ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT OF DISI WELLFIELD PROJECT

Biodiversity Study

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1. Introduction

1.1 Background

The Dubaydib Wellfield Expansion Project, which was launched in 2024 as a component of the Jordanian Ministry of Water and Irrigation's nationwide plan, aims to enhance the water provision to the Greater Amman Area. The project entails the digging of supplementary wells to augment the production capacity of the Disi aquifer, guaranteeing the provision of an additional 20 million cubic meters of water per year. This increased supply is crucial in order to fulfill the growing water needs of Amman and the surrounding areas, hence supporting the long-term viability of Jordan's water resources.

In accordance with the environmental impact assessment (EIA) standards set by the Ministry of Environment, it is necessary to conduct a thorough biodiversity study to examine the possible impacts of the wellfield expansion on the nearby ecosystems. This report presents an analysis of the expected impacts of the Dubaydib Wellfield Expansion on biodiversity, encompassing both flora and fauna. It also offers a structured approach to implementing methods that would minimize any negative consequences. The assessment evaluates both the phases of construction and operation, emphasizing possible impacts and suggesting actions to prevent, reduce, or offset negative effects on biodiversity.

1.2 Study Objectives

The study aims to:

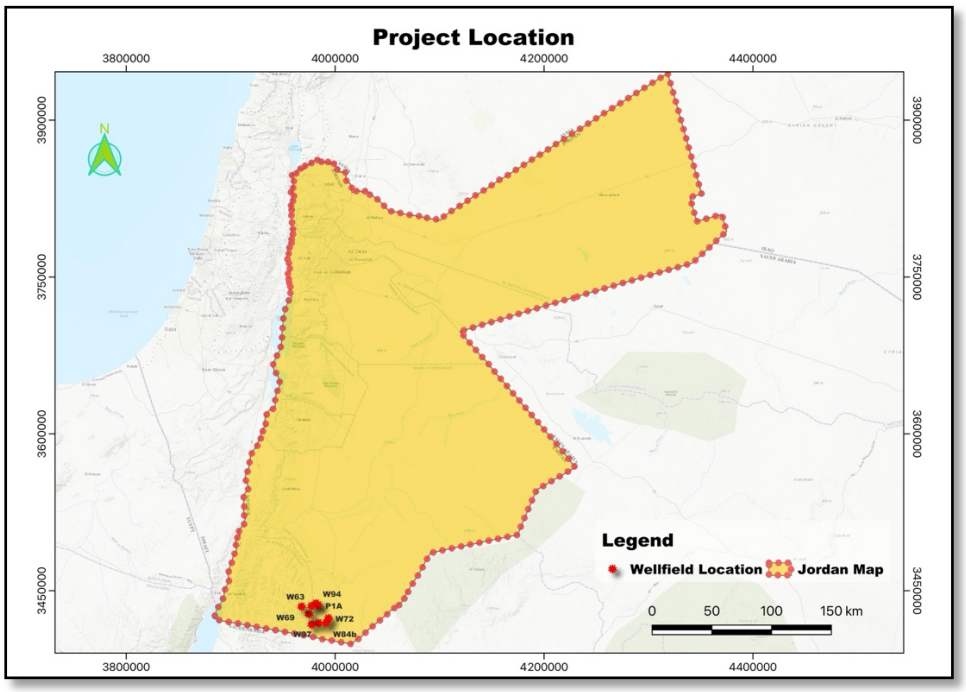
- Review and update terrestrial flora and fauna species recorded in the site and adjacent areas.
- Establish a comprehensive baseline of the biodiversity within the project area, including species inventories of flora and fauna, ecosystem types, and key ecological processes.
- Identify key species and habitats of conservation concern within the project area, including threatened or endemic species, and assess their sensitivity to the proposed development activities.
- Identify potential impact on terrestrial fauna and flora species from the project operation.
- Assess the project direct and indirect impact on biodiversity aspects during the two phases of the project: construction and operation.
- Propose mitigation measures where necessary to ensure protecting species and their habitats.

- Develop a long-term biodiversity monitoring plan to track the effectiveness of mitigation measures and ensure that biodiversity is preserved throughout the project lifecycle.

1.3 Location

The Dubaydib Wellfield Expansion Project is located in southern Jordan, within the Disi-Mudawarra region, which is part of the vast Arabian Desert. This area is characterized by its arid and semi-arid climate, with low annual rainfall and high temperatures. The landscape is dominated by desert plains, rocky outcrops, and sparse vegetation, typical of the Saharo-Arabian biogeographic zone. Despite its harsh environment, the area supports a unique biodiversity, including drought-tolerant plant species and wildlife adapted to the desert conditions. The project area also lies near key ecological zones, with certain sections located close to wadis (valleys) that contain vegetation such as Acacia and Haloxylon plants, which serve as important habitats for various species.

In addition to its environmental significance, the project area is strategically important for Jordan's water security. The Disi aquifer, a fossil water resource, extends beneath this region, supplying water to major cities like Amman and Aqaba. The wellfield is located approximately 325 km south of Amman (Map 1) and is connected to the capital via an extensive water conveyance system. The project area's proximity to the Rum Important Bird Area (IBA) and its unique desert ecosystems necessitates a careful consideration of biodiversity impacts, ensuring that water extraction activities do not compromise the ecological integrity of the surrounding landscapes.



Map 1: Project Location

2. Biodiversity Baseline Conditions

2.1 Study Approach for Biological Environment

The study adopted a comprehensive approach to evaluate the biological environment by analyzing key ecological components in relation to their physical settings. This method allows for a holistic understanding of the potential environmental impacts the project may have. The following key biological elements were targeted and linked with the physical environment units of the project area:

Biogeographical Zones and Vegetation Types: The study focused on identifying the specific biogeographical zones and vegetation types present within the project area. These zones are essential for understanding the environmental conditions, including soil type, climate, and natural plant communities, which in turn influence the distribution of flora and fauna.

Flora: An assessment of plant species within the project area was conducted to identify the diversity, abundance, and conservation status of the vegetation. Special attention was paid to endemic, rare, or threatened plant species that could be impacted by project activities.

Fauna: The study selected key wildlife groups to assess the status of fauna in the project area. Mammals, birds, and reptiles were chosen based on their national conservation status, ecological importance, and sensitivity to habitat disturbance. The focus was on species that are vulnerable to habitat changes or disturbances from human activities.

Sensitive Habitats: The study identified and analyzed areas of significant biological importance within and around the project area, such as Protected Areas, Rangeland Reserves, and Important Bird Areas (IBA). These habitats are crucial for the survival of certain species and require special consideration during project planning and execution.

Critical Habitat: A Critical Habitat Screening was conducted to determine whether any areas within the project site meet the criteria for critical habitat as defined by IFC Performance Standard 6 (PS6) and EIB Social and Environment Standard 4. This includes habitats of significant importance for endangered and endemic species, migratory birds, and unique or threatened ecosystems.

Ecosystem Services: The study also assessed the range of ecosystem services provided by the local environment. The potential impacts of the project on these services were analyzed to ensure that ecosystem functions are maintained and not compromised by development activities.

2.1.1 Literature review

As part of the study, the team conducted an extensive literature review to gather all relevant data previously collected from the project site and its surrounding areas. This involved reviewing a wide range of sources, including:

- Previous Environmental Impact Assessments: These assessments provided baseline data on environmental conditions, species inventories, and potential environmental risks.
- Surveys and Biodiversity Assessments: If available, data from earlier surveys were incorporated to supplement the existing information and offer a more comprehensive view of the site's ecological characteristics.
- Additional Scientific Research: The team also consulted relevant scientific literature and databases to gather information on regional biodiversity trends, habitat types, and conservation priorities.

The desktop study focused on analyzing the available information and identifying knowledge gaps that needed to be addressed through further field visits. The key areas of focus during this review were:

- **Flora and Fauna Species**: The presence and distribution of plant and animal species in the project area were examined, paying particular attention to species of conservation concern, such as those that are threatened, endangered, or endemic to the region.
- **Habitat Types and Species Communities**: The study investigated the types of habitats present, such as desert ecosystems, wadis, and rangelands, and the characteristic species that define these habitats. This provided a broader understanding of the ecological dynamics and species interactions within the project area.

By combining the findings from the literature review with field assessments, the study aimed to provide a detailed and scientifically robust evaluation of the biological environment and the potential impacts of the project on biodiversity.

2.1.2 Field Work rapid assessment

The field visit for the rapid biodiversity assessment was conducted over two days, from the 6th to the 7th of August 2024. The assessment involved surveying the wells' locations and the access roads to twelve wells (W63, W69, W72, W84b, W86, W94, W97, W98, W95GT, W65GT, W64GT and P1A). At each well site, flora and fauna species were observed and recorded within a 50-meter radius from the well location. To maximize wildlife observation opportunities, visits to each site were scheduled for early morning or late afternoon, as these times are optimal for detecting wildlife activity.

Data collection during the fieldwork was carefully organized. Handheld GPS devices were used to mark the exact coordinates of each point and to log the locations of any species of conservation importance. Observations were systematically documented on specially designed data sheets, ensuring accurate and efficient recording of data. This methodical approach enabled a precise assessment of biodiversity in the area while facilitating effective data management for subsequent analysis.

2.2 Baseline Conditions for Biological Environment

2.2.1 Biogeographic Zones

Jordan is categorized into four separate biogeographic regions: the Mediterranean, the Irano-Turanian, the Saharo-Arabian, and the Sudanian. The lines delineating the zones are purely suggestive, and many species can be observed in more than one region. (Al-Eisawi, 1996)

The project site is situated within two biogeographic zones: the Sudanian and Saharo-Arabian zones. Five wells (W84b, W86, W97, W98, and W69) are located in the Sudanian zone, sometimes referred to as the subtropical or Afrotropical region. This zone is confined to the warmest parts of Jordan, including areas such as Wadi Rum, Wadi Araba, and the region around the Dead Sea. Extending north toward Dair 'Alia, it is characterized by extremely hot summers, with temperatures ranging from 15 to 45°C, and relatively warm winters. Occasionally, temperatures may exceed these limits on certain days. This region is notable for its location in the lowest point on Earth, the Dead Sea, which lies around -400 meters below sea level. The region receives minimal rainfall, ranging between 50 and 100 millimeters annually, and the soil is predominantly saline, sandy, or Hammada, often found in sand dunes. The vegetation here consists of tropical species, including *Acacia spp.*, *Ziziphus spina-christi*, and other important shrubs and annual herbs. Over 300 plant species in this region are endemic to Jordan, adding significant ecological value to the area. (Al-Eisawi, 1996)

The Saharo-Arabian zone, where the remaining seven wells (W63, W72, W94, W95GT, W65DT, W64GT and P1A) are located, represents the vast desert or Badia region of Jordan. This region is characterized by extremely arid conditions, with very poor soils that are generally saline, sandy-loam, or Hammada in texture. The landscape is dominated by gravelly plains rather than sand dunes, which are typical of other deserts. Rainfall is scarce, averaging between 50 to 100 millimeters per year, and temperatures can soar above 40°C in summer and drop below freezing in winter. Vegetation in this zone is sparse and mainly restricted to wadis where moisture is available. Common plant species include *Artemisia herba-alba*, *Achillea fragrantissima*, *Phlomis spp.*, *Astragalus spp.*, and *Stipa spp.*, which are well-adapted to the harsh desert environment. (Al-Eisawi, 1996)

Dominant plants that can be referred to the Sudanian element include many trees shrubs and herbs, such as: (Al-Eisawi, 1996)

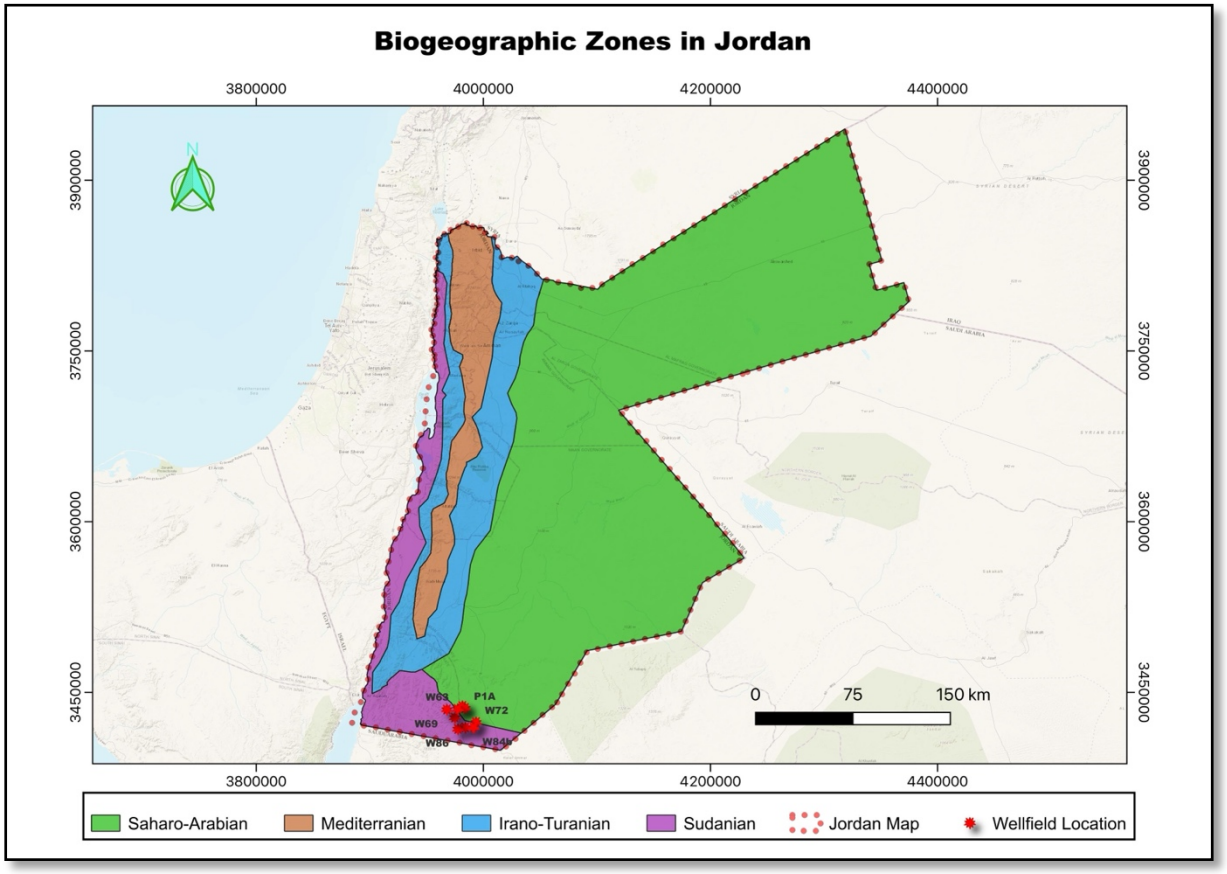
Haloxylon persicum, *Calitropos procera,*

Moringa peregirena, Acacia raddiana,

Ziziphus spina cristi, Belanites aegyptiaca,

Zygophylum dumosum, Salvadora persica,

Ochradenus baccatus Cucumis prophetarum.



Map 2: Biogeographic Zones of Jordan (Al-Eisawi, 1996)

2.2.2 Vegetation Types

There are three vegetation types present in the project area as shown on Map 3 these are:

Sand Dune Vegetation Type

This vegetation can only be found in the Sudanian Biogeographical Region, and the Wadi Rum Protected Area in Jordan is where the best examples of it can be seen. It is dominated by shrubs, which are known as sand dunes fixatives. The most prominent species of these shrubs include *Haloxylon persicum, Retama raetam, Calligonum comosum, Neurada procumbens* and *Hammada scopiara*. (Al-Eisawi, 1996)

Acacia and Rocky Sudanian Vegetation Type

This vegetation type can only be found in the rocky regions of the area. Occasionally, it is seen in conjunction with the Sand Dune Vegetation Type in certain locations. These are the primary species that are representative of this type: *Acacia raddiana, Anabasis articulata, Caralluma spp., Fagonia spp., Gymnocarpos decndrum* and *Helianthemum lippii*. (Al-Eisawi, 1996)

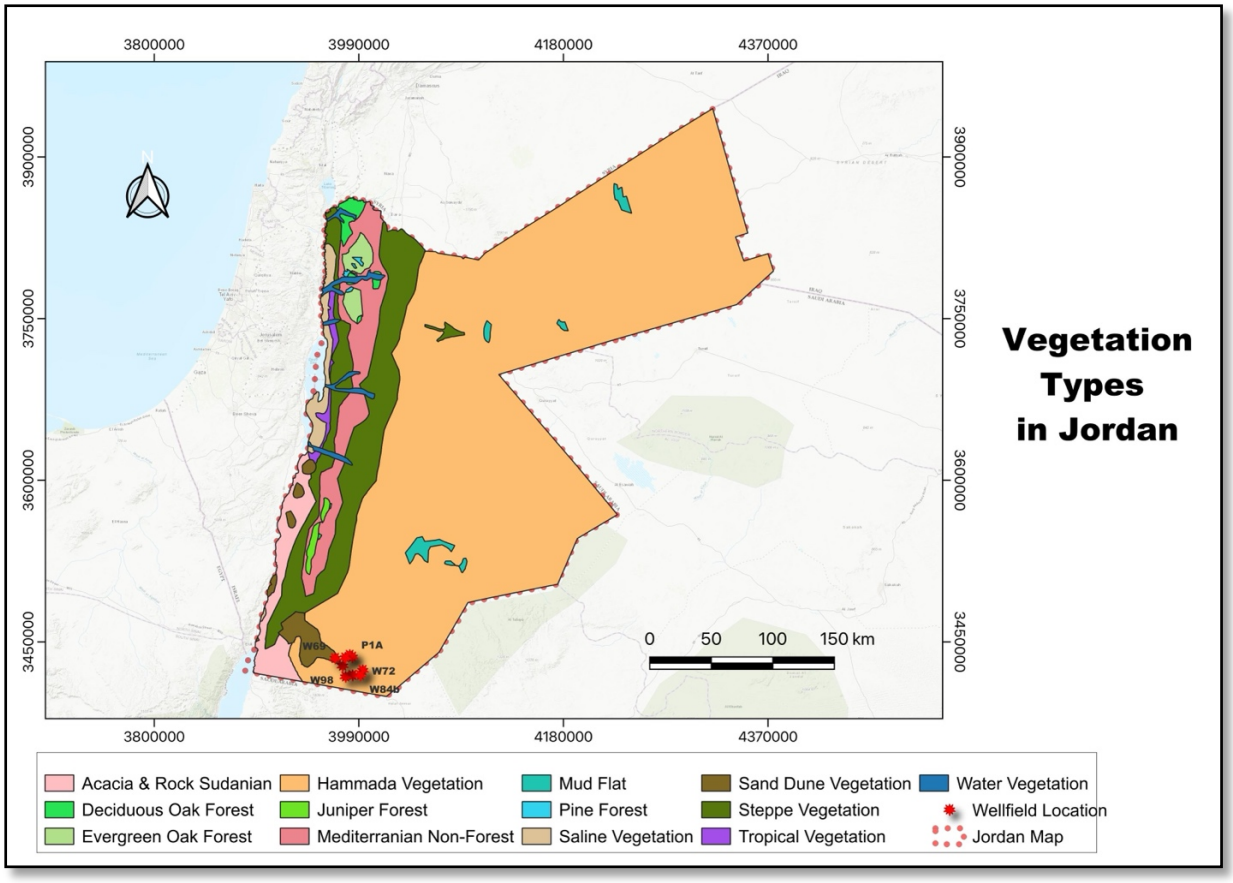
Hammada Vegetation

The majority of the Saharo-Arabian region in Jordan is classified as Hammada, covering approximately 50% of the country's total area. Hammada is further divided into four main types based on soil composition and topography: run-off hammada, gravel hammada, pebble hammada, and sandy hammada (Al-Eisawi, 1996). Three types present in the project area:

Run-off Hammada: Vegetation in run-off hammada is mainly confined to wadis and watershed areas, where water collects and supports denser plant life compared to the surrounding arid zones. The size of these areas can vary significantly, from a few meters to over a kilometer wide. For example, Wadi Bayer can exceed one kilometer in width, while Wadi Rajil and Wadi AL-Hazeem are typically much narrower. Vegetation varies by location; for example, along the Ma'an-Mudawarah road, common species include *Acacia tortilis*, *Acacia raddiana*, and *Tamarix spp.*

Gravel Hammada: This is the largest and flattest part of Jordan's Eastern Desert, characterized by clayey loam soils covered in gravels. The vegetation consists mainly of low shrubs such as *Seidlitzia rosmarinus* and various annual herbs. Leading species include *Mesembryanthemum nodiflorum*, *Filago desertorum*, and *Gymnarrhena micrantha*.

Sandy Hammada: This type is most common along Jordan's borders with Iraq and Saudi Arabia, and parts of it are found in the Ash-Shumari Reserve. The soil here is a mixture of gravel, pebbles, and sandy deposits originating from Saudi Arabia. In some areas, sand becomes dominant, leading to sand dune formations. Key species include *Seidlitzia rosmarinus*, *Atriplex spp.*, *Artemisia herba-alba*, and *Anabasis articulata*.



Map 3: Vegetation Types in Jordan (Al-Eisawi, 1996)

The table that follows presents a selection of vegetation species that have been documented from the region that are of significant conservation importance.

Table 1: List of important plant species reported from the area (Taifour & El-Oqlah, 2014)

Family	Species	National Status
CARYOPHYLLACEAE	*Silene danaensis*	Rare, endemic South Jordan
CHENOPODIACEAE	*Haloxylon persicum*	Vulnerable
COMPOSITAE	*Anthemis melampodina*	Critically Endangered
	Anthemis scrobicularis	Critically Endangered
	Artemisia jordanica	Endangered
	Artemisia judaica	Vulnerable
	Onopordum jordanicolum	Rare, endemic
	Onopordum transjordanicum	Rare, endemic
	Verbesina encelioides	Critically Endangered
CUPRESSACEAE	*Juniperus phoenicea*	Endangered
LABIATAE	*Lavandula coronopifolia*	Near Threatened
	Micromeria graeca	Vulnerable
LEGUMINOSAE	*Acacia gerrardii*	Vulnerable
	Vachellia tortilis	Vulnerable
POLYGONACEAE	*Calligonum comosum*	Endangered
SCROPHULARIACEAE	*Scrophularia xylorrhiza*	Rare

The project area is part of a desert ecosystem, characterized by arid conditions and minimal vegetation. Due to the harsh environment, vegetation is typically confined to wadis, where water collects during sporadic rainfall events. However, the area has been significantly degraded by human activities, exacerbated by climate change and the scarcity of rain. Overgrazing, the expansion of vehicle tracks, and other forms of land disturbance have contributed to the degradation of the ecosystem, limiting the natural regeneration of plant species.

Within the wadis near the well locations, *Acacia gerrardii* and *Retama raetam* were among the primary species observed, indicating the resilience of these plants in such dry conditions. Despite the presence of vegetation in these pockets, the majority of the land surrounding the wells remains barren, with almost no vegetation cover. The high level of human disturbance, including grazing and vehicle movement, has further hindered the potential for vegetation to thrive, leaving the landscape in a highly degraded state. Following is each well location description:

W94 and W95GT

The area surrounding Well W94 and W95GT is classified as Hammada, characterized by a barren, gravelly landscape with minimal to no vegetation directly at the site. However, close to the wells, a small wadi provides a more favorable microhabitat for plant life, where species such as *Seetzenia lanata*, *Acacia tortilis*, *Artemisia judaica*, *Pulicaria undulata*, *Citrullus colocynthis* and *Ochradenus baccatus* were observed. These species are typical of desert environments, thriving in areas where moisture can accumulate, and support limited but vital vegetation.

Picture 1: W94 Location

Despite the presence of these species in the nearby wadi, the overall area is highly disturbed by human activity. Heavy movement of vehicles has resulted in numerous tracks crisscrossing the landscape, contributing to significant land degradation. These disturbances further limit the potential for vegetation recovery and reduce the overall biodiversity at the site, leaving much of the surrounding area bare and unable to support a robust ecosystem.

Picture 2: Acacia tortilis

P1A

The area around Well P1A is completely devoid of any flora species, with no vegetation observed at the site. It is classified as a Hammada landscape, characterized by barren, gravelly soil. The site shows clear signs of heavy disturbance, with numerous vehicle tracks crisscrossing the area, further contributing to the degradation of the already harsh environment. The lack of vegetation and the evident human impact make this location particularly susceptible to continued environmental degradation.

Picture 3: P1A sign of high disturbance

Picture 4: P1A sign of high disturbance

W72

The area surrounding Well W72 is a bare Hammada desert, with little to no vegetation directly at the site. However, a small seasonal water stream from the surrounding hills creates a more favorable environment for the growth of annual flora during brief periods of water

availability. These seasonal streams support limited plant life, providing a temporary habitat for species that can take advantage of the short bursts of moisture. Despite the overall barren landscape, this small water stream plays a critical role in sustaining pockets of biodiversity in the otherwise harsh desert environment.

Picture 5: Annuals close to W72

W84b

The site surrounding Well W84b has some vegetation cover, with a few common species observed, including *Citrullus colocynthis*, *Asteriscus graveolens*, and *Artemisia judaica*. The area is classified as a runoff Hammada, where water from occasional rainfall collects and supports vegetation growth. This type of landscape allows for slightly denser plant life compared to the barren Hammada, especially in areas where runoff channels or small wadis provide essential moisture. The presence of these species highlights the site's ability to sustain limited biodiversity in an otherwise arid environment.

Picture 6: W84b location

Picture 7: Vegetation at W84b

W86

The area surrounding Well W86 is dominated by sand dunes with no vegetation cover directly at the site. However, nearby, there is a wadi that supports a dense growth of *Retama raetam*. This wadi acts as a important habitat in the otherwise barren landscape, providing a refuge for plant life that can thrive in areas where water occasionally accumulates.

Picture 8: W86 Location

Picture 9: Vegetation close to W86

W97

The area surrounding Well W97 is a bare land located at the edge of a mud flat, where vegetation growth is extremely limited. The harsh conditions of the mud flat, with poor soil and minimal moisture retention, make it difficult for plant species to establish and thrive. As a result, the site is largely devoid of vegetation, reflecting the challenging environmental conditions typical of such areas in desert ecosystems.

W63

The area around Well W63 is a mud flat with no vegetation present.

W69

The area around Well W69 is characterized by sand dunes with scattered plant species.

W98

The area surrounding Well W98 consists of a combination of mud flats and sand dunes, with no vegetation cover observed at the site.

W64GT and W65GT

The wells W65GT and W64GT are located in a bare, rocky area that has been heavily disturbed by extensive vehicle tracks. The disturbance has significantly impacted the local environment, with only very limited vegetation present.

Picture 10: W97 location

Picture 11: W63 location

Picture 12: W69 location

Picture 13: W98 location

Access Roads

All wells in the project area are accessible via dirt roads that are commonly used by locals to reach the region. These access roads are generally devoid of vegetation, as they are situated far from water collection points such as wadis and small seasonal water streams. The lack of proximity to these moisture-rich areas results in barren, dry conditions along the roads, further limiting the potential for any plant life to establish.

2.2.3 Fauna

Reptiles

Studies have identified a total of 35 reptile species in the project area and its vicinity, representing nine different families. These families include *Gekkonidae* (geckos), *Chamaeleonidae* (chameleons), *Agamidae* (agamas), *Lacertidae* (lizards), *Scincidae* (skinks), *Varanidae* (monitor lizards), *Leptotyphlopidae* (thread snakes), *Colubridae* (non-venomous snakes), and *Viperidae* (vipers). This diversity reflects the adaptability of reptile species to the arid desert environment, where they play an essential role in the local ecosystem.

Among these species, two are of special conservation concern according to the IUCN Red List. *Uromastyx aegyptia* (Egyptian spiny-tailed lizard) is classified as vulnerable, while *Coluber sinai* (Sinai racer) is listed as near threatened. Additionally, three species—*Chamaeleo chamaeleon* (common chameleon), *Ablepharus rueppellii* (Rüppell's snake-eyed skink), and *Lacerta cf. kulzeri*—are believed to be relicts from a former, more humid period in the area's history. These species inhabit limited and fragmented habitats, making their conservation particularly important. (Abu Baker, et al., 2004)

Table 2: List of species and their ecological importance (Disi, et al., 2001) (IUCN, 2024)

Family	Species	Common Name	IUCN Status
Gekkonidae	*Bunopus tuberculatus*	Baluch Ground Gecko	Least Concern
	Hemidactylus mindiae		Least Concern
	Pristurus rupestris	Rock Semaphore Gecko	Least Concern
	Ptyodactylus guttatus	Fan-footed Gecko	Least Concern
	Ptyodactylus hasselquistii		Least Concern
	Stenodactylus doriae	Dune Sand Gecko	Least Concern
	Stenodactylus sthenodactylus	Elegant Gecko	Least Concern
	Tropiocolotes nattereri	Natterers Gecko	Least Concern
Chamaeleonidae	*Chamaeleo chamaeleon*	Mediterranean Chameleon	Least Concern
Agamidae	*Laudakia stellio*	Starred Agama	Least Concern
	Phrynocephalus arabicus	Arabian Toad-headed Agama	Least Concern
	Pseudotrapelus sinaitus	Sinai Agama	Least Concern
	Uromastyx aegyptia	Egyptian Spiny–tailed Lizard	Vulnerable
Lacertidae	*Acanthodactylus boskianus*	Bosc's Fringe-toed Lizard	Least Concern
	Acanthodactylus opheodurus	Snake-tailed Fringe-toed	Least Concern
	Acanthodactylus schmidtii	Schmidt's Fringe-toed Lizard	Least Concern
	Lacerta cf. kulzeri		Rare
	Mesalina brevirostris		Least Concern
	Mesalina guttulata	Small-spotted Desert Racer	Least Concern
	Mesalina olivieri		Least Concern
Scincidae	*Ablepharus rueppellii*		Least Concern
	Chalcides ocellatus	Ocellated Skink	Least Concern
	Scincus scincus	Common Skink	Least Concern
Varanidae	*Varanus griseus*	Desert Monitor	Least Concern
Leptotyphlopidae	*Leptotyphlops macrorhynchus*	Hook-snouted Worm Snake	Least Concern
Colubridae	*Coluber elegantissimus*	Elegant Racer	Least Concern
	Coluber rhodorachis	Wadi Racer	Least Concern
	Coluber Sinai	Sinai Banded Racer	Near Threatened
	Eirenis coronella		Least Concern
	Lytorhynchus diadema	Crowned Leaf-nosed Snake	Least Concern
	Psammophis schokari	Forskal's Sand Snake	Least Concern
	Spalerosophis diadema	Diadem Snake	Least Concern
	Telescopus dhara	Arabian Cat Snake	Least Concern

Viperidae	*Cerastes gasperettii*	Arabian Horned Viper	Least Concern
	Echis coloratus	Hajar Saw-scaled Viper	Least Concern

Although the study area is known to host a rich diversity of reptiles, including 35 species across nine families, no reptiles were recorded during the field visit. This absence is likely due to the short duration of the study.

Mammals

In their native environments, a total of 26 different species of mammals were observed and documented from previous studies. These mammals were classified into the following categories: one ungulate, nine carnivores, eleven rodents, three bats, one insectivore, and one species of the family Hyraxidae. The conservation and ecological significance of a number of species is particularly noteworthy (Table 3).

Table 3: Conservation Important Species Reported from the Area

Common Name	Scientific Name	Global Status	National Status
Canidae			
Grey Wolf	*Canis lupus*	Least Concern	Endangered
Blanford's Fox	*Vulpes cana*	Vulnerable Mediterranean	Endangered
Felidae			
Caracal	*Caracal caracal*	Near threatened Mediterranean	Critically endangered
Sand Cat	*Felis margarita*	Near threatened Mediterranean	Critically endangered
Hyaenidae			
Hyena	*Hyaena hyaena*	Endangered	Near threatened
Rodentia			
Asian Dormouse	*Eliomys melanurus*	Least Concern	Near threatened
Hyraxidae			
Rock Hyrax	*Procavia capensis*	Least Concern	Endangered
Artiodactyla			
Dorcas Gazelle	*Gazella dorcas*	Vulnerable	Critically endangered
Nubian Ibex	*Capra ibex nubiana*	Vulnerable	Endangered

No mammal species were recorded during the survey. This absence of mammalian observations could indicate two possibilities, the presence of human activity within the area deterring wildlife, or the areas surveyed lacking sufficient habitat features to support a visible population of mammals.

Avifauna

A significant portion of the migration path that birds take between Africa, Asia, and Europe passes through Jordan. There are millions of birds that migrate over Jordan every year, and the majority of the avifauna that lives in Jordan also belongs to this migration. As a result of the large number of migratory birds that visit Jordan twice a year, the country has become an extremely important location for the avifauna of the entire world. According to BirdLife International, it is estimated that at least 500 million migratory birds belonging to more than 230 different species travel through Jordan twice a year and rest in Important Bird Areas (IBAs) located in the Middle East. There are 18 locations in Jordan that have been designated as Important Birds Areas. (Birdlife International , 2024)

An instrument for sensitivity mapping has been created by Birdlife International in order to evaluate the migratory soaring birds. For the purpose of determining the significance of the place for migrating soaring birds, this instrument was utilized. The soaring species that may be found on the site are listed in Table 4, along with their current conservation status. (Birdlife International , 2024)

Table 4: Important birds reported from the Area (Birdlife International , 2024)

Scientific Name	**Common Name**	Status
Aquila heliaca	Imperial Eagle	Vulnerable
Gypaetus barbatus	Bearded Vulture	Near Threatened
Neophrom percnopterus	Egyptian Vulture	Endangered
Falco concolor	Sooty Falcon	Vulnerable
Falco biarmicus	Lanner	Regionally Near Threatened
Falco cherrug	Saker Falcon	Endangered
Aquila Verreauxii	Verreaux's Eagle	Regionally Threatened
Circus cyaneus	Hen Harrier	Regionally Vulnerable

A total of 18 bird species were recorded during the survey, reflecting the avian diversity of the project area. Notably, two species observed have conservation status: the *Sooty Falcon* (*Falco concolor*), which is listed as Near Threatened, and the *Lesser Kestrel* (*Falco naumanni*), which is classified as Vulnerable according to the IUCN Red List. Both species are significant in terms of regional conservation efforts. The remaining bird species identified during the survey are considered common and resident to the area, indicating a stable avian population adapted to the local desert ecosystem.

Table 5: Bird Species Recorded during the field visit

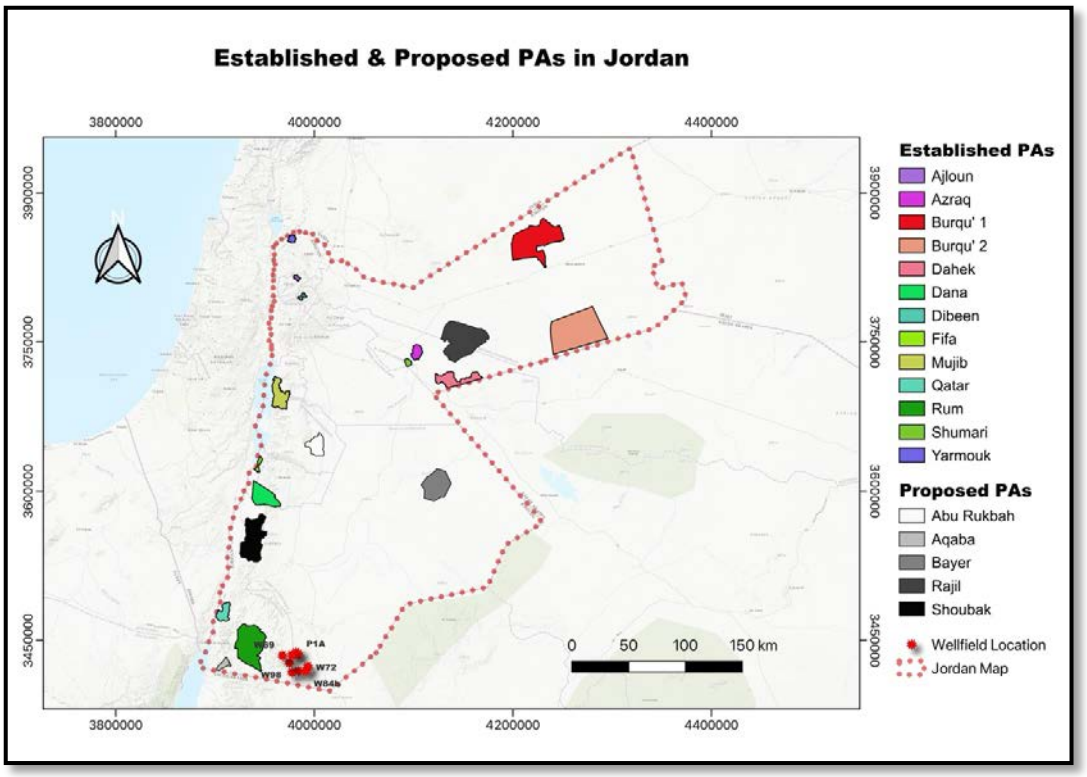
Scientific Name	Common Name	Conservation Status
Aquila nipalensis	Steppe Eagle	Least Concern
Falco tinnunculus	Kestrel	Least Concern
Falco naumanni	Lesser Kestrel	Vulnerable
Falco concolor	Sooty Falcon	Near Threatened
Ammomanes cincturus	Bar-tailed Lark	Least Concern
Eremophila bilopha	Temminck's Horned Lark	Least Concern
Galerida cristata	Crested Lark	Least Concern
Calandrella rufescens	Lesser Short Toed Lark	Least Concern
Ammomanes deserti	Desert Lark	Least Concern
Corvus ruficollis	Brown Necked Raven	Least Concern
Oenanthe leucopyga	White Crowned Wheatear	Least Concern
Oenanthe isabellina	Isabelline Wheatear	Least Concern
Oenanthe deserti	Desert Wheatear	Least Concern
Hirundo rustica	Barn Swallow	Least Concern
Spilopelia senegalensis	Palm Dove	Least Concern
Columba livia	Rock Dove	Least Concern
Oena capensis	Namaqua Dove	Least Concern
Sylvia nana	Desert Warbler	Least Concern

2.2.4 Sensitive Habitats

Protected Areas

Jordan has established a total of 12 protected areas, covering approximately 5.3 % of the country's total land area. These protected areas, managed primarily by the Royal Society for the Conservation of Nature (RSCN), play a crucial role in conserving the country's unique biodiversity, safeguarding ecosystems, and providing refuge for endangered species. The RSCN continues to work toward expanding and managing these areas to ensure long-term ecological sustainability and balance with human development.

The closest protected area to the project site is the Rum Protected Area, located approximately 18 kilometers away (Map 4). While the project site does not fall within the boundaries of this protected area, its proximity to Rum Protected Area is notable due to the ecological significance of the region. Rum Protected Area is a vital habitat for numerous species, including some that are of conservation concern. The distance from the project suggests that direct impacts on the protected area are unlikely, but indirect effects, such as disturbances to wildlife corridors or migration patterns, should be considered during the assessment process.

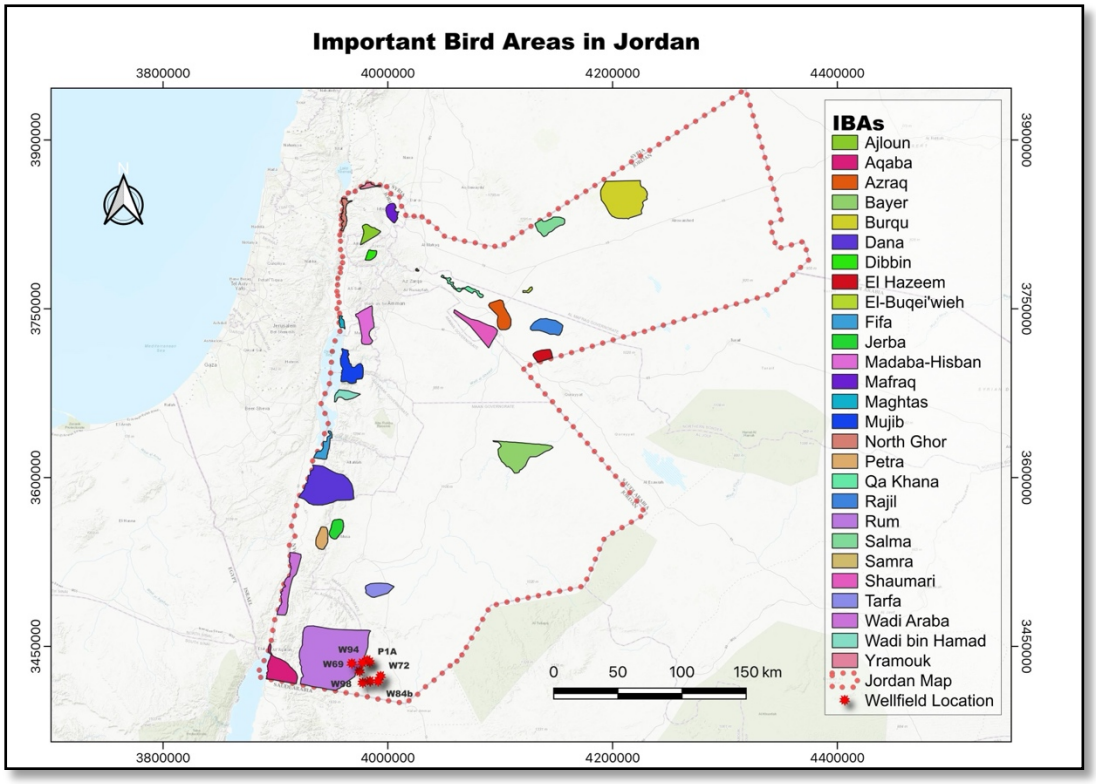


Map 4: Protected Areas in Jordan (RSCN, 2024)

Important Bird Areas

The Rum Important Bird Area (IBA) is a vital site for avian conservation in Jordan (Map 5). Its diverse landscape, dominated by rugged mountains, vast sandy plains, and deep valleys, provides a variety of habitats that are crucial for both migratory and resident bird species. Serving as a important stopover for migratory birds, the Rum IBA plays a pivotal role in connecting Africa with Europe and Asia along important migratory routes. Among the notable species found here are the *Sooty Falcon* and the *Sinai Rose Finch*, both of which are of high conservation concern due to their specialized adaptations to the harsh desert environment. Additionally, the area's high cliffs offer essential nesting grounds for raptors such as the *Lappet-faced Vulture* and the *Egyptian Vulture*, which depend on the scarce water sources found in some valleys for their survival. This combination of unique habitats and important conservation species makes the Rum IBA an invaluable conservation site within Jordan. (Birdlife International , 2024)

As part of the project, two wells, W69 and W98, are situated within the boundaries of the Rum Important Bird Area (IBA), highlighting the need for careful consideration of potential impacts on the area's bird populations and habitats. These wells lie in a region of the IBA that is essential for both resident and migratory bird species. The remaining wells in the project are located close to the IBA's eastern borders, further underscoring the importance of implementing measures to minimize disturbances to the surrounding environment.

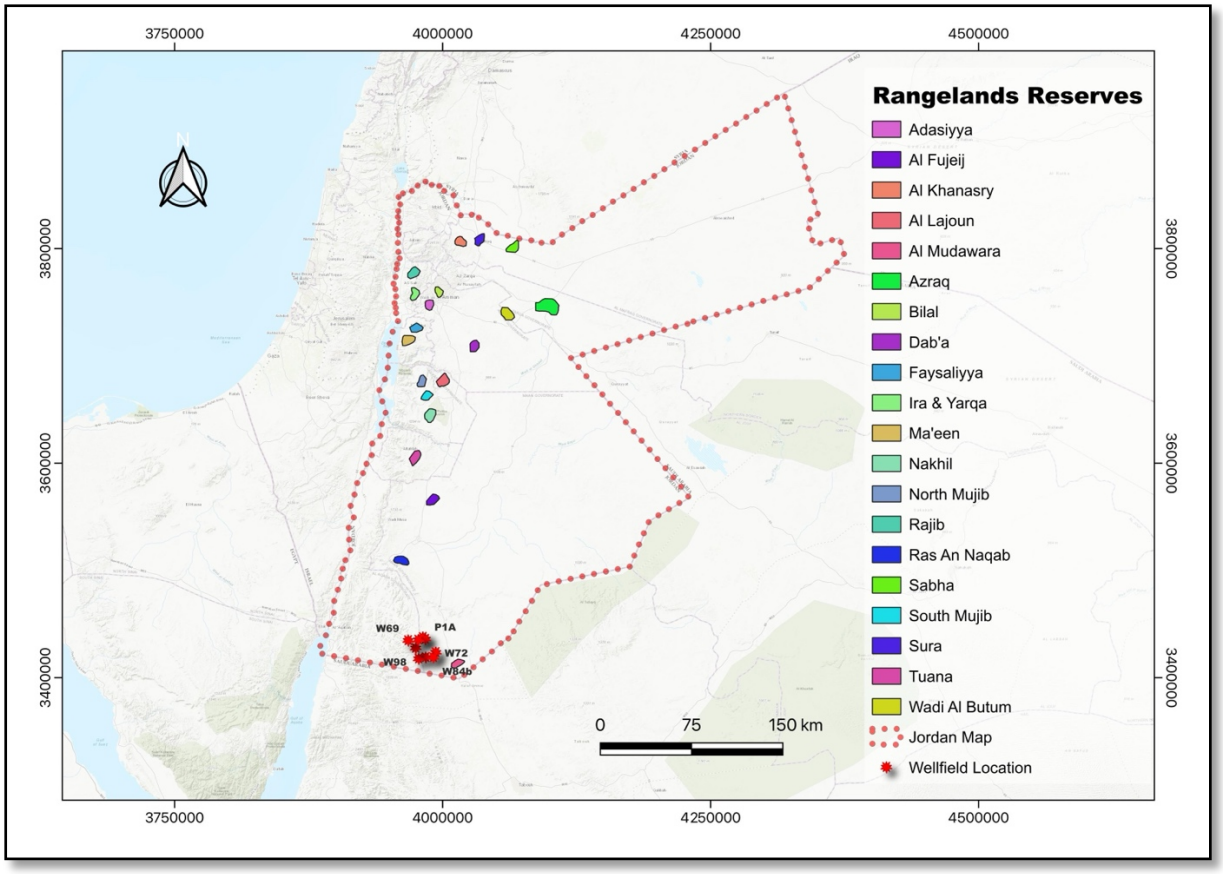


Map 5: Important Bird Areas in Jordan (RSCN & Birdlife, 2000)

Rangeland Reserves

Jordan has established 20 rangeland reserves, which play a role in conserving the country's fragile desert ecosystems and supporting sustainable land use. These reserves are essential for maintaining the health and productivity of natural rangelands. Rangeland reserves provide grazing areas for livestock, helping to regulate grazing pressures on more vulnerable ecosystems while promoting sustainable land management practices. They also act as habitats for a variety of wildlife species, particularly in arid and semi-arid regions, supporting biodiversity and mitigating the effects of land degradation caused by overgrazing, desertification, and climate change.

The project site is located approximately 15 kilometers from the nearest rangeland reserve, Al Mudawara. Al Mudawara Rangeland Reserve, like others in Jordan, plays a vital role in preserving the delicate balance of the desert ecosystem and ensuring that natural resources are used sustainably. Ensuring that the project does not disrupt these efforts is crucial to maintaining the ecological and economic benefits provided by rangeland reserves.



Map 6: Rangelands Reserves in Jordan

Critical Habitat

The Critical Habitat (CH) screening has been developed to evaluate the potential presence of critical habitat within and around the footprint of the Disi Wellfield project area. The report is prepared in accordance with the International Finance Corporation's (IFC) Performance Standard 6 and the European Investment Bank (EIB) Environmental and Social Standard 4. These standards require projects financed by international institutions to assess and avoid adverse impacts on critical habitats and ensure the conservation of biodiversity. (Full CH Screening **Annex 12** within the ESIA Report)

The Disi Wellfield project involves the drilling of several groundwater wells and the construction of associated infrastructure, such as access roads and electricity transmission lines. While the project footprint is limited in size and many areas show signs of ecological degradation and sparse vegetation, its proximity to sensitive ecological features, especially the Rum Important Bird Area (IBA), necessitates a thorough review of potential impacts on habitats and species of conservation concern.

Critical habitat, as per international standards, refers to areas with high biodiversity value that are essential for the survival of species or the functioning of ecosystems. This may include habitats supporting threatened or endemic species, important congregations, or ecosystems with unique ecological functions.

The methodology for this critical habitat screening followed the guidance of IFC Performance Standard 6 (PS6), as well as the complementary framework outlined by EIB Environmental and Social Standard 4. The process involved the following key steps:

Desktop Assessment and Field Survey

A comprehensive desktop review was conducted to gather information on biodiversity features relevant to the Disi Wellfield project area. The desktop review followed by a field visit was conducted over two days (6–7 August 2024) to ground-truth the desktop findings and document local flora and fauna.

Application of IFC PS6 Critical Habitat Criteria

Each of the five criteria for defining critical habitat under IFC PS6 was assessed systematically, using a combination of field data, literature sources, and spatial analysis. The criteria are

- Habitat of significant importance to critically endangered and/or endangered species (International Union for Conservation of Nature and Natural Resources (IUCN) Red List)
- Habitat of significant importance to endemic and/or restricted-range species
- Habitat supporting globally significant concentrations of migratory species and/or congregatory species
- Highly threatened and/or unique ecosystems
- Areas associated with key evolutionary processes

Species or ecosystems that triggered any of the above criteria were examined to determine the following:

- Whether their presence or use of the area is confirmed, likely, or unlikely.
- Whether the project footprint overlaps or is near important habitat features.
- Whether impacts are expected to be significant, residual, or irreversible.

Application of EIB E&S Standard 4: Biodiversity and Ecosystem

Critical habitat is the most sensitive of the high-value biodiversity features and is defined as comprising one of the following:

1. A highly threatened and/or unique ecosystem.
2. A habitat of priority and/or significant importance to critically endangered, endangered, or vulnerable species, as defined by the IUCN Red List of threatened species and in relevant national legislation.
3. A habitat of priority and/or significant importance to a population, range, or distribution of endemic or restricted-range species, or highly distinctive assemblages of species.

4. A habitat required for the survival of migratory species and/or congregatory species.
5. Biodiversity and/or an ecosystem of significant social, economic, or cultural importance to local communities and indigenous groups.
6. A habitat of key scientific value and/or associated with key evolutionary processes.

Risk Assessment

An expert evaluation was used to determine the potential likelihood of critical habitat triggers. In addition, consideration was given to the scale of project activities, the condition of the habitat, and existing disturbances. Where ambiguity existed, a **precautionary principle** was applied, recommending further investigation where necessary.

Conclusion of Screening

Based on the comprehensive assessment of the five Critical Habitat (CH) criteria under the IFC Performance Standard 6 and EIB Environmental and Social Standard 4, the following conclusions are drawn:

1. **Critically Endangered or Endangered Species: Not Triggered**

Although species of conservation concern have been recorded regionally, including Uromastyx aegyptia and Falco naumanni, the project site itself is highly degraded, and no significant populations were recorded.

2. **Restricted-range and Endemic Species: Not Triggered**

No endemic or restricted-range species were confirmed through literature review or the walkover survey, and none of the well locations support the required threshold of ≥10% of a global population.

3. **Migratory and Congregatory Species: Not Triggered**

Not formally triggered. While the eastern part of the project overlaps with the Rum IBA, and several migratory bird species of conservation concern (e.g., Sooty Falcon, Lesser Kestrel) were observed during the field visit, the scale of the project, the limited and disturbed footprint, and the absence of core nesting or roosting habitats reduce the likelihood of significant impact. According to IFC PS6 thresholds, the site does not appear to regularly support ≥1% of any migratory species' global population. Therefore, Criterion 3 is not formally triggered, although precautionary measures are still advised due to the ecological sensitivity of the area.

4. **Threatened Ecosystems: Not Triggered**

The site includes Saharo-Arabian and Sudanian habitats, but these are not listed as CR or EN in the IUCN Red List of Ecosystems, nor are they identified as high conservation priority by national planning frameworks.

5. **Key Evolutionary Processes: Not Triggered**

The site does not support recognized evolutionary processes such as major ecological gradients, refugia, centers of endemism, or unique species assemblages. No evidence of key ecological connectivity or evolutionary significance was identified through the literature or field visits. Consequently, Criterion 5 is not triggered.

6. **Ecosystems of Importance to Communities: Not Triggered**

Although rangelands are used locally, the project area is located in degraded and rarely used lands, and no biodiversity features of social, cultural, or economic significance to local communities were identified.

Ecosystem Services

The location of the project, which is situated within the arid desert ecosystems of Jordan, offers a wide range of ecosystem services that, despite their inconspicuous nature, significantly contribute to the preservation of environmental health and the provision of support for both human and wildlife populations. The regulation of water resources is one of the most important ecosystem services that the region provides because of its importance. Seasonal wadis and water collection points serve a crucial role in recharging groundwater, which is essential for supporting limited plant life, wildlife, and human activities. This is the case despite the fact that rainfall is scarce. In spite of the fact that they are only transitory, these water flow regions contribute to the preservation of soil moisture in specific locations, which in turn fosters the growth of vegetation that would otherwise be impossible in such a dry climate.

It is also important to note that the provision of habitat for biodiversity is an essential ecological service. wadis and tiny valleys support species such as Acacia gerrardii and Retama raetam, which in turn give shelter and food for a variety of desert fauna, including reptiles and migrating birds. Despite the fact that the area is generally devoid of vegetation, wadis and valleys help to sustain these species. Several species of conservation concern, including as the Sooty Falcon and the Sinai Rose Finch, rely on the project area as a stopping place during migration or as nesting grounds. These habitats are essential for the survival of these species, which are important for the conservation of environmental resources. Through the stabilization of soil, the provision of food for herbivores, and the support of the larger food web, the presence of diversified flora, despite its restricted presence, contributes to the overall sustainability of the ecological system.

Additionally, the project site offers regulating services, such as carbon sequestration and soil stabilization, which are important in mitigating the effects of desertification and climate

change. The vegetation, although sparse, helps to prevent soil erosion by anchoring the sandy and gravelly soil, particularly in the wadis. In areas like the Saharo-Arabian and Sudanian zones, this natural soil stabilization is crucial for preventing further land degradation, which could worsen desertification and reduce the area's ability to support both human and ecological needs. Furthermore, the limited plant life in the region contributes to carbon sequestration, helping to mitigate the global impact of greenhouse gas emissions, although at a small scale.

For the local communities surrounding the project site, particularly those engaged in pastoralism, rangelands are an essential resource for their livelihoods. These lands provide important grazing areas for livestock, which is a primary source of income, food, and cultural identity for many nomadic and semi-nomadic communities in Jordan. The natural vegetation in the rangelands, such as *Acacia* and other drought-resistant species, offers forage for sheep, goats, and camels, helping to sustain local economies and preserve traditional ways of life. The well-being of these rangelands directly affects the economic stability of the local communities, as overgrazing or land degradation can lead to diminished forage availability.

3. Assessment of Potential Environmental and Social Impacts

3.1 Assessment Approach

The assessment strategy for evaluating the implications on biodiversity and ecosystem services for the Disi Wellfield project incorporates both desktop studies and fieldwork to ensure a full understanding of the ecological baseline and potential impacts. This technique was established to ensure that the project would be successful. In the beginning, a comprehensive review of the present environmental data was carried out. This review made use of prior environmental impact assessments, surveys, and biodiversity assessments that were pertinent to the area where the project was being carried out. A significant number of species, habitats, and ecosystem services that are present inside and around the project site were identified with the assistance of this literature review.

Field surveys were then planned and executed to validate the findings from the desktop study and to provide up-to-date information on the biodiversity and ecological features. The field teams recorded all flora and fauna observed, emphasizing species of conservation concern and indicators of ecosystem health. This dual approach of combining historical data with fieldwork is crucial for assessing the direct and indirect impacts of the project on local ecosystems and for developing targeted mitigation measures to maintain ecological integrity.

Incorporating the findings from the biodiversity study, the assessment approach also includes an analysis of potential impacts during both the construction and operation phases of the project. The biodiversity study concluded that the project activities are unlikely to cause significant adverse impacts on biodiversity, especially with the implementation of the proposed mitigation measures.

The carefully planned mitigation measures, detailed below, are designed to minimize any potential impacts on these species and the broader ecosystem to the lowest possible extent. This proactive approach aims to ensure that the project adheres to environmental sustainability principles while mitigating potential disturbances to the local biodiversity and ecosystem services.

3.2 Potential Impacts on the Biological Environment

The impact assessment for the project evaluates the potential effects of activities such as drilling, road construction, and the installation of electricity transmission lines on the local environment, with a focus on flora, fauna, sensitive habitats, and ecosystem services. The project area is located in a desert ecosystem characterized by low vegetation cover and significant human disturbance from activities such as grazing and vehicle movement. These factors have already degraded much of the local environment, reducing its ecological sensitivity. As a result, the overall impact of the project is likely to be somewhat mitigated by the existing disturbances and the sparse vegetation, which limits the extent of habitat destruction and species displacement. Nevertheless, careful consideration is required to ensure that remaining sensitive habitats, such as wadis, and species of conservation concern are protected from further degradation.

The following sections will cover the impacts of both the construction and operation phases of the project. Each phase will be analyzed in detail, focusing on the specific activities involved—such as drilling, road construction, and the installation of electricity transmission lines—and their potential effects on the local environment.

3.2.1 Construction Phase

1. Impact on Flora

During the construction phase the potential impacts on flora can be significant, primarily due to physical disturbances and habitat alterations.

- **Direct Loss of Vegetation**: Land clearance for drilling sites leads to the removal of plant species, particularly in wadis and runoff zones where vegetation like *Acacia gerrardii* and *Retama raetam* are concentrated. Desert ecosystems regenerate slowly, so once vegetation is removed, it may take years or decades for plants to re-establish, resulting in prolonged habitat degradation.
- **Soil Compaction**: The use of heavy machinery during drilling compacts the soil, making it difficult for plant roots to penetrate and for seeds to germinate, hindering vegetation recovery.
- **Increased Soil Erosion**: With vegetation removed, there is a higher risk of wind and water erosion, particularly in sandy and loose soil areas, leading to further habitat degradation.
- **Loss of Water Retention Capacity**: Vegetation in wadis helps retain water during rare rain events, and its removal decreases the area's ability to store moisture, negatively affecting plant growth.

- **Reduction in Biodiversity**: The destruction of habitats due to drilling, road opening, and other activities reduce plant diversity, affecting the ecological balance and reducing the overall health of the ecosystem.
- **Pollution**: Project activities can introduce pollutants such as drilling fluids, fuel, oil, and other chemicals into the environment. Accidental spills or improper waste disposal can contaminate the soil and nearby water sources, particularly in wadis, negatively affecting plant life and degrading habitats.
- **Workers' Illegal Activities**: Workers involved in operations may engage in illegal activities, such as unauthorized cutting of plants for firewood or other uses, further depleting the already scarce vegetation.
- **Improper Waste Disposal**: If waste from different operations, including non-biodegradable materials and hazardous waste, is not properly managed, it could accumulate in the area, leading to long-term pollution that affects both flora and fauna.
- **Disturbance to Wildlife and Habitat from Human Presence**: Increased human activity during the construction phase, including workers and machinery, could disturb local wildlife and contribute to further degradation of plant habitats, particularly in sensitive areas like wadis.
- **Introduction of Invasive Species**: Workers and equipment may unintentionally introduce non-native plant species into the area, which could outcompete local flora and further disrupt the fragile desert ecosystem.
  It has been observed that several non-native tree species have been planted near the already operating wells, which is considered an introduction of non-native species into the site. Introducing such species can disrupt the local ecosystem by outcompeting native flora and altering habitat conditions for local fauna. To protect the integrity of the desert ecosystem, it is recommended that this practice be prohibited near the new wells. Additionally, the existing non-native trees should be gradually replaced with native species that are better adapted to the local environment, promoting biodiversity and ecosystem balance.
- **Edge Effects**: Roads create new micro-environments along their edges, altering moisture, light, and temperature conditions, which can negatively impact the growth of native plants.

2. Impact on Fauna

- **Habitat Displacement**: Project activities may lead to the loss or degradation of key habitats, forcing fauna to relocate. This displacement can increase stress on wildlife, particularly for reptiles, small mammals, and birds that rely on specific microhabitats.
- **Disturbance from Noise and Human Activity**: The noise and increased human presence associated with construction work can disrupt wildlife behavior, including feeding, breeding, and migration patterns. Sensitive species may abandon areas near roads due to disturbance.

- **Increased Mortality Risk**: The movement of heavy machinery and vehicles poses a direct threat to small fauna such as reptiles and small mammals.
- **Pollution Impact on Fauna**: Spills of chemicals, fuels, or other pollutants from machines can contaminate water sources, which can harm or even kill animals that drink from these contaminated areas. The spread of toxic substances can also affect the food chain, impacting predators and prey alike.
- **Disruption of Breeding Cycles**: Increased human activity, noise, and habitat disruption during drilling and construction works may interfere with the breeding cycles of certain species. For example, bird species may abandon their nests, leading to lower reproductive success.
- **Introduction of Non-native Species**: Human activity related to construction work may unintentionally introduce non-native species such as pets, which can compete with local fauna for resources, further stressing already fragile wildlife populations.
- **Illegal Hunting**: The presence of workers in remote areas may increase the risk of illegal hunting. Some workers may engage in hunting local wildlife for food or sport, which can severely impact already vulnerable species. Roads provide easier access for humans to previously remote areas, increasing the risk of poaching and illegal hunting, which can further threaten wildlife populations.
- **Collision Risk for Birds**: Overhead transmission lines pose a significant risk of collisions for birds, particularly larger species such as raptors, and migratory birds like the *Sooty Falcon* and *Lesser Kestrel*, which can be injured or killed by striking the wires.
- **Electrocution Risk**: Birds and other wildlife that perch on power lines or towers may be at risk of electrocution, particularly larger birds that may span across conductive components.
- **Disturbance to Migratory Routes**: Transmission lines could interfere with established migratory routes for birds, especially in sensitive areas such as Rum Important Bird Areas, which may cause birds to alter their natural migration patterns, leading to exhaustion or decreased survival rates.

3. Impact on Sensitive Habitat

The drilling activities and associated infrastructure development near or within the Rum IBA pose a significant disturbance to bird populations, particularly species of conservation concern such as the Sooty Falcon, Lesser Kestrel, and Sinai Rose Finch. Increased noise, vibrations, and human presence can disrupt key behaviors such as nesting, feeding, and migratory stopovers. Sensitive species may abandon their nesting sites or experience lower breeding success due to these disturbances, leading to long-term population declines. Migratory birds, which rely on the IBA as an essential stopover during their journeys, may be forced to alter their routes or stop at suboptimal locations, further impacting their survival. Additionally, large raptors, which are particularly sensitive to human activity, could face habitat abandonment, diminishing the ecological value of the IBA for bird conservation.

However, given the relatively limited size of the project activities and the possibility of implementing targeted mitigation measures, these impacts can be minimized or avoided altogether, preserving the ecological integrity of the IBA.

4. Impact on Ecosystem Services

The project's activities, including drilling, road construction, and the installation of electricity transmission lines, are likely to affect several ecosystem services in the region. One of the most significant services is water regulation, particularly in desert environments where water is scarce. Wadis and runoff areas play a crucial role in collecting and storing water during rare rain events, supporting vegetation and wildlife that depend on these moisture-rich zones. Drilling and road construction may disrupt natural water flow, reducing the ability of these areas to retain water, leading to decreased availability for plants and animals. Additionally, the compaction of soils and removal of vegetation can increase runoff and erosion, further reducing the water retention capacity of the land and threatening both flora and fauna that rely on these water sources.

Another key ecosystem service impacted by the project is soil stabilization. In desert ecosystems, vegetation plays a vital role in preventing soil erosion by anchoring the soil with its roots. The removal of plants for drilling operations, road construction, and transmission lines can lead to soil erosion, particularly in sandy or loose soils. Without vegetation cover, the area is more vulnerable to wind and water erosion, which can degrade the land and lead to desertification. The loss of vegetation also reduces carbon sequestration, although it is minimal in desert ecosystems, contributing to the global challenge of climate change. Furthermore, the degradation of habitats may impair the area's ability to support biodiversity, disrupting the intricate balance of ecosystem services that sustain both wildlife and local communities.

3.2.2 Operation Phase

During the operation phase of the project, there are potential ongoing impacts on flora, fauna, sensitive habitats, and the broader ecosystem services that require careful management to minimize long-term environmental damage.

1. Impact on Flora

- **Continued Vegetation Disturbance**: The operation of wells, roads, and transmission lines may prevent the natural regeneration of vegetation in disturbed areas, particularly in desert ecosystems where recovery is already slow. Regular maintenance activities could further compact the soil and limit plant regrowth.

- **Invasive Species Spread**: During the operation phase, human activities and continued presence in the area may unintentionally promote the spread of invasive plant species, which can outcompete native flora and further degrade the ecosystem.
- **Edge Effects from Infrastructure**: Infrastructure such as roads and transmission lines will continue to create edge effects, altering light, moisture, and temperature conditions that negatively affect native plant species near the infrastructure, making it difficult for them to thrive

2. Impact on Fauna

- **Habitat Displacement**: The continued operation of wells and associated infrastructure may displace wildlife, especially if regular maintenance activities increase human presence in the area. Species that are sensitive to disturbances, such as birds and reptiles, may abandon habitats near the wells.
- **Collision and Electrocution Risks for Birds**: Overhead transmission lines remain a collision hazard for birds during the operation phase, especially for larger birds and migratory species. Electrocution risks also persist for birds that may perch on power lines or towers.
- **Noise and Human Activity Disturbance**: Maintenance activities, vehicle movements, and noise associated with the operation of the project can disturb local wildlife. Sensitive species may alter their foraging, nesting, or breeding behavior in response to the ongoing disturbance.
- **Increased Access for Illegal Activities**: The presence of operational infrastructure may provide easier access to remote areas, leading to increased risk of illegal hunting or poaching, which could threaten vulnerable wildlife species in the area.
- **Alteration of Migration and Movement Patterns**: Wildlife corridors may be further impacted during the operation phase as infrastructure continues to act as a barrier to the movement of animals, especially for migratory birds and larger mammals that rely on large, connected habitats.

3. Impact on Sensitive Habitats

The operation phase of the project poses ongoing risks to sensitive habitats, particularly in areas like wadis and the Rum Important Bird Area. Habitat fragmentation remains a major concern, as the presence of infrastructure such as roads and transmission lines can disrupt wildlife corridors and reduce the connectivity of key habitats. This fragmentation limits the movement of migratory birds and other wildlife, leading to isolated populations and reduced biodiversity. In particular, species of conservation concern, like those that rely on the IBA, may experience reduced breeding success and altered migration patterns due to ongoing human disturbance and infrastructure presence.

Furthermore, increased human activity during the operation phase, including maintenance work and vehicle access, also introduces the risk of continued disturbance to wildlife and the potential spread of invasive species, which could further degrade these crucial habitats.

4. Impact on Ecosystem Services

The operation phase of the project is likely to have lasting effects on key ecosystem services in the region, particularly water regulation and soil stabilization. Soil stabilization, a vital service provided by desert vegetation, may be compromised by the continued disturbance of flora around operational infrastructure, increasing the risk of erosion and land degradation.

In addition, ecosystem services related to carbon sequestration, though minimal in desert environments, could also be impacted by the removal or degradation of vegetation over time. As native plants are slow to recover in arid conditions, any long-term damage to flora may further reduce the ecosystem's capacity to sequester carbon. The degradation of sensitive habitats may also diminish their ability to provide essential services like habitat provision for wildlife, further disrupting the ecological balance and affecting the communities that depend on these natural systems for grazing, water collection, and other resources.

3.3 Impact Assessment

The following tables summarize the environmental impacts identified during the assessment process for construction and operation phases. Each impact is categorized by its **severity** and **likelihood**. These factors help to understand the potential consequences of project activities (drilling, road construction, and electricity transmission) on key environmental components. The severity of each impact reflects the degree of harm it may cause, while likelihood indicates the probability of its occurrence.

- **Severity**: High (H), Moderate (M), Low (L)
- **Likelihood**: High (H), Moderate (M), Low (L)

Table 6: Impact Assessment During Construction Phase

Construction Phase				
Environmental Component	**Impact Type**	**Severity**	**Likelihood**	**Comments**
Flora	Vegetation loss and degradation	High	Moderate	Direct removal of native species in wadis and other sensitive areas.
	Invasive species introduction	High	Low	Roads and human activity may introduce non-native species that outcompete natives.
	Increased Soil Erosion	Moderate	High	Wind and water erosion, especially on sandy and loose soils, increases with vegetation removal, degrading habitat.
	Soil compaction	Moderate	High	Machinery use and construction activities compact the soil, limiting plant regrowth.

Construction Phase

Environmental Component	Impact Type	Severity	Likelihood	Comments
	Loss of Water Retention Capacity	Moderate	Low	Changes in runoff areas affect plant growth, especially in wadis.
	Reduction in Biodiversity	High	Low	Construction work destroys habitats, lowering plant diversity and ecosystem health.
	Pollution	Low	Low	Fuel, drilling fluids, and other substances can pollute the environment during construction. In wadis, accidental spills or inappropriate trash disposal can contaminate soil and water supplies, harming plant life and habitats.
	Workers' Illegal Activities	Moderate	Low	Workers may illegally chop plants for firewood or other usage, depleting precious vegetation.
	Improper Waste Disposal	Moderate	Low	If non-biodegradable and hazardous trash from operations is not adequately managed, it could accumulate and pollute the environment for years.
	Disturbance to Wildlife and Habitat from Human Presence	Moderate	High	Workers and machines may disturb local wildlife and degrade plant habitats, especially in sensitive places like wadis, while drilling.
	Edge Effects	Moderate	High	Road edges produce new micro-environments that change moisture, light, and temperature, which can harm native plant growth.
Fauna	Wildlife disturbance	Moderate	High	Noise, human presence, and construction activities disrupt natural behaviors.
	Habitat loss	Moderate	Moderate	Loss of key habitats affects wildlife populations, particularly in sensitive areas.
	Mortality risk (vehicle collisions)	Moderate	High	Increased traffic leads to higher risks for small fauna, especially reptiles.
	Bird collisions with power lines	High	Moderate	Power lines pose significant risks for birds, particularly large species and raptors.
	Electrocution	Moderate	Low	Birds perched on transmission lines are at risk of electrocution.
	Illegal hunting and poaching	Moderate	Low	Increased human access may lead to illegal hunting, threatening local wildlife.
	Disruption of migratory patterns	High	Low	Infrastructure may interfere with bird migration routes, particularly near IBAs.

Construction Phase				
Environmental Component	**Impact Type**	**Severity**	**Likelihood**	**Comments**
	Pollution Impact on Fauna	High	Low	Roads and infrastructure cut across natural wildlife corridors, disrupting movement.
	Disruption of Breeding Cycles	High	Low	Key areas like wadis and IBAs may be severely fragmented by project activities.
	Introduction of Non-native Species	Moderate	Low	Wells and roads may alter natural water retention areas, affecting sensitive habitats.

Table 7: Impact Assessment During Operation Phase

Operation Phase				
Environmental Component	**Impact Type**	**Severity**	**Likelihood**	**Comments**
Flora	Continued Vegetation Disturbance	Moderate	Low	Wells, roads, and transmission lines may limit vegetation regeneration in disturbed environments, especially desert ecosystems with delayed recovery. Regular maintenance may compact soil and hinder plant development.
	Invasive Species Spread	Moderate	Low	Human activities and presence during operation may propagate invasive plant species, which can outcompete local flora and harm the ecology.
	Edge Effects from Infrastructure	Low	Low	Edge impacts from roadways and transmission lines will continue to modify light, moisture, and temperature, making it hard for native plant species to thrive.
Fauna	Habitat Displacement	Moderate	Moderate	Wells and infrastructure may displace wildlife, especially if maintenance increases human presence. Birds and reptiles may leave well zones due to disruptions.
	Collision and Electrocution Risks for Birds	Moderate	Moderate	In operation, overhead electricity wires provide a collision risk for birds, especially larger and migratory species. Birds perched on electrical lines or towers risk electrocution.
	Noise and Human Activity Disturbance	Moderate	High	Project maintenance, vehicle movements, and noise might disturb wildlife. Due to the disruption, sensitive animals may change their foraging, nesting, or breeding habits.
	Reduction in Food Availability	Low	Low	Wells and associated infrastructure can reduce local vegetation, which can reduce food availability for

				herbivorous species and predator populations that depend on them.
	Increased Access for Illegal Activities	Low	Low	Operational infrastructure may make distant locations more accessible to illegal hunting and poaching, which could endanger sensitive wildlife species.
	Alteration of Migration and Movement Patterns	Low	Low	During operation, infrastructure may hinder wildlife mobility, especially migratory birds and larger mammals that need extensive, connected habitats.

4. Recommended Mitigation Measures

4.1 Recommended Mitigation Measures for Biological Environment

4.1.1 Construction Phase

Environmental Component	Impact Type	Mitigation Measures
Flora	Vegetation loss and degradation	• Implement strict controls on clearing and grading activities, limit them to designated areas only. • When possible, save and transplant native plants. • Re-vegetate disturbed areas with native species using appropriate seed mixes and planting techniques.
	Invasive species introduction	• Clean construction equipment and vehicles thoroughly before entering the site to prevent the introduction of invasive plant seeds. • Regularly monitor the site for invasive species and implement control measures if necessary. • Prohibit workers from planting invasive species
	Increased Soil Erosion	• Implement erosion control measures. • Minimize soil disturbance during construction.
	Soil compaction	• Limit vehicle access to designated areas. • Use low ground pressure machinery when possible.
	Loss of Water Retention Capacity	• Design roads and structures to minimize disruption of natural drainage patterns. • Install erosion control measures to prevent sedimentation in wadis and other water bodies. • Implement water conservation measures during construction.
	Reduction in Biodiversity	• Avoid construction in sensitive areas. • Create buffer zones around sensitive areas to minimize disturbance.
	Pollution	• Implement a Spill Prevention, Control, and Countermeasure (SPCC) Plan to manage potential spills of fuel and other hazardous materials. • Properly dispose of all construction waste and debris at designated landfills. • Train workers on proper handling and disposal of hazardous materials.
	Workers' Illegal Activities	• Educate workers about the importance of environmental protection and the consequences of illegal activities. • Supervise workers during construction activities. • Implement penalties for violations.
	Improper Waste Disposal	• Implement a comprehensive waste management plan that includes recycling and reuse of materials where possible. • Ensure that hazardous waste is disposed of at approved facilities. • Conduct regular waste audits to ensure compliance with waste management plan.

Environmental Component	Impact Type	Mitigation Measures
	Disturbance to Wildlife and Habitat from Human Presence	• Restrict construction activities during sensitive periods like breeding seasons. • Implement noise and light mitigation measures to minimize disturbance to wildlife.
	Edge Effects	• Minimize the creation of new edges by limiting road width and footprint. • Re-vegetate road edges with native plants to create a buffer zone.
Fauna	Wildlife disturbance	• Restrict construction activities during sensitive periods like breeding seasons. • Implement noise and light mitigation measures to minimize disturbance to wildlife.
	Habitat loss	• Avoid construction in sensitive habitats. • Minimize habitat fragmentation by clustering construction activities. • Create wildlife corridors to connect fragmented habitats.
	Mortality risk (vehicle collisions)	• Implement speed limits and traffic calming measures in construction areas. • Install wildlife crossing structures where necessary. • Educate workers about wildlife awareness.
	Bird collisions with power lines	• Design power lines with bird-friendly features like markers and diverters. • Monitor bird activity and implement mitigation measures if necessary.
	Electrocution	• Design power lines with bird-friendly features like insulated perches. • Regularly inspect and maintain power lines to prevent electrocution hazards.
	Illegal hunting and poaching	• Educate workers about the importance of wildlife conservation and the consequences of illegal hunting. • Increase surveillance and enforcement in construction areas.
	Disruption of migratory patterns	• Avoid construction in sensitive areas during migration seasons. • Implement lighting and noise mitigation measures to minimize disturbance to migrating birds.
	Pollution Impact on Fauna	• Implement strict erosion and sediment control measures to prevent pollution of waterways. • Properly manage and dispose of hazardous materials to prevent contamination of soil and water. • Conduct regular water quality monitoring.
	Disruption of Breeding Cycles	• Avoid construction in sensitive habitats during breeding seasons. • Implement noise and light mitigation measures to minimize disturbance to breeding wildlife.
	Introduction of Non-native Species	• Prohibit workers from introducing animals to the site • Educate workers about the impact of non-native species on wildlife

4.1.2 Operation Phase

To mitigate the impacts during operation phase, it is important to implement effective management strategies during this phase. These should include:

Environmental Component	Impact Type	Mitigation Measures
Flora	Continued Vegetation Disturbance	• Implement a long-term monitoring and maintenance plan for vegetation in disturbed areas. • Minimize soil disturbance during maintenance activities. • Use native plant species for revegetation and landscaping.
	Invasive Species Spread	• Continue regular monitoring for invasive species and implement control measures promptly. • Educate staff and contractors about invasive species identification and control.
	Edge Effects from Infrastructure	• Plant native vegetation along infrastructure edges to create buffer zones and reduce edge effects. • Monitor vegetation health along edges and implement corrective measures if necessary.
Fauna	Habitat Displacement	• Conduct regular wildlife monitoring to assess impacts on habitat use. • Implement measures to minimize human presence and disturbance in sensitive areas. • Create artificial habitats or nesting structures to compensate for habitat loss.
	Collision and Electrocution Risks for Birds	• Install bird flight diverters on power lines. • Implement regular maintenance and inspection of power lines to prevent electrocution hazards.
	Noise and Human Activity Disturbance	• Implement noise mitigation measures such as mufflers and sound barriers. • Schedule maintenance activities during periods of low wildlife activity. • Restrict vehicle access to designated areas.
	Increased Access for Illegal Activities	• Increase surveillance and enforcement in remote areas. • Educate workers and local communities about the importance of wildlife conservation and the consequences of illegal activities.
	Alteration of Migration and Movement Patterns	• Maintain or create wildlife corridors to facilitate movement. • Implement measures to reduce barriers to movement, such as fencing and roads. • Monitor wildlife movement patterns and adjust management practices if necessary.

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