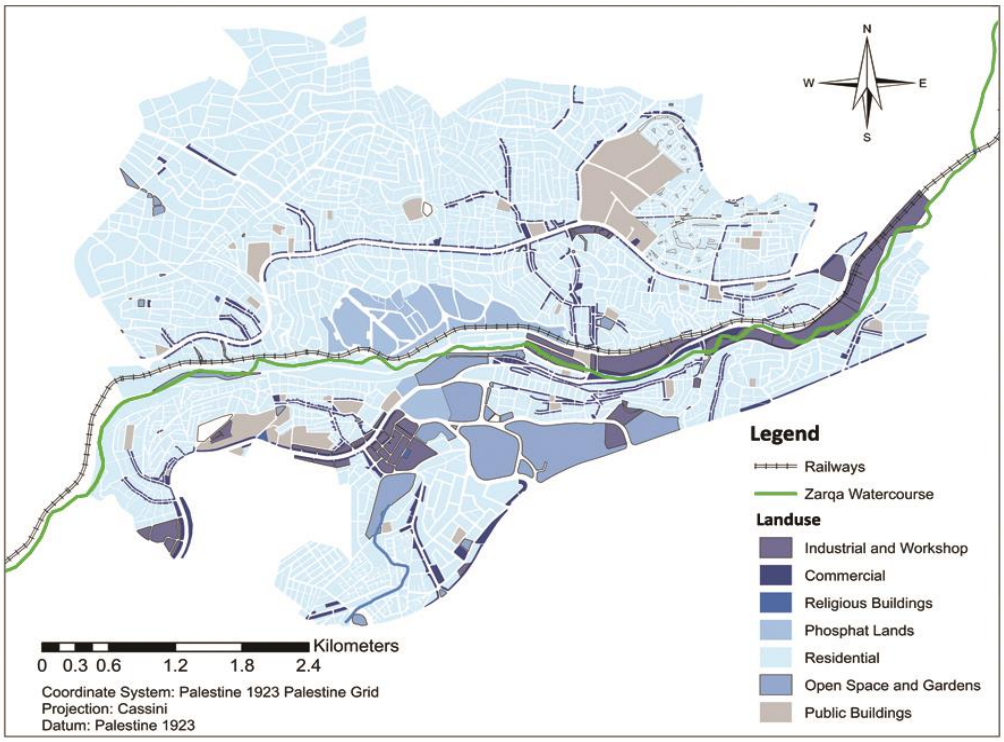

Figure 3: Russeifa land use map

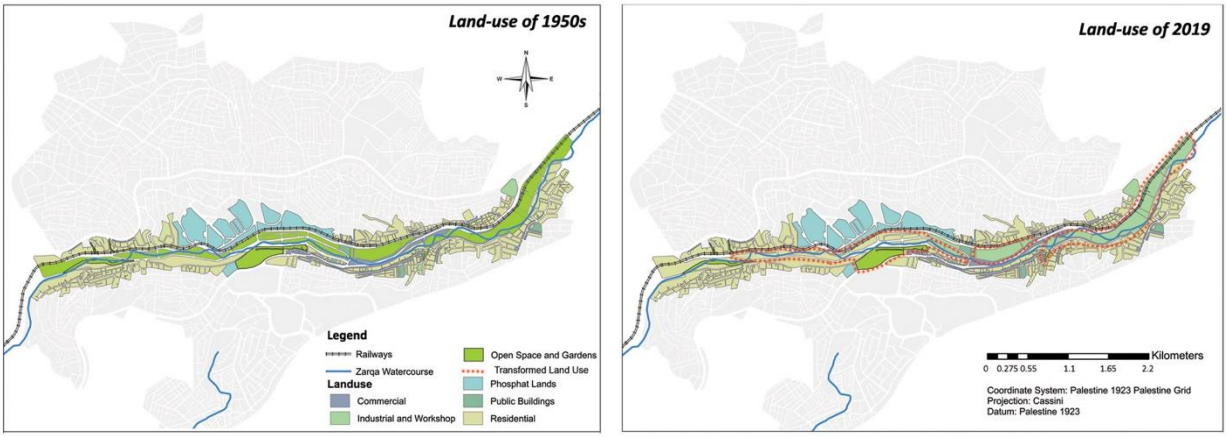

Figure 4: Land uses conversion

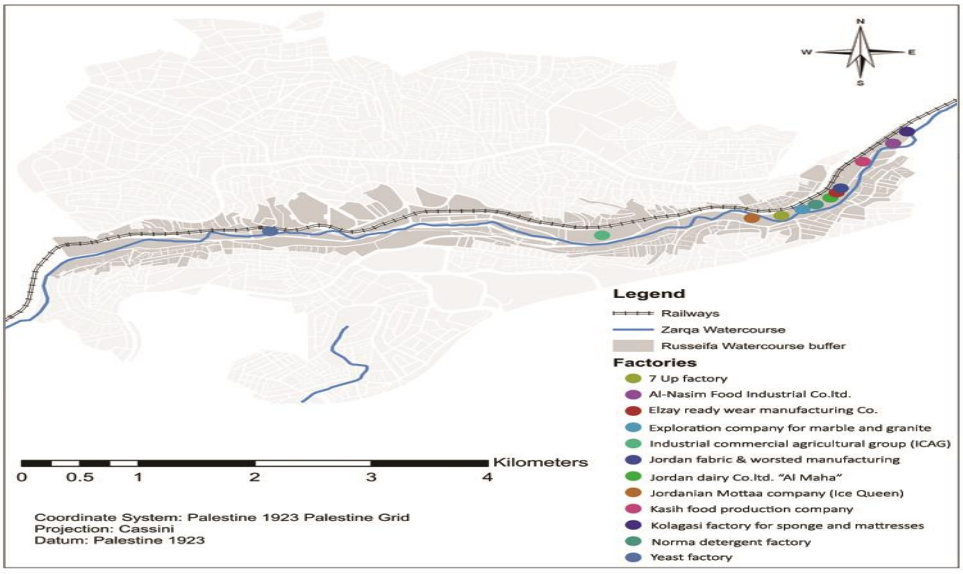

Figure 5: Factories location along Russeifa watercourse

VI. Surveys

The second phase consists of structured interviews with officials as well as residents in Russeifa, as follows:

A. Structured interviews with officials.

Interviews with decision-makers were conducted with Russeifa Municipality staff. These interviews focused on knowing the chronological and historical evolution of the Russeifa watercourse and the periods of its prosperity and uses at that time. In addition to the beginning of its decline and its causes, there is its current condition.

Officials in the Russeifa municipality mentioned that the watercourse was a vital source for regions and cities that pass through, either as a source of drinking and irrigation or as a habitat for many organisms. Initial migrations of the region, such as the Circassians, Chechens, and Armenians, have helped in the emergence of an agricultural revival. It has become a magnet for traders and residents. Officials believe that the beginning of the problems facing the Zarqa River watercourse has begun, as follows:

- In the 1960s, Russeifa began industrial transformation with factories like Al-Khameirah, Al-Ajwakh, and Al-Entaj established near the watercourse for street access and water use. This shift prioritized economic gains over environmental concerns, though regulations required each factory to have a purification plant.
- In the 1980s, Amman faced a water shortage, prompting the municipality to dig wells, depleting groundwater and reducing flow in the watercourse.
- In the 1990s, land use along the watercourse shifted from agricultural to residential and industrial due to industrialization, urbanization, population growth, and residents' pursuit of personal benefits.

Officials attribute the watercourse's current poor condition to the absence of deterrent sanctions in the past and resident encroachment, such as installing irrigation pumps or disposing of waste. They consider these issues difficult to manage due to rapid population growth, which accelerated urbanization and housing development without a comprehensive plan.

They emphasize that rehabilitation should be guided by scientific and feasibility studies, coordinated with relevant authorities, and linked to investment projects benefiting the city. Proposed solutions include reducing pollution by roofing parts of the watercourse and establishing a transport station above it. However, officials doubt the feasibility of reviving it as a blue-green corridor, viewing it as a non-permanent project with limited direct benefits for residents.

They also noted that past efforts to rehabilitate the Zarqa watercourse Basin with international support, such as from the Spanish Agency for International Development Cooperation (AECID), were largely unsuccessful due to high financial requirements.

a. Structured interviews with residents.

Interviews with residents were divided into two categories based on age groups, as follows:

b. First group.

The first group, aged over 50, had witnessed the watercourse's evolution. Interviews focused on its periods of prosperity, personal interaction, memories, and the causes and effects of its degradation. Responses indicated that the watercourse once had abundant clean, potable water from rainfall-fed springs and served as a major source for irrigation, supporting orchards with citrus, vegetables, walnuts, grapes, and almonds. These orchards, developed through Circassian agricultural expertise, were a defining feature. The watercourse also hosted various organisms, including fish, water snakes, crabs, and frogs. Respondents noted that private land use along its banks reduced water abundance and public access. They emphasized that the best rehabilitation approach would be restoring the watercourse to its former state.

c. Second group.

The second category includes the youth age group—aged between 20 and 50 years—. Questions with this group centered on their current uses and interaction with the watercourse and their needs and suggestions for its development.

Most young residents reported little to no interaction with the watercourse. Some noted parts used for recreation, such as agricultural water pools. However, there was consensus that the watercourse is dangerous, prone to frequent winter floods that have caused child and youth fatalities. Residents agreed its main use is as a landfill, resulting in pollution, foul odors, and rodents, which, along with flooding, have eroded nearby house foundations. They also highlighted the lack of pedestrian paths, with only two crossing the entire watercourse. Despite these issues, residents see potential for recreational and park development, addressing the city's shortage of green and public spaces, and hope rehabilitation plans will also provide job opportunities.

d. Field observation.

The study documented multiple problems along the watercourse and its banks (Figure 6), including polluted and blackened water, scattered waste, weak or absent flow, and sewage odors. The western side features private orchards partially used for irrigation, while the eastern side is dominated by rugged mountains and industrial areas. Northern brick workshops contribute large amounts of solid waste, and biological features are limited to some plants, with adjacent streets running alongside the watercourse.

Elements of a blue-green corridor were observed, such as grasses, rocks, and some shrubs, though trees are mostly absent due to paved streets and private lands. Private orchards contained richer vegetation, and retaining walls were noted along streets.

Regarding open spaces, the corridor reaches up to 40 meters in width on both banks but remains largely unused for green spaces, gardens, or recreation. Some residents, particularly children, use it informally for play and swimming.

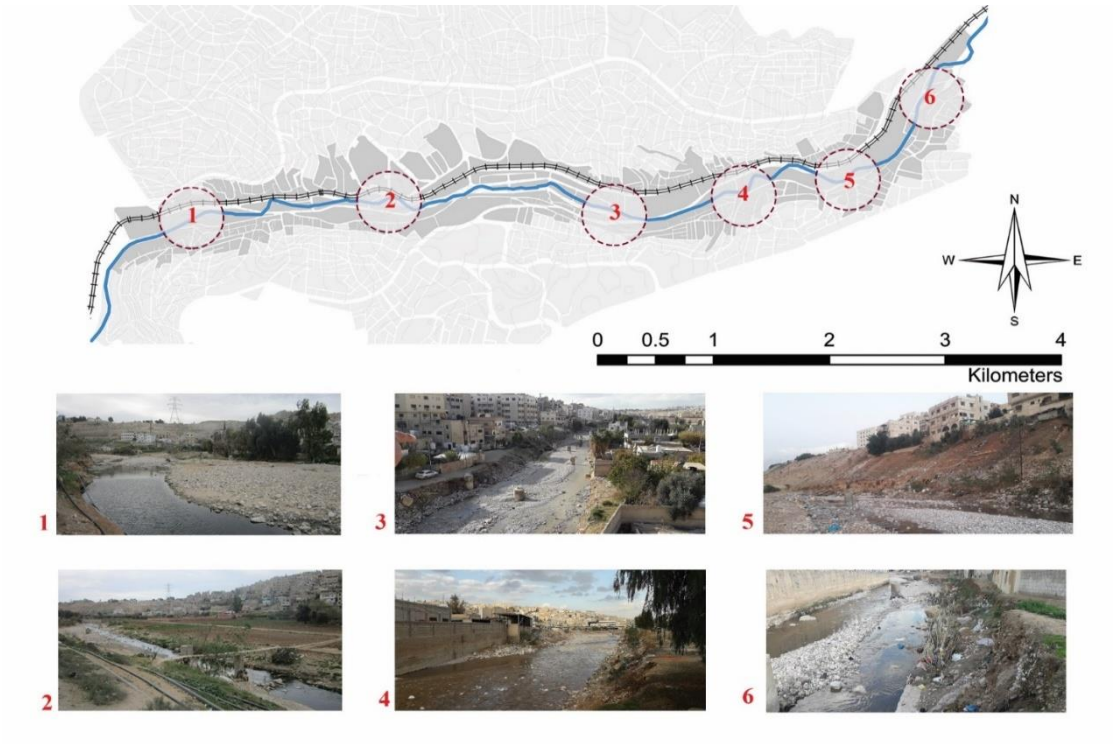

Figure 6: Pictures documenting the current condition of Russeifa watercourse

B. Second stage: Case Study Analysis

After analyzing several successful watercourse rehabilitation case studies, a table was developed summarizing the main environmental problems and the mechanisms used to address them (Table 1). The cases varied in location, challenges, and applied solutions. They included Wadi Hanifah Basin in Riyadh, Saudi Arabia (4,498 km²); Quaggy River in London (500 m); Godinton Stour River in Kent, England (200 m); Wensum River in Norfolk, England (700 m); Avon River in southern England (125 m); Cheonggyecheon Stream in Seoul, South Korea (5 km long, 72 m wide); and the San Antonio River in Texas, USA (386 km across five counties).

Table 1: Watercourse rehabilitation mechanisms

Case study	Problems	Mechanisms
Wadi Hanifah basin	Flooding	Widening the river beds. Reducing the bank bodies' slope. Erecting catchment areas on both river banks.
	Industrial and municipal waste	Installing wires and riffles to remove pollutants and bacteria. Implementing bioremediation using a hybrid of natural systems. Constructing three large pools with denitrification and aeration systems to eliminate bacteria and support an eco-friendly food chain. Designing and developing a new bioremediation facility. Developing a natural biological food chain to minimize negative impacts. Denitrifying water and removing odors through the food chain. Implementing a system of inlet and outlet pools, bio-cells, fountains, and aeration.
	The decrease in the riparian habitat	Adopting a naturalization process to manage a wildlife inventory of existing animal and plant species. Initiating greenhouse complex.
River Quaggy, Chinbrook Meadows	Floodplain	Cutting the channel old gravels. Building a room along the river corridor to allow for natural adjustment. Planting channel margins. Building flood storage ponds.
	Not accessible to the public	Creating a local amenity. Creating and dipping ponds. Building an adjacent educational area. Exchanging the concrete fences and high privet hedges near each bank with natural plants. Replacing the concrete channel in the park with a sinuous one.
Godinton Park Channel Enhancements (Stour River)	Riverbank erosion and over-widening.	Narrowing the channel to increase the flow speed. Using coir rolls staked to the river bed and back-filled with existing river silt. Fencing off the restored banks from cattle. Creating a stock watering point. Creating a shallow slope to cut down the water's edge using a digger and reinforcing the bottom with compacted, graded stone.
Wensum River at Bintree, Norfolk	Floodplain	Environmental scoping assessment. Replacing the gravel bed. Removing spoil banks to reconnect the river with its floodplain. Narrowing channel. Creating gravel glides. Raising the river bed. Improvements to create varied flow conditions. Using the novel biodegradable mattress to stabilize the new riverbank.
Avon River	Riverbank erosion and flooding	Applying bio-engineering methods, including extensive use of willow. Redefining specific channel characteristics. Installing low-cost groins from various materials. Allowing natural channel narrowing through sediment deposition. Fencing the river to restrict access. Preventing livestock from entering the river. Planting marginal vegetation to stabilize the new channel edge.
	Poor habitat diversity	Planting vegetation to create habitat for lamprey and cyprinid fish fry. Allowing marginal plants to colonize, naturalizing structures and stabilizing banks.
The Cheonggyecheon stream revitalization	Safety risks and increasing air and noise pollution	Removing the elevated highway concrete structure. Daylighting a previously covered urban stream. Using diamond wire and wheel saws to minimize noise and dust. Constructing embankments designed to withstand extreme floods.
	Low public accessibility	Creating an extensive new open space along the delightful stream. Creating pedestrian amenities and recreational spaces. The construction of 21 new bridges reconnects the urban fabric. Preserving relics and street beautification. Giving a special arrangement for street vendors. Implementing parking reforms to stimulate commercial activity.
San Antonio River	Flood risk	Constructing a flood bypass channel. Cutting off a major meander. Constructing a series of flood gates. Maintaining flood protection in the bypass channel. Creating a new, modern flood control system. Channelization of 31 miles of the San Antonio River. Flood control tunnels to transport water.

C. Third stage: Proposing the most suitable mechanisms

Based on the previous table of rehabilitation mechanisms, the most suitable options for addressing the Russeifa watercourse's problems were selected (Table 2). The selection was guided by criteria derived from case studies and consultations with local authorities, focusing on three main factors: low cost to match municipal or external funding capacity, compatibility with Russeifa's existing infrastructure, and feasibility of implementation under current conditions.

Table 2: Suitable watercourse rehabilitation mechanisms to be adopted in Russeifa

Problems	The suitable mechanism
Flooding	• Reducing the slope of riverbanks. • Installing catchment areas along both banks. • Removing old channel gravels. • Planting vegetation along channel margins. • Constructing flood storage ponds. • Removing spoil banks to reconnect the river with its floodplain. • Creating gravel glides. • Building a flood bypass channel with floodgates. • Establishing a modern flood control system. • Installing low-cost groins using various materials.
Riverbank erosion and over-widening	• Installing coir rolls staked to the riverbed and backfilled with existing silt. • Fencing restored banks to prevent cattle access. • Creating a stock watering point. • Forming a shallow slope at the water's edge, reinforced with compacted, graded stone. • Installing low-cost groins made from various materials. • Planting marginal vegetation to stabilize the new channel edge.
Industrial waste	• Implementing bioremediation using a hybrid of natural systems. • Developing a natural biological food chain to minimize negative impacts. • Denitrifying water and removing odors through the biological food chain. • Installing a system of inlet and outlet pools, bio-cells, fountains, and aeration.
Poor habitat diversity and the decrease in the riparian habitat, and Poor agricultural practices	• Adopting a naturalization process including vegetation of empty lands that surround the river to manage a wildlife inventory of existing animal and plant species.
Low public accessibility	• Creating a local amenity. • Creating an extensive new open space along the delightful stream. • Creating pedestrian amenities and recreational spaces. • Constructing pedestrian bridges.

D. Fourth stage: Integrating the chosen mechanisms with the study area

In this stage, the suitable rehabilitation mechanisms have been projected on the Russeifa watercourse map by illustrating the zones of the problems (Figure 7).

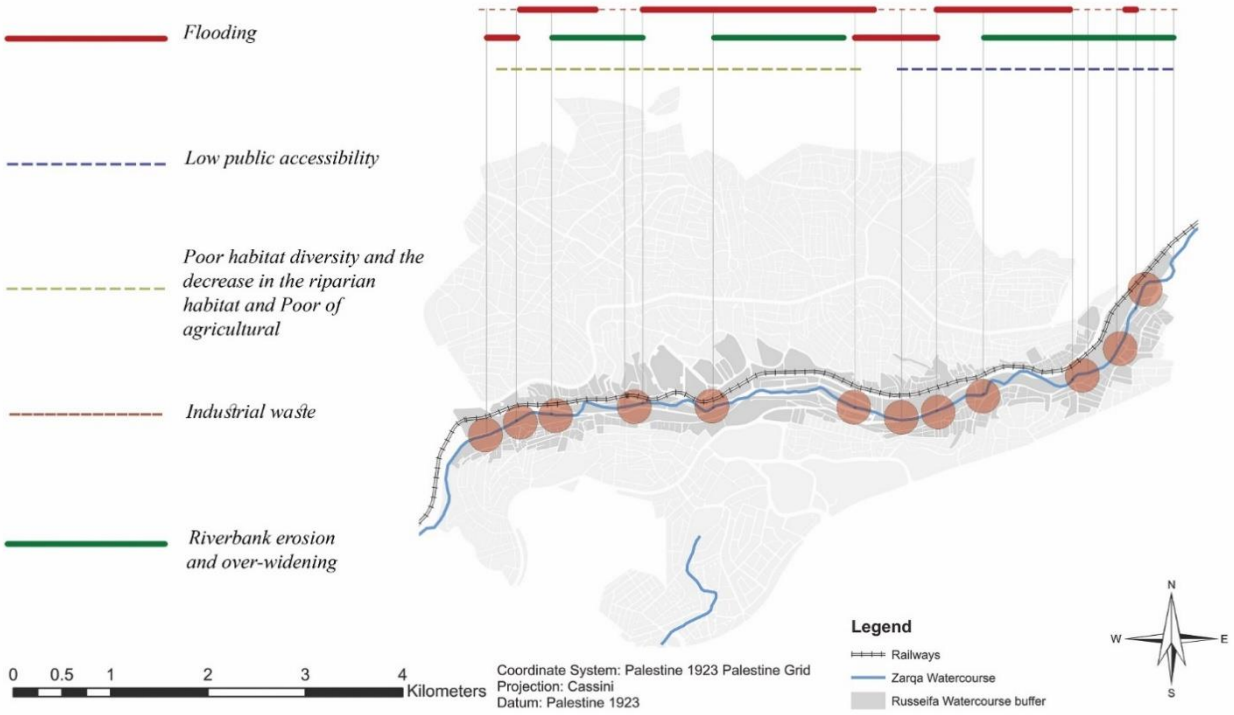

Figure 7: Integrating the chosen mechanisms with the study area

VII. Discussion

Previous studies indicate that the watercourse's problems and pollutants are largely similar, including nearby industrial and residential lands, domestic waste, and drainage into the stream. Despite evidence showing severe pollution and risks to both the environment and residents' health, no strict measures have yet been taken to control the pollution or rehabilitate the watercourse.

Interviews with Russeifa residents of various ages and municipal officials revealed both agreement and divergence. All agreed on the watercourse's historical value—passed down through generations—and on its degradation causes, mainly the city's industrial transformation. However, officials attributed the issue to the city's growing population density, while residents blamed poor land-use management and weak enforcement, noting that many polluting factories were once agricultural lands.

Differences also emerged regarding the future vision for the watercourse. Residents emphasized that rehabilitation should address current risks—such as floods and erosion affecting nearby homes—while creating job opportunities and restoring the watercourse to its natural, green state. In contrast, municipal officials prioritized the economic aspect and financial returns, a perspective that may not align with residents' needs.

Field visits to the study area revealed issues not captured in interviews, such as foul odors and the spread of rodents, creating an unpleasant and unsightly scene in the city. These findings highlight the urgent need for swift and effective solutions.

The case studies reviewed in this research varied across developing and developed countries. Their success depended on setting clear, context-appropriate goals and objectives. For instance, flood management methods used in Saudi Arabia's Wadi Hanifah differ from those in the United States due to differences in resources and infrastructure. Similarly, selecting mechanisms for the Russeifa watercourse considered these variations, emphasizing that each region must develop solutions suited to its specific conditions and needs.

Limitation

The study faced main limitations, which were the lack of maps and documents related to Russeifa city, such as maps for land uses before the conversion that occurred. Due to this limitation, a rough map showing the locations of these changes was created based on information from the Russeifa municipality officials. Furthermore, the absence of topographic maps of the city poses a significant challenge, as such maps are essential for river rehabilitation projects.

Further research

Future research and studies may take into consideration the results and recommendations of this paper to study how to involve the stakeholders, as well as the concerned and supportive parties, in such a project. In addition, to provide a

holistic plan regarding the rehabilitation of the watercourse as a blue-green corridor, including design and construction.

Recommendations

The responsible authorities should take into account carrying out development and rehabilitation projects and should start with the watercourse due to its potential in improving the environment as well as socio-economic aspects. The study recommends the adaptation of a phased rehabilitation strategy, considering the needs and demands of the population, as they are the main element in the success of any project in the long-term. Furthermore, the study recommends establishing a coordination unit between the municipality and the local community to implement community engagement programs, including workshops and awareness campaigns, to involve residents in maintaining and monitoring the watercourse. Moreover, the study recommends that the relevant authorities should issue laws limiting encroachment on the watercourse and issuing penalties for lawbreakers.

Conclusion

Rehabilitating watercourses as blue-green corridors offers significant environmental and socio-economic benefits, and many countries are adopting this strategy. Russeifa, with its high population density, pollution from factories and landfills, and shortage of green spaces, urgently needs such an approach. While the municipality focuses on financial returns, involving residents is vital for long-term success. Their main concerns—flooding and pollution from the watercourse—can be addressed through rehabilitation, improving environmental, social, and recreational conditions. Future studies should build on this research to develop comprehensive design and construction plans while engaging both residents and stakeholders

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