

STRATEGY AND EXECUTION PLAN FOR ECOSYSTEM RESTORATION IN ALULA

April 2025

TABLE OF CONTENTS

LIST OF FIGURES 4
LIST OF TABLES 6
ABBREVIATIONS 7
EXECUTIVE SUMMARY 9
1. INTRODUCTION 11
2. ANALYIS OF THE CURRENT SITUATION 16
2.1. Objective of the Analysis of the Current Situation 16
2.2. Ecological Context 16
2.2.1. Key findings 17
2.2.2. Identified gaps 19
2.3. International and Regional Context 19
2.3.1. Key Findings 20
2.4. Drivers-Pressures-State-Impact-Response (DPSIR) Framework: a focus on socio-economic context 23
2.4.1. Key Findings 23
2.5. Conclusion 27
3. BASELINE ASSESSMENT 28
3.1. Sharaan National Park (SNP) 29
3.2. Harrat Uwayrid Biosphere Reserve (HUBR) 30
3.3. Harrat AlZabin Nature Reserve (HZNR) 31
3.4. Gharameel Nature Reserve (GNR) 32
3.5. Khaybar White Volcano Geopark (KWVG) 33
3.6. Wadi Nakhlah Nature Reserve (WNNR) 34
3.7. Selection of priority areas for restoration and next steps for scaling up 35
3.7.1. The results of these assessments lead to identify 22 priority areas that require ecological restoration in those 6 Protected Areas. 35
3.7.2. Plant species of interest for Ecological Restoration 35
3.8. Conclusion 36
4. VALUATION OF ECOSYSTEM SERVICES 38
4.1. Categorisation of ecosystem services 38
4.2. Quantitative assessment and spatial analysis 40
4.3. Economic valuation 44
4.4. Social value assessment 46
4.5. Conclusion 46
5. COST OF ECOSYSTEM DEGRADATION AND RESTORATION 47

5.1. Introduction to Cost of ecosystem degradation 47
5.1.1. Estimation of Land Use and Cover Changes between 2017-2022 47
5.1.2. Projected Land Use and Land Cover Changes: 2040 scenarios 48
5.1.3. Summary of results 48
5.2. Conclusion 51
6. ECOSYSTEMS STRATEGIC GUIDELINES AND PRINCIPLES 52
6.1. Existing restoration guidance and key principles 53
6.1.1. The UN Decade on Ecosystem Restoration guidance 53
6.1.2. The Society for Ecological Restoration guidance 53
6.2. RCU Principles for Ecosystem Restoration 54
6.3. Strategic guidelines for ecosystem restoration 55
6.3.1. Identifying Restoration Targets, Goals, and Objectives 55
6.3.2. Key Standards of Practice for Application in AlUla County 56
6.3.3. Stakeholder engagement 63
6.4. Conclusion 64
7. PLAN FOR SCALING UP ECOLOGICAL RESTORATION IN ALULA 65
7.1. Determining Restoration Priorities 65
7.1.1. Initial Prioritisation 65
7.1.2. Categorisation of potential restoration areas 67
7.2. Sequential Prioritisation (Phasing) of Restoration 70
7.3. Case Studies 73
7.3.1. Case Study 1 73
7.3.2. Case Study 2 75
7.4. Conclusion 76
8. STRATEGIC COMPONENTS OF THE STRATEGY 80
8.1. Vision, Mission, and Pillars of the Strategy with Nested Initiatives and Projects 80
8.2. Key Performance Indicators 83
8.3. Conclusion 83
9. ECOSYSTEM RESTORATION ACTION PLAN 85
9.1. Conclusion 90
10. GOVERNANCE AND FUNDING MODEL 91
10.1. Governance Model 91
10.1.1. Capacity building programme for improved governance 97
10.2. Funding Model 99
10.2.1. Considerations for Funding KPIs 102
10.3. Conclusion 102
11. RISKS AND MITIGATION 103
11.1. Main Risks Considerations and Proposed Mitigation Measures 104
11.2. Limitations of the Modelling Outputs and Future Recommendations 108

11.3. Conclusion 109

12. CONCLUSION 110

12.1. Key outcomes of the Strategy for Ecosystem Restoration 110
12.1.1. Stakeholder engagement 110
12.1.2. Identification of key areas for restoration for 2025-2035 110
12.1.3. Sustainable development and local governance 111

12.2. Implementation of the Strategy for Ecosystem Restoration 111
12.2.1. Key considerations for implementation of Phase 1 (2025-2030) 111
12.2.2. Key considerations for implementation of Phase 2 (2030-2035) 112
12.2.3. Key recommendations for the implementation of the Strategy for Ecosystem Restoration Phase 1 and Phase 2 112

LIST OF REFERENCES 114

Annex (1) - habitats' maps of the six protected areas 116

Annex (2) - list of plant species of interest for ecological restoration 122

Annex (3) - areas per protected area and habitat under category 1, 2 and 3. 133

LIST OF FIGURES

Figure 1.1- Key outcomes delivered from the 3rd UNCCD scientific conference 12
Figure 1.2-Vision 2030 key performance indicators RCU is contributing to. 14
Figure 1.3-Summary of the ten deliverables that will later be individually detailed in the report 15
Figure 2.1- Contexts under the analysis of the current analysis supporting the development of the Strategy for Ecosystem Restoration 16
Figure 2.2- Identification of priority areas of biodiversity hotspots in three protected areas 17
Figure 2.3- Summary of initial assessment of vegetation communities and habitats 18
Figure 2.4- Key recommendations for shaping the strategy's next steps. 27
Figure 3.1-The 9 habitats existing in AlUla protected areas 28
Figure 3.2-Ophioglossum polyphyllum A.Braun ex Seub 29
Figure 3.3-Red sandstone buttes habitat 29
Figure 3.4-Dunes habitat 29
Figure 3.5-Deep and loosely sandy soil 30
Figure 3.6-HUBR 30
Figure 3.7-Cleome Chrysantha 31
Figure 3.8-Wadis found in HZNR 31
Figure 3.9-Stony gravelly soil from turbulent alluvial deposit in wadi 31
Figure 3.10-Sandy open environments habitat 32
Figure 3.11-Very shallow sandy soil from plain 32
Figure 3.12-Artemisia Judaica L 33
Figure 3.13-Sandy-silty shallow soil accumulated in micro-depression from lava formations 33
Figure 3.14-Sparse vegetation in lava fields 33
Figure 3.15-Capparis Cartilaginea Decne. 34
Figure 3.16-Species rich open shrubland formation 34
Figure 3.17-Compact sandy to sandy-loam soil with surface gravels 34
Figure 3.18- Illustration of examples of species of interest for ecological restoration for the six Protected Areas 36
Figure 3.19-Next steps of the strategy based on the baseline assessment outcomes, based on SNP baseline assessment 37
Figure 4.1- Categorisation of ecosystem services in AlUla based on MA 2005 39
Figure 4.2-Summary of the quantitative assessment and spatial analysis 42
Figure 4.3-Hotspots in A) SNP, B) HUBR, C) HZNR, D) GNR, E) WNNR and F) KWVG 43
Figure 5.1- Summary of historical trends 49
Figure 5.2- Summary of methodology to estimate cost of land degradation 50
Figure 6.1-The SER Restorative Continuum 52
Figure 6.2- Global guidance in relevance to AlUla context 54

Figure 6.3-The ecological recovery wheel recommended for arid land with attributes and sub-attributes 56

Figure 6.4- Information utilised for developing reference models in AlUla County. 57

Figure 6.5 - Conceptualizing ground truthing. Categories 1, 2, and 3 refer to the mapping Categories in the spatial model that helps to identify priority areas for ecological restoration across AlUla Protected Areas under the Strategy (see the chapter 7 entitled 58

Figure 6.6- Process to identify restoration interventions per habitat. 60

Figure 6.7- The three types of monitoring for restoration activities. 62

Figure 7.1- Gharameel NR ecological conditions zoning 67

Figure 7.2- Mapping Category development and description. 67

Figure 7.3- Gharameel Nature Reserve areas per habitat under Categories 1, 2, and 3. 68

Figure 7.4-Sequential restoration prioritisation and implementation timeline 70

Figure 7.5- Final Maps Showing Phased Restoration Approach in upper left WNNR, upper mid SNP, upper right KWVG, lower left HZNR, lower mid HUBR and lower right GNR 72

Figure 7.6- Project area mosaic identified in Gharameel NR, with two habitats: red sandstone buttes and sandy open environments 73

Figure 7.7- Full area designated as mosaic project area 73

Figure 7.8- Steps for case study 1. 74

Figure 7.9-Steps for case study 2. 75

Figure 10.1- Functional and technical capacity building. 97

Figure 10.2- Steps for developing and implementing a capacity building programme 98

Figure 10.3- Global biodiversity conservation financing in 2019. 100

LIST OF TABLES

Table 1.1 - RCU's Vision, Mission and Objectives 13

Table 1.2 - SDG targets aligned with RCU's mission (Transforming our world: The 2030 Agenda for Sustainable Development). 14

Table 2.1-Comparative analysis of differences in national ecological restoration strategies 21

Table 2.2-- Summary of Drivers, Pressures, States and Impacts. 23

Table 2.3- Summary of responses 25

Table 4.1- Hot spots identified and their main characteristics 41

Table 4.2-Ecosystem services selected for economic valuation. 44

Table 4.3- Alignment of valuation methods with the SEEA 45

Table 4.4- Economic value of selected ecosystem services 45

Table 5.1- Summary of historical trends in percent land cover 49

Table 5.2- Hectares estimated to convert to rangeland by 2040 50

Table 7.1- Scoring levels per ecological parameter. 66

Table 7.2 - Mapped project areas per Protected Area by overlap with 2024 Priority Areas and preliminary community suggested restoration sites (excluding harrat sites). 69

Table 7.3-Phased approach for restoration implementation where Phase 1 and Phase 2 show the total area where final restoration sites of 65,000 ha will be selected from 71

Table 7.4- Recommended Overall Restoration Interventions Based on Parameter Scoring 76

Table 7.5-Summary of interventions per current habitat and target habitat 77

Table 7.6-Summary of planting densities based on categories 1, 2 and 3. 79

Table 8.1-RCU Mission, Vision, and Objectives 81

Table 8.2- RCU’s vision, mission, pillars, and strategic objectives, and initiatives for the Strategy for Ecosystem Restoration. 82

Table 8.3– Strategic and operational KPIs of the Strategy for Ecosystem Restoration. 84

Table 9.1- Action Plan Summary. 87

Table 9.2- Action plan timeline (Green indicates completed project) 89

Table 10.1- Key governance roles for internal and external entities and stakeholders for each pillar of the Strategy. 92

Table 10.2- Summary of stakeholder engagement priorities. 95

Table 10.3- Capacity building recommendations by pillar. 98

Table 10.4- Prospective funding types for the Strategy. 101

Table 11.1- Risk assessment matrix for the Strategy. 105

Table 11.2 Risk assessment matrix for the Strategy. 2 106

ABBREVIATIONS

AG: RCU Agriculture Department
C-SP: RCU Culture - Sector Planning Department
CBD: UN Convention on Biological Diversity
CBO: Community-based organisation
CBR: RCU Breeding and Reintroduction Department
CERP: Certified Ecological Restoration Practitioner (SER)
CERPIT: Certified Ecological Restoration Practitioner-in-Training (SER)
CIFOR-ICRAF: The Center for International Forestry Research and World Agroforestry
DD: RCU Destination Development Department
ELD: Economics of Land Degradation
ERW: Ecological Recovery Wheel
ES: RCU Environment and Safety Department
ESIA: Environmental and Social Impact Assessment
ESV: Ecosystem Service Values
FAO: UN Food and Agriculture Organization
FERM: Framework on Ecosystem Restoration Monitoring
FPA: RCU Financial Planning and Analytics Department
FPIC: Free, prior, and informed consent
GLI: G20 Global Land Initiative
GNR: Gharameel Nature Reserve
HRPGD: RCU Hotels and Resorts Planning and Guidelines Development
HUBR: Harrat Uwayrid Biosphere Reserve
HZNR: Harrat AlZabin Nature Reserve
InVEST: Integrated Valuation of Ecosystem Services Trade-offs
ISF: Restoration Project Information Sharing Framework
IUCN: International Union for Conservation of Nature
KM-GBF: Kunming-Montreal Global Biodiversity Framework
KPI: Key Performance Indicator
KSA: Kingdom of Saudi Arabia
KWVG: Khaybar White Volcano Geopark
LDN: Land Degradation Neutrality
LRI: Lebanon Reforestation Initiative
MA: Millenium Ecosystem Assessment Framework
MEA: Multilateral Environmental Agreement
MECP: Mitigation and Ecological Compensation Program
METT: Management Effectiveness Tracking Tool
MEWA: Ministry of Environment, Water, and Agriculture
MGI: Middle East Green Initiative

NCVC: National Center for Vegetation Cover (KSA)
NDVI: Normalized Difference Vegetation Index
NGO: Non-governmental organization
NIR: Near Infra-Red
NP: National Park
PA: Priority Area
RCU: Royal Commission for AlUla
ROWA: International Union for Conservation of Nature, Regional Office for West Asia
RTA: Restoration Training Academy
SCC: Social Cost of Carbon
SDGs: UN 2030 Sustainable Development Goals
SEEA: System of Environmental Economic Accounting
SER: Society for Ecological Restoration
SER Standards: International Principles and Standards for the Practice of Ecological Restoration
SGI: Saudi Green Initiative
SLO: Social licence to operate
SME: Small and medium-sized enterprise
SMU: Soil Map Unit
SNP: Sharaan National Park
SOPs: Standards of Practice
SOW: Scope of work
SP: RCU Strategy and Performance Department
STU: Soil Typological Unit
TGBS: The Global Biodiversity Standard
The Strategy: Strategy and Execution Plan for Ecosystem Restoration in AlUla County
TK: Traditional knowledge
UN Decade: UN Decade on Ecosystem Restoration
UNCCD: United National Convention to Combat Desertification
UNDP: United Nations Development Programme
UNEP: United Nations Environment Programme
UNFCCC: United Nations Framework Convention on Climate Change
USAID: U.S. Agency for International Development
WADI: Wadi for Sustainable Ecosystems Development
WM: RCU Water Management Department
WNNR: Wadi Nakhlah Nature Reserve
WWF: World Wildlife Fund

EXECUTIVE SUMMARY

The Royal Commission of AlUla (RCU) was established to protect and safeguard AlUla, a region of outstanding natural and cultural significance in North-West Saudi Arabia. The RCU is embarking on a long-term master plan to develop and deliver a sensitive and sustainable transformation of the region. Under Saudi Arabia's Vision 2030 Plan, RCU will work to 1) preserve and restore the natural heritage of AlUla, 2) develop a sustainable economic development to protect AlUla for future generations and 3) empower AlUla residents through training, education and skills development. The Strategy and Execution Plan for Ecosystem Restoration in in AlUla (herein the Strategy for Ecosystem Restoration) has been developed to contribute to RCUs goals to protect and enhance the diverse ecosystems across the AlUla Protected Areas, aligning with international standards for ecosystem restoration. This will also crucially contribute to national commitments concerning habitat regeneration and desertification control.

Over a timeframe of ten years (2025-2035), The Strategy for Ecosystem Restoration will ensure the good and successful implementation of ecosystem restoration projects in line with RCU overall vision, mission, and strategic objectives. A team of multi-disciplinary experts, led by the International Union for Conservation of Nature, Regional Office for West Asia (IUCN ROWA) conducted a series of ten deliverables over the length of two years (2023-2025) to deliver a complete and comprehensive Strategy for Ecosystem Restoration that includes:

- Analysis of past and current data generated by RCU since its establishment;
- Development of new ecological data through thorough baseline assessments important for the development of ecosystem restoration plans. The baseline assessment conducted research such as 1) field pedological work, soil survey, and georeferenced soil database development; 2) vegetation survey; and 3) ecosystem mapping of the six Protected Areas of AlUla County: Gharmeel Nature Reserve (GNR), Harrat AlZabin Nature Reserve (HZNR), Harrat Uwayrid Biosphere Reserve (HUBR), Khaybar White Volcano Geopark (KWVG), Sharaan National Park (SNP) and Wadi Nakhlah Nature Reserve (WNNR).
- Categorization and valuation of important ecosystem services that will improve livelihoods and overall human well-being. The multiple ecosystem services provided by the natural ecosystems in AlUla have been quantified and estimates provided of their economic and social values;
- Development of strategic guidelines and principles for ecosystem restoration in AlUla, based on international standards, including key restoration interventions per habitat, stakeholder engagement plan and risk and mitigation analysis;
- Sequential and spatial analysis based on all data available and generated (such as current habitat, soil and vegetation communities) to prioritise ecosystem restoration areas and develop a scale up plan for restoration in AlUla County, and

where ecological and socio-economic parameters were integrated into the analysis;

- A clear Vision, Mission and Objectives for ecosystem restoration in AlUla, helping to clearly communicate the value ecosystem restoration will deliver for AlUla where four key pillars were identified;
- Development of governance and funding models to sustain restoration and economic development efforts on the county level, where roles of local stakeholders are integrated into the models.

The overall Strategy for Ecosystem Restoration is based on an interdisciplinary approach that brings together diverse social sciences and natural sciences to ensure that the key objectives are met and will be implemented over two phases: Phase One (2025-2030) aiming to restore 23,500 hectares and Phase Two (2030-2025) aiming to restore 41,500 hectares throughout the key current habitats identified in the six Protected areas: Arid thorn woodlands, Dunes, Sandy open environments, Wadis and colluvial fans, Abandoned agricultural lands, Harrats, Ephemeral flooded plains, Red sandstone buttes.

Thirty-nine projects have been developed under the four pillars, to be implemented under Phase One and Phase Two. The projects integrate the ecological, social and economic aspects of AlUla County with recommendations on best practices for their successful implementation also presented throughout the chapters. Such recommendations include the selection of native species suitable for restoration. The selection was based on the species ecological importance, interactive services, natural-cultural preservation value and regeneration potential.

The vision for the Strategy for Ecosystem Restoration is to result in a positive transformation of the natural heritage of AlUla County, contributing to the overall goals of the Vision 2030. It will also work to ensure ecosystem restoration can be a mechanism to provide tangible, long-term benefits to local communities

1. INTRODUCTION

Worldwide, over two billion hectares of land are affected by land degradation, which affects a variety of land types, including urbans, rangelands, mining, agricultural, and forests. Land degradation adversely impacts biodiversity, soil organic carbon, ecosystem services, social and human well-being, and biological and economical productivity of ecosystems. Several SDG targets are directly linked to the implementation of the United Nations Convention to Combat Desertification (UNCCD).

As a recognition the urgency of this dilemma, international policymakers alongside with technical experts have increasingly prioritized land and ecosystem restoration. Several initiatives such as the Bonn Challenge and commitments under the UN Conventions on Biological Diversity and Desertification have provoked global efforts to restore degraded lands. In response, and as part of the Rio conventions and the Bonn Challenge, 115 countries have committed to restore a total of 765.4 million to 1.0 billion hectares of degraded land (Sewell, van der Esch, and Löwenhardt 2020). Moreover, the Kunming-Montreal Global Biodiversity Framework Target 2 entails in restoring 30% of all degraded terrestrial, inland water, coastal and marine ecosystems by 2030.

The United Nations launched the Decade on Ecosystem Restoration (2021–2030) a clarion call for the protection and revival of ecosystems worldwide. The Decade aims to prevent, halt, and reverse ecosystem degradation, contributing directly to major environmental conventions including the UNCCD, CBD, and UNFCCC. It serves as a catalyst to accelerate restoration efforts by uniting governments, civil society, scientists, Indigenous communities, and the private sector under a common global goal: restoring the planet and securing a sustainable future. Its objectives are firmly embedded in the 2030 Agenda for Sustainable Development, particularly in achieving land degradation neutrality and fostering resilience to climate change. IUCN has developed a Restoration Barometer, which is the only tool currently used by national and sub-national governments to track progress on the implementation of restoration targets across all terrestrial ecosystems, including coastal and inland waters.

Guided by ten principles, the UN Decade promotes an inclusive, rights-based, and science-driven approach to restoration. These principles call for long-term commitment, participatory processes, and context-specific actions that empower local communities and prioritize ecological integrity. The Decade also emphasizes the need for sustainable financing, capacity-building, and robust monitoring systems to track restoration impacts.

Ecosystem restoration is defined as the process of assisting the recovery of ecosystems that have been degraded, damaged, or destroyed, with the aim of re-establishing their ecological functionality and enhancing the services they provide. Restoration can take many forms—from reforestation and agroforestry to rangeland rehabilitation and wetland recovery—depending on the ecosystem type and its level of degradation. Beyond ecological outcomes,

restoration contributes to climate mitigation and adaptation, supports biodiversity conservation, and enhances human well-being by improving livelihoods and food security. In arid regions such as Gulf countries, restoration also plays a crucial role in combating desertification and safeguarding cultural and natural heritage.

In 2016, Under the leadership of the Custodian of the Two Holy Mosques, King Salman bin Abdulaziz Al Saud, and His Royal Highness Prince Mohammed bin Salman bin Abdulaziz, Crown Prince and Prime Minister, Saudi Arabia embarked on a journey toward a brighter future with the launch of Vision 2030. The Vision is a blueprint that is diversifying the economy, empowering citizens, creating a vibrant environment for both local and international investors, and establishing Saudi Arabia as a global leader. The Vision 2030 has integrated ambitious objectives aligned with the UN Decade on Ecosystem Restoration Strategy 2021-2030 and UNCCD's mission and key outcomes delivered from the 3rd UNCCD scientific conference.

The 3rd UNCCD scientific conference on combating desertification/land degradation and drought for poverty reduction and sustainable development, attended by a Saudi Arabia delegation, focused on the contribution of science, technology, traditional knowledge and practices and enhancing interactions between scientists and multi-stakeholders. Figure 1.1 describes the key outcomes agreed upon by more than 90 countries who participated in the conference.

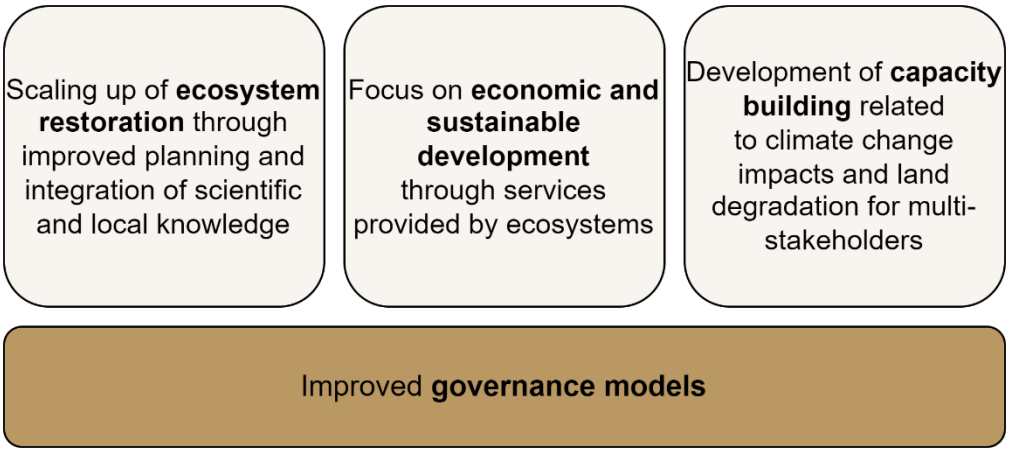


Figure 1.1- Key outcomes delivered from the 3rd UNCCD scientific conference

Under the Vision 2030 projects, the Royal Commission of AlUla has committed to 1) transform AlUla into a global destination, 2) empower AlUla residents through training, education and skills development and 3) implement sustainable practices to protect AlUla for future generations, while nationally contributing to key indicators of the Vision 2030.

Table 1.1 - RCU's Vision, Mission and Objectives

RCU Vision
We preserve, protect, and develop AlUla, an area of rich culture, heritage, and outstanding natural beauty in Saudi Arabia. • AlUla is firmly on the map from a global wildlife & ecotourism perspective • Wildlife is once more thriving in restored habitats, including large predators, both within and beyond protected areas • Habitat restoration and wildlife reintroduction create a blossoming ecotourism sector that diversifies the economy and provides opportunities for local communities
RCU Mission
To enable AlUla development for its communities and visitors through regenerating and protecting its cultural landscape and providing quality of life.
Primary RCU Objectives under Wildlife and Natural Heritage Department
• To create nature reserves to conserve the region's ecosystems, fragile habitats, and biodiversity • To restore and enhance degraded ecosystems, ecological processes through protection, management, research and community engagement, for the benefit of present and future generations • To conserve and reintroduce native species of outstanding universal value

Strategic RCU Objectives	
Tourism	Develop a successful and responsible global tourism destination
Heritage and culture	Discover and activate and conserve heritage Develop Arts & Culture offerings and communities
Nature and wildlife	Conserve nature and wildlife
Economic and social development	Develop a vibrant, prosperous and engaged community Develop a sustainable economy
Institutional excellence	Attain organizational excellence Foster innovation

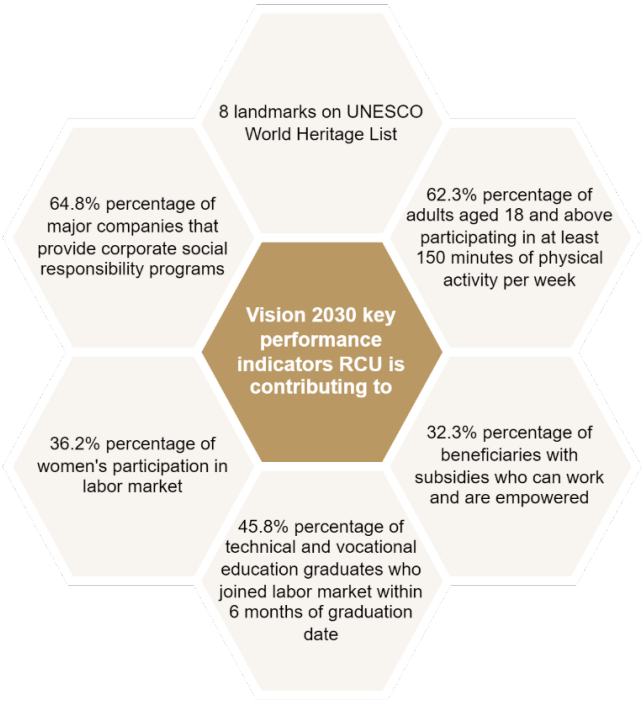


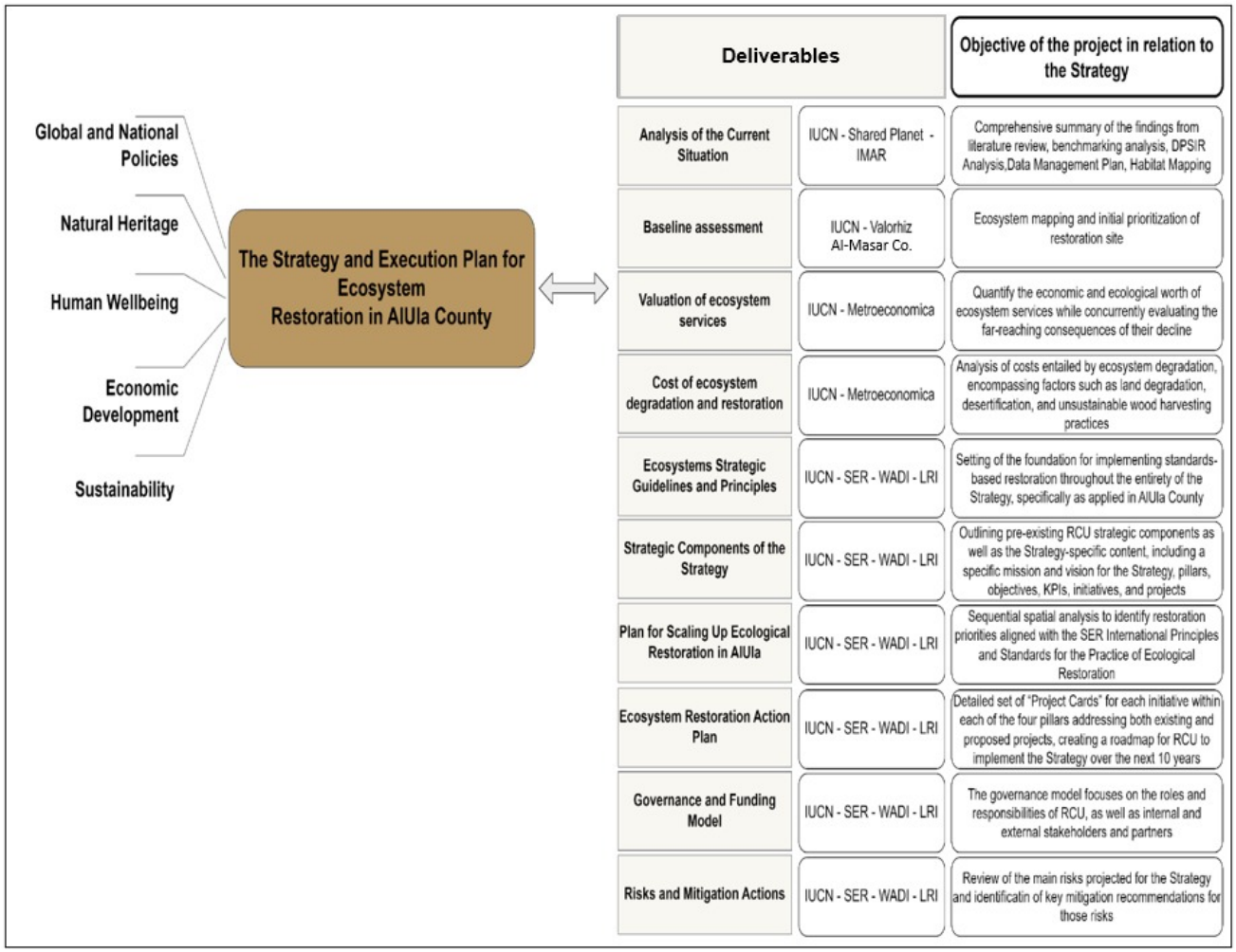
Figure 1.2-Vision 2030 key performance indicators RCU is contributing to.

RCU aims at protecting and safeguarding AlUla, a region of outstanding natural and cultural significance in north-west Saudi Arabia. RCU's mission directly aligns to several Sustainable Development Goals (SDG) targets linked to preserving natural heritage, improving human wellbeing, economic development and ensuring sustainability. RCU is contributing to key performance indicators of the Vision 2030, described in figure 1.2.

Table 1.2 - SDG targets aligned with RCU's mission (Transforming our world: The 2030 Agenda for Sustainable Development).

SDG Target	National and Local Context
SDG 15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation neutral world.	Conservation of **natural heritage** and its biodiversity
SDG 15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.	Conservation of **natural heritage** and its biodiversity
SDG 15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.	Conservation of **natural heritage** and its biodiversity
SDG 15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.	Ensuring **economic development** for all citizens and community groups
SDG 15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.	Ensuring **sustainability** through governance and financial models

RCU set to develop the Strategy and Execution Plan for Ecosystem Restoration in AlUla (herein the Strategy for Ecosystem Restoration), which main purpose is to ensure the successful implementation of standards-based ecosystem restoration projects to support delivery and achievement of RCU's overall vision, mission, and strategic objectives, under the global, national and local contexts. During the 2023-2025 timeframe, RCU conducted ten deliverables (figure 1.3) to ensure the development of a strategy that meets the requirement of standard-based ecosystem restoration, partnering with a multi-disciplinary group of experts, aligning with international and national policies in the fields of conservation of natural heritage, human well-being, economic development and sustainability.



Deliverables		Objective of the project in relation to the Strategy
Analysis of the Current Situation	IUCN - Shared Planet - IMAR	Comprehensive summary of the findings from literature review, benchmarking analysis, DPSIR Analysis,Data Management Plan, Habitat Mapping
Baseline assessment	IUCN - Valorhiz Al-Masar Co.	Ecosystem mapping and initial prioritization of restoration site
Valuation of ecosystem services	IUCN - Metroeconomica	Quantify the economic and ecological worth of ecosystem services while concurrently evaluating the far-reaching consequences of their decline
Cost of ecosystem degradation and restoration	IUCN - Metroeconomica	Analysis of costs entailed by ecosystem degradation, encompassing factors such as land degradation, desertification, and unsustainable wood harvesting practices
Ecosystems Strategic Guidelines and Principles	IUCN - SER - WADI - LRI	Setting of the foundation for implementing standards-based restoration throughout the entirety of the Strategy, specifically as applied in AlUla County
Strategic Components of the Strategy	IUCN - SER - WADI - LRI	Outlining pre-existing RCU strategic components as well as the Strategy-specific content, including a specific mission and vision for the Strategy, pillars, objectives, KPIs, initiatives, and projects
Plan for Scaling Up Ecological Restoration in AlUla	IUCN - SER - WADI - LRI	Sequential spatial analysis to identify restoration priorities aligned with the SER International Principles and Standards for the Practice of Ecological Restoration
Ecosystem Restoration Action Plan	IUCN - SER - WADI - LRI	Detailed set of "Project Cards" for each initiative within each of the four pillars addressing both existing and proposed projects, creating a roadmap for RCU to implement the Strategy over the next 10 years
Governance and Funding Model	IUCN - SER - WADI - LRI	The governance model focuses on the roles and responsibilities of RCU, as well as internal and external stakeholders and partners
Risks and Mitigation Actions	IUCN - SER - WADI - LRI	Review of the main risks projected for the Strategy and identificatin of key mitigation recommendations for those risks

Figure 1.3-Summary of the ten deliverables that will later be individually detailed in the report

2. ANALYIS OF THE CURRENT SITUATION

2.1. OBJECTIVE OF THE ANALYSIS OF THE CURRENT SITUATION

Data-driven strategies are essential for any mission to 1) improve decision making processes, 2) define actionable goals with achievable outcomes, 3) integrate a multi-disciplinary approach to goals and objectives and 4) minimize risks affecting the mission's outcomes and sustainability. The Analysis of the Current Situation brings together a summary of all learnings, data generated and key analysis, prior to the implementation start of the Strategy for Ecosystem Restoration, from phases that focused on a primary assessment of the state of the ecological habitats of AlUla, socio-economic context of AlUla in relation to land degradation and ecosystem restoration, and key recommendations for the development of a comprehensive and data-based strategy. The current analysis permitted identification of ecological and socio-economic data gaps that would hinder the development of a strategy that is aligned to global, national and local strategies and objectives for ecosystem restoration, prioritizing nature and human wellbeing. The analysis is based on three contexts: ecological context, policy context and socio-economic context.

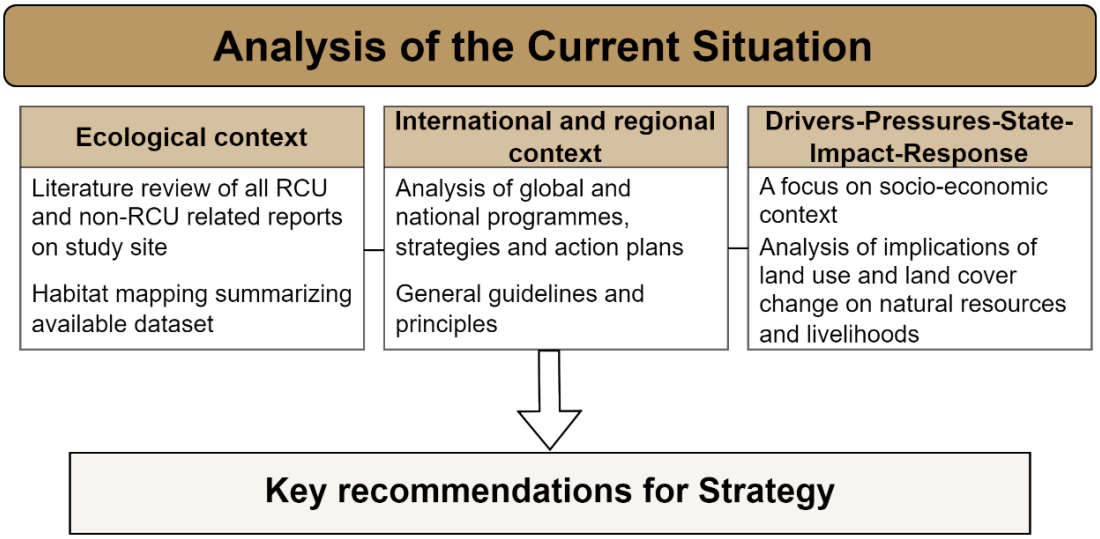


Figure 2.1- Contexts under the analysis of the current analysis supporting the development of the Strategy for Ecosystem Restoration

2.2. ECOLOGICAL CONTEXT

A strong baseline of ecological knowledge had already been established since the establishment of the RCU in 2017. It included a general top line understanding of the ecology of AlUla County.

2.2.1.KEY FINDINGS

Inventory of fauna and flora.

Prioritization of biodiversity hotspots for Gharameel Nature Reserve, Harrat Uwayrid Biosphere Reserve, & Harrat AlZabin Nature Reserve were recommended from a rapid fauna survey mission, generated by the AlUla Protected Areas Network Project (APAN).

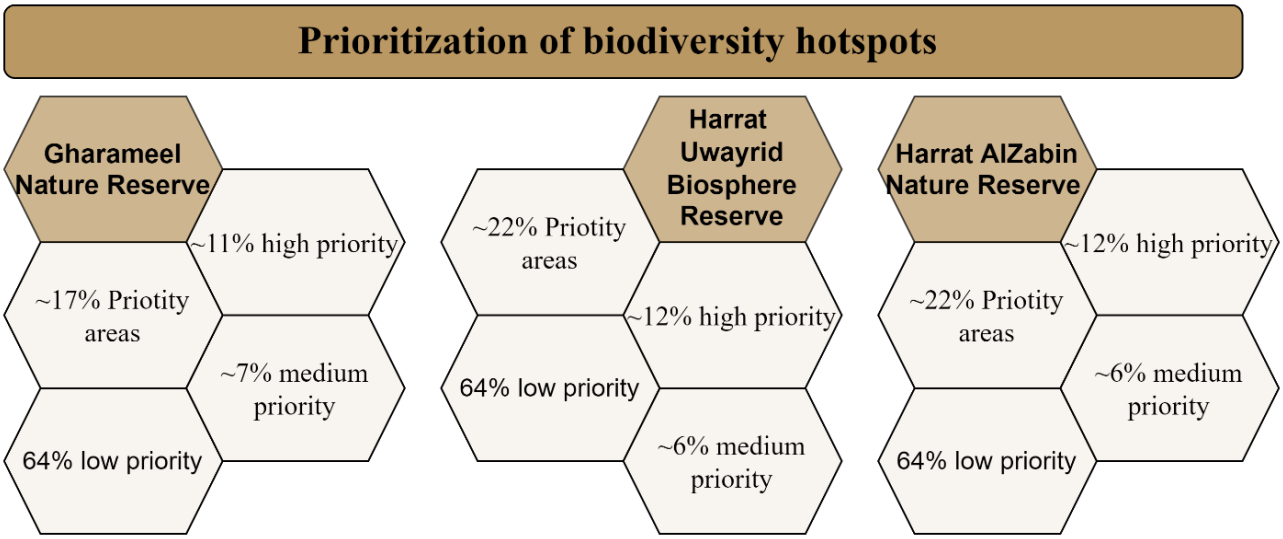


Figure 2.2- Identification of priority areas of biodiversity hotspots in three protected areas

Moreover, areas with high probability of occurrence of target species were also identified in the protected areas: *Capra nubiana*, or Nubian ibex, *Gazella arabica*, The Arabian Gazelle, *Gazella marica*, Arabian Sand Gazelle, *Oryx leucoryx*, Arabian Oryx, *Struthio camelus*, Red-necked Ostrich, *Falco peregrinus*, Peregrine Falcon, *Chlamydotis macqueenii*, Asian Houbara. Optimal sites for target species release using Species Distribution Models (SDMs) in AlUla were determined with areas of habitat suitability estimated in Gharmeel Nature Reserve, Harrat AlZabin Nature Reserve, Harrat Uwayrid Biosphere Reserve, Khaybar White Volcano Geopark, Sharaan National Park and Wadi Nakhlah Nature Reserve as high, moderate, low and unsuitable areas.

The mapping and identification of habitats/biotopes at the county level.

The Habitat Mapping summarizes and references the existing habitat mapping and available dataset including historical climate data, soil, land use, vegetative communities and topographic data. It also lists the criteria of selecting priority areas for the protection of important flora as well as priority degraded rangeland and

ecosystems areas for rehabilitation and ecological restoration. It further summarizes existing habitat mapping done for RCU and lists a typical process for mapping habitat using geospatial tools and provides recommendations on next phases of this project, specifically the baseline assessment phase. The overall floristic diversity are fueled by data from botanical surveys, offering insights into vegetation ecology in arid ecosystems and the composition of plant communities.

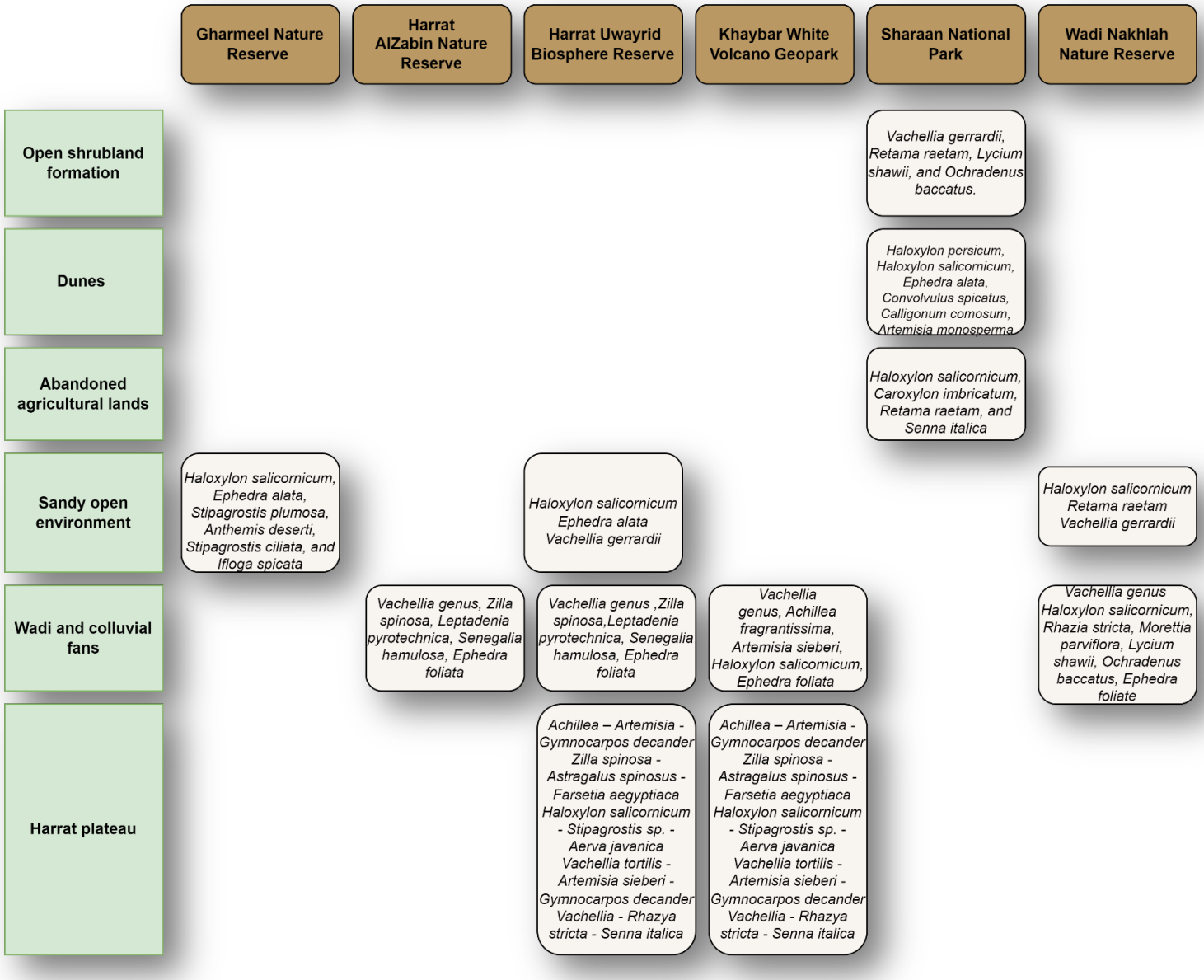


Figure 2.3- Summary of initial assessment of vegetation communities and habitats

2.2.2.IDENTIFIED GAPS

Habitat mapping: There are several sources that focus on habitat mapping within AlUla County, however the habitat of the entire county has not yet been studied in great detail, including vegetative communities. This should be completed for the most accurate assessment of habitat in the county.

Soil data is less developed: There is a need to commission further research to fill the knowledge gaps on the soil degradation and status across AlUla, such as compaction level, abiotic and biotic characteristics of the topsoil, status of the seed bank within the topsoil, and presence of crust. This should be followed by a study of microorganisms and microbes.

Community-focused data: Although the ongoing restoration and governance of natural heritage in AlUla follow a top-down approach, key to any ecosystem restoration programme is the involvement and engagement (and buy-in) of the local community. This is an underdeveloped area of knowledge, which should be filled before the ecosystem restoration programme begins.

There is an inconsistency in boundary demarcation: Different studies and information use different boundaries leading to an inability to precisely compare data on the county. This is further exacerbated by the fact that different vendors have used different approaches and polygons for analysis.

More detailed surveys on particular fauna: There is an opportunity to produce more detailed surveys on invertebrates and bats, breeding birds and particular fauna species that are of special value or high conservation value.

Surveys focusing on invasive species: Invasive species are an important consideration for any ecosystem restoration programme. We found relatively little data and investigation of invasive species, which is an area that could benefit from further investigation.

2.3. INTERNATIONAL AND REGIONAL CONTEXT

Existing strategies, action plans, guidelines and principles that relate to ecological restoration were assessed and their components, structure, learnings and solutions that have potential implications for the work of RCU were analysed, focusing primarily on semi-arid and arid landscapes and regional initiatives. Examples of ecological restoration strategies at the international, regional, national and sub-national levels from different landscapes were assessed as well.

2.3.1.KEY FINDINGS

The benchmarking analysis of key policies, action plans and guidelines allowed having well defined and developed regional and global references for the development of the Strategy Ecosystem Restoration. The results describe 1) analysis of regional national programs, 2) analysis of international national strategies and action plans and 3) analysis of international best practice guidelines and principles.

Regional national programmes

The benchmarking analysis analysed the national programmes of six countries in the Middle East and North Africa region: Jordan, Morocco, Kuwait, Tunisia, Oman and Saudi Arabia. A number of key lessons and strategies that may be applied to the case of AlUla were identified, including:

- Rangeland management practices require a comprehensive understanding of past and present eco-hydrological processes to be successful. Eco-hydrological processes refer to elements of the water cycle that affect the distribution, structure and function of ecosystems, which can be key contributors to ecosystem degradation in arid zones (Zhao and Cheng, 2002).
- Ecological rehabilitation in arid regions should consider focusing on sites that are protected from wind and frost.
- Rehabilitation initiatives must also target the causes of degradation linked to human activities.
- The identification of tree species that can withstand local climatic and environmental conditions is essential for project success.
- Native species planting brings positive changes to the ecosystem through the creation of microclimates, plant litter deposits and water filtration.
- The establishment of tree nurseries represents an alternative income-generating activity for local farming communities.
- Mechanised water harvesting can reduce the negative impacts of surface runoff and soil erosion on rangeland hillslopes.
- Where water is scarce, wastewater treatment can present a viable alternative water source for regreening programmes.
- The protection of existing plants and/or roots over a sustained period of time can allow for regeneration.
- Reseeding is more successful than rangeland protection where degradation has reached the threshold of irreversibility.
- The participation of the local community and key stakeholders can help raise awareness of and generate support for ecosystem rehabilitation initiatives.

Given the similar climatic conditions across these states, successful strategies could be replicated in the context of the AlUla project.

Identified key gaps

Compared to other regional national programmes, two key activities were absent in the national programme of Saudi Arabia:

Establishment of native seed banks: Important to ensure high quality native plant material is available for restoration projects.

Development of water harvesting models for arid regions: Important to ensure conservation of water resources in national programmes, flood control and agriculture.

International strategies

The increasing focus on biodiversity and climate change has resulted in regional organisations and national governments beginning to consider frameworks and strategies to guide ecological restoration. This means that most ecological restoration strategic recommendations are often found in documents that are wider in scope – e.g., a national nature plan, a national biodiversity strategy and action plan (linked with the Global Biodiversity Framework), or a climate change adaptation and mitigation plan. The benchmarking report analysed national strategies and action plans on ecosystem restoration adopted by Australia, the Czech Republic, Chile, Costa Rica, Peru, Colombia and Japan.

Table 2.1-Comparative analysis of differences in national ecological restoration strategies

National ecological restoration strategies	# of countries adopting
Connecting society with nature and fostering a recognition of its value within society.	4
Inclusion of local communities, tribes and indigenous populations in restoration and conservation efforts.	5
Existence of Urban ecosystem restoration components.	4
Identify and reduce drivers and causes of ecosystem degradation and damage.	4
Building and sharing knowledge in ecological restoration by providing up-to-date relevant information.	7
Transform the way natural resources are used to ensure their long-term preservation.	3
Support biodiversity flourishing in the long term.	4
Active planting and protection of native species.	3
Control of invasive species.	2
Establishment of national areas of priority (i.e., protected areas).	3
Establish and foster national, regional, and international partnerships to align restoration efforts.	4
Recover the structure and functionality of ecosystems and degraded forest lands in prioritised areas.	5
Strengthen capacities of the actors involved for the management and development of restoration.	4
Strengthen the governance of the public sector stakeholders involved in restoration.	3
Produce more opportunities for employment through ecological restoration strategy.	4
Create multistakeholder platforms and engagement restoration.	4
Promotion of environmentally sustainable resource business and value chains.	3
Create national monitoring and evaluation strategies to assess impact and success of ecological restoration	5
Embedded communication strategies and campaigns with stakeholders.	4

The comparative analysis of the national ecological restoration strategies of the seven countries shows that most countries include the following areas in their strategies (more than five out of seven countries):

- Inclusion of local communities, tribes and indigenous populations in restoration and conservation efforts.
- Building and sharing knowledge in ecological restoration by providing up-to-date relevant information.
- Recover the structure and functionality of ecosystems and degraded forest lands in prioritised areas.
- Create national monitoring and evaluation strategies to assess impact and success of ecological restoration.

Identified key gaps

The comparative analysis of the national ecological restoration strategies of the seven countries shows that the following areas are not included in the strategies of most countries (less than 3 out of seven countries):

- Transform the way natural resources are used to ensure their long-term preservation.
- Active planting and protection of native species.
- Control of invasive species.
- Establishment of national areas of priority (i.e., protected areas).
- Strengthen the governance of the public sector stakeholders involved in restoration.
- Promotion of environmentally sustainable resource business and value chains.

International best practice guidelines and principles

The findings of the analysis indicate that the guidelines created by IUCN are the most comprehensive, covering more components compared to FAO, the Convention on Biological Diversity (CBD) and Society for Ecological Restoration (SER). IUCN is distinguished by its emphasis on enhancing long-term ecosystem resilience and building sustainable livelihoods through ecosystem restoration, while also providing guidelines for tourism and visitor management, which are particularly valuable in the context of this project. In contrast, the FAO and CBD guidelines tend to focus more on the fundamental components of ecosystem restoration, such as establishing goals, collaborating with stakeholders, and encouraging knowledge-sharing, particularly at the international level. Finally, the SER's guidelines are unique in their inclusion of a component that underscores the importance of seeking the highest possible level of recovery in ecosystem restoration. Ultimately, any project must take into consideration the recommendations of all four bodies to be most comprehensive.

2.4. DRIVERS-PRESSURES-STATE-IMPACT-RESPONSE (DPSIR) FRAMEWORK: A FOCUS ON SOCIO-ECONOMIC CONTEXT

The overarching goal of the DPSIR analysis is to develop realistic and effective solutions for ecosystem restoration in the AlUla region, while also regulating the effects on the environment, local climate, and local communities. The DPSIR framework serves as a holistic tool to identify and establish causal links between indicators, leveraging indigenous knowledge and stakeholder interactions. The analysis researched the drivers and implications of land use and land cover change, as well as climate change, on the environment, water, and livelihoods in AlUla County, and its relationship with habitat restoration. By applying DPSIR in AlUla County, the aim is to improve communication and facilitate collaborative interactions between policymakers, stakeholders, and scientists, thus contributing to science-based resource management decisions and, ultimately, identify solutions and a roadmap for ecosystem restoration.

2.4.1.KEY FINDINGS

The analysis was based on three main categories and sub-categories identified within the AlUla context: 1) micro-communities, 2) local community, and 3) local governance under ecological, social and economic contexts. This ensures that all individuals and groups are well represented and taken into consideration for their inclusion in the Strategy for Ecosystem Restoration

Table 2.2-- Summary of Drivers, Pressures, States and Impacts.

Drivers: Elements that compel human behaviour and satisfy fundamental human needs, which are often regarded as essential for a decent life, excellent health, positive social interactions, security, and freedom.			
Context / **Social structure level**	**Ecological drivers**	**Social/cultural drivers**	**Economic drivers**
Micro-community	Natural resources	Modernization of activities and lifestyle	Land use for economic benefit
Local community	Restoring ecological functions in identified habitats	Local community integration	Diversification of income generating activities
Local governance	Model for restored and sustainable ecological processes	Global social integration and cultural awareness	Model for improved and sustainable economic growth

Pressures: Human behaviours and activities that are derived from the drivers and have the potential to negatively impact the environment.		
Context / **Social structure level**	**Primary pressures** Human activities	**Secondary pressures** Environmental pressures caused by primary pressures
Micro-community	Shift from traditional knowledge	Land use pressures and changes in micro-habitats
Local community	Modernization of main sectors	Limited sustainable natural resources
Local governance	Fast development of many sectors	Extreme environmental risks (floods/erosions)

States: Condition of both the natural and built environment, encompassing physical, chemical, and biological components, as well as human systems such as population levels and individual attributes.
Urbanized areas: The fast development in AlUla leads to concentrated populations and societal changes that in turn intensify the effects of climate change. The Master Plan describes the future of urban development in AlUla, but to our knowledge, has so far limited integration of ecological considerations into the planning and the state of the natural heritage of AlUla, from its biodiversity, geological features and others. The housing demand is increasing, and construction is ongoing.
Farmlands/productive lands: From agriculture to mining or other types of activities, the reliance on a mono-production heavy system is having a negative impact on natural resources, such as soil, water and beneficial microorganisms. However, the Agriculture Department in RCU is developing an agro-ecology strategy and piloting new projects on-site, that would provide some initial guidance to conserve natural resources.
Abandoned lands: On the outskirts of the reserves and/or adjacent to farmlands/productive lands, vegetative competition is very strong, and invasive species are establishing first and better adapted to the degraded nature and rough conditions of the lands. It is noticeable that natural regeneration of the native flora is very limited or inexistent.
Protected areas: These areas are considered the closest to intact ecosystems. Some areas in the nature reserve could be used for the development of reference models for the development of the ecosystem restoration strategy, however, they have been subject to previous anthropogenic activities and affected native vegetation, soil health, geological processes and others.
Impacts: Ecosystem degradation leads to ecological, social and economic impacts within a community, country or region.

Context / **Social structure level**	**Ecological impacts**	**Social/cultural impacts**	**Economic impacts**
Micro-community	Loss of genetic diversity and unhealthy native populations. Decreased resilience to natural threats.	Younger generations lose traditional values that ensures preservation of indigenous landscape attributes (plants and animals).	Community members at risk of outward migration, leading to unsustainable economic growth.
Local community	Limitation for fauna to move across the landscape with population declines and/or population genetic isolation.	Increased pressure for land use change occurring when communities are not engaged in activities and have limited understanding of the processes.	Higher dependence on subsidies as economic growth takes hold.
Local governance	Loss of ecosystem services and features leading to societal and economic stress.	Contemporary management does not reflect traditional ecosystems with limited integration of societal aspects.	Inadequate land stewardship leading to decreased governance, coordination and collaboration.

Responses are actions taken by groups or individuals in society and government to prevent, compensate, ameliorate, or adapt to changes in the state of the environment. Responses may also seek to control Driving Forces through policies or economic decisions that directly influence sectors. In this analysis, responses were directly linked to protection, conservation and restoration contexts, while taking into consideration a balance between social divisions and economic development and based on cost-effective long-term solutions for biodiversity loss, land degradation, and provide a crucial contribution to achieving international biodiversity and climate objectives, simultaneously (Maes, et al., 2012). Table 2.3 summarizes the responses based on the ecological, social and economic contexts. Moreover, responses were identified on a watershed level of AlUla, ensuring that the Strategy for Ecosystem Restoration would focus on a model for connectivity between the diverse sectors of AlUla county with a focus on community integration.

Table 2.3- Summary of responses

	Ecological Responses	Social/cultural Responses	Economic Responses
Micro-community level			
Main outcome from Responses	**Genetic diversity is maintained as individual populations are healthy. Resilience emerges to natural threats (e.g. flooding, wildfire) with local sources of regenerative material.**	**Preservation of indigenous landscape attributes (plants and animals) will help younger generations maintain traditional values.**	**Long-term sustainable Economic growth for community members at risk of departure.**
Pressure-based responses	Increase support from the Native Plant Nursery and Seed bank in Agroecology projects managed by Agriculture Department.	N/A	Promote native species that have ecological and economic importance. Such species are: 1) *Artemisia monosperma* that plays a role in stabilizing dunes and as a medicinal plant and 2) *Vachellia gerardi* that can be integrated into grazing areas for shade for animals, cattle, shepherds.
State-based responses	Develop pilot project with nature champions in their land to promote sustainable agroecology and act as a showcase site for other community members. Identify pilot studies that integrate nature-based solutions (NBS) in unprotected areas aiming at re-establishing ecosystem functionality and reversing negative trends (5).	Develop a more concrete role of nature champions in ecosystem restoration and within the communities, with a better understanding of ecosystems and their functioning. Development of certification programs for youth and other groups of the community providing types of education other than traditional educational systems. NBS offering substantial health co-benefits and achieving food and water security (6).	Develop NBS programs that can generate employment and social benefits and aiming at re-establishing important ecosystem services from the area (5).
Local community/authority level			
Main outcome from Responses	**Animal populations are able to move across the landscape more freely. Populations that have seen decline may expand with higher quality habitat and protection measures.**	**Decreased pressure for land use change will occur if communities are engaged in activities and understand the entire system/processes.**	**Lower dependence on subsidies as economic growth takes hold.**
Pressure-based responses	N/A	N/A	N/A
State-based responses	N/A	Awareness raising campaigns targeting more communities.	Need for a more local level dependency of several economic sectors.

	Ecological Responses	Social/cultural Responses	Economic Responses
		Engagement of schools through involvement of students in research, field trips and development of school curriculums.	
Impact-based responses	Adoption of sustainable practices by incorporating biodiversity considerations into planning and design to reduce negative human-related impacts.	N/A	N/A
Local governance level			
Main outcome from Responses	**The "voice of conservation" will emerge as people see restored ecosystems as contributors to society and the economy, leading to higher ecosystem function as a desirable outcome.**	**Traditional ecosystems being reflected in contemporary management will help bring conservation and development mindsets to the table.**	**Recognition of effective land stewardship on quality of life can lead to increased governance/coordination/collaboration.**
Pressure-based responses	N/A	Creation of local advisory groups trained by RCU and acknowledging the local knowledge within ecosystem restoration.	Local governance model that should be applied by local authorities and further developed to ensure sustainable job opportunities (fig 9).
State-based responses	Identification of Reference Model types within AlUla County, supporting the restoration strategy at the landscape level. Development of baseline assessment models and protocols to ensure more accurate measurements of restoration actions and their impacts.	Development of a training program provided to the local community of AlUla, comprising different subjects related to ecosystem restoration. The aim would be to develop and rely on the local expertise in the long-term.	A watershed level restoration strategy is achieved also within RCU and improvement of its internal governance. Departments need to collaborate internally.
Impact-based responses	The watershed level should be considered to ensure that pressures outside the reserves are minimized and impacts on nature reserves are also minimized (fig 8). Improvement of the science-policy interface where Sustainable Development Goals are met. Identify ecological functions to restore to meet RCU's restoration objectives on the county level and not only the reserves identified.	Development of local systems that contribute to the economic sector and that are accessible internationally. An example would be to promote local systems for tourism with local personnel.	N/A

2.5. CONCLUSION

By identifying important data gaps within the studies and assessments implemented by RCU between 2017 and 2023, specific projects and studies will ensure that crucial baseline data is generated to improve planning of ecosystem restoration in AlUla. While the data that RCU has generated to date is of high quality, it is somewhat disconnected and disparate. The Strategy for Ecosystem Restoration as a project was formulated to meet that disconnect and provide a structured, connected and comprehensive multi-disciplinary strategy, aligning with international, national and local objectives. The following key recommendations identified in the analysis of the current situation phase were thus implemented.

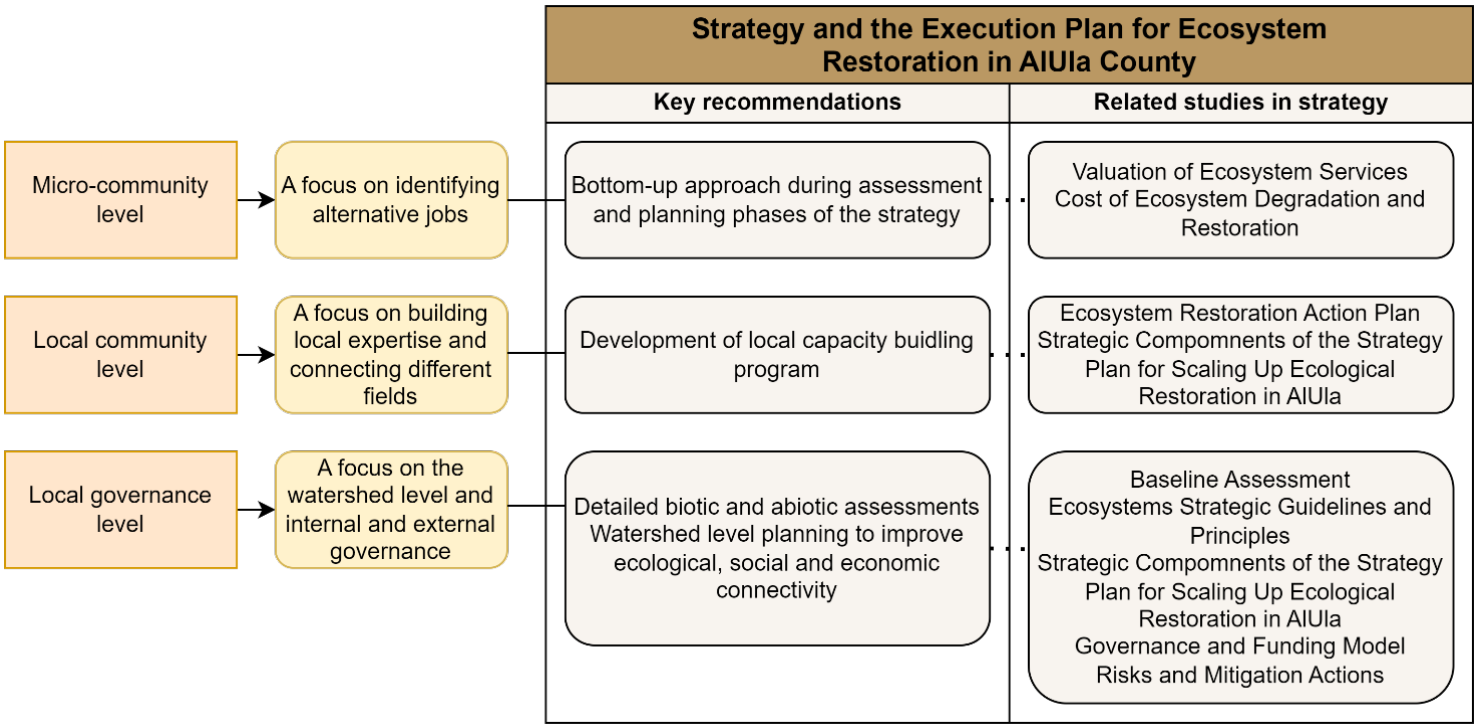


Figure 2.4- Key recommendations for shaping the strategy's next steps.

3. BASELINE ASSESSMENT

Following the analysis of the current situation, making use of the available data and outputs from the executed and current projects, additional baseline ecological surveys in targeted areas were implemented to support the development of the Strategy for Ecosystem Restoration and identify priority areas for restoration and the conservation of important flora and fauna.

The baseline assessment conducted research such as 1) field pedological work, soil survey, and georeferenced soil database development; 2) vegetation survey; and 3) ecosystem mapping of the six Protected Areas of AlUla County: in Gharmeel Nature Reserve (GNR), Harrat AlZabin Nature Reserve (HZNR), Harrat Uwayrid Biosphere Reserve (HUBR), Khaybar White Volcano Geopark (KWVG), Sharaan National Park (SNP) and Wadi Nakhlah Nature Reserve (WNNR). This data will be integrated in a model to prioritize zones that require active restoration and to define the zones that need to be conserved in those six mentioned Protected areas. In the subsequent sections, a small briefing of each protected area findings is presented, focusing on field pedological work, vegetation survey and habitat mapping.



Figure 3.1-The 9 habitats existing in AlUla protected areas

3.1. SHARAAN NATIONAL PARK (SNP)

Soil Assessment

SNP covers an area of approximately 1600 km² and highlights the characteristic natural beauty of the AlUla region. The protected area's coverage consists of 55% soil and 45% rocks (mainly sandstone formations). On the protected area, 9 soil map units (SMU) have been mapped, and 11 soil type units (STU) have been identified.

From a geomorphological point of view, this protected area is composed of canyons dissected in sandstone and basalt, large plains, and the Harrat plateau to the northwest. The dominant soil types found are the result of erosion/deposition by wind (aeolian soil group) and water and/or gravity (alluvial-colluvial soil group).

Vegetation Communities

The vegetation analysis has identified and mapped four primary vegetation communities: plant community 1: *Acacia gerrardii – Ziziphus – Retama*; plant community 2: *Haloxylon salicornicum – Stipagrostis ciliata – Stipagrostis plumosa*; plant community 3: *Ephedra – Artemisia – Moltkiopsis*; and plant community 4: *Morettia – Anastatica – Heliotropium.* These plant communities add substantially to the understanding of vegetation composition related to habitats and degradation impact.



Figure 3.2-Ophioglossum polyphyllum A.Braun ex Seub



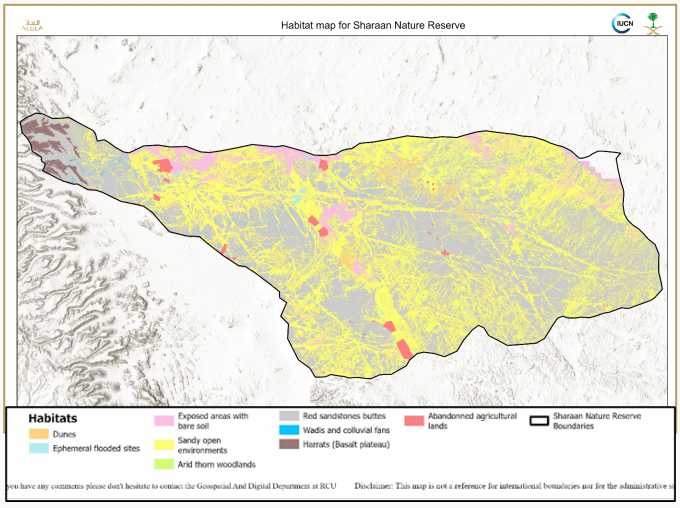
Figure 3.3 -Red sandstone buttes habitat



Figure 3.4-Dunes habitat

Habitats

SNP is primarily covered with red sandstone buttes and sandy environments. Furthermore, the habitat map highlighted a significant portion of the protected area as being degraded, mainly due to past anthropogenic activities. This map will serve as an important resource for future ecological restoration initiatives (Annex 1).



3.2. HARRAT UWAYRID BIOSPHERE RESERVE (HUBR)

Soil Assessment

HUBR covers an area of 4680 km². The protected area's coverage consists of 75% soil (including the Harrat soil) and 25% rocks. Eleven soil map units (SMU) have been mapped, and 20 soil type units (STU) have been identified.

From a geomorphological point of view, HUBR includes a vast central plateau-oriented North-South, called Harrat, resulting from volcanic activity from 10 million years ago. On either side towards the West, East, and South, the slopes and residual reliefs are formed, dissected by hydric erosion. These extend into valleys and plains that widen further away from Harrat.

The major factors in soil formation on the site are essentially related to erosion processes related to water, wind and gravity, and conditioned by the stability of the parental material and the strength and speed of the erosion factors. The formed soils are essentially alluvial-colluvial.

Vegetation Communities

The analysis has identified and mapped five primary vegetation communities: plant community 1: Acacia gerrardii – Retama raetam – Achillea fragrantissima – Zilla spinosa; plant community 2: Acacia tortilis - Acacia tortilis subsp. Raddiana - Ochradenus baccatus; plant community 3: Acacia tortilis - Acacia tortilis subsp. Raddiana - Ochradenus baccatus; plant community 4: Anastatica hierochuntica – Rumex vesicarius – Trichodesma africanum, and plant community 5: Asparagus horridus – Otostegia fruticosa – Cymbopogon schoenanthus. These plant communities add substantially to our understanding of vegetation composition related to habitat occurrences and degradation level.



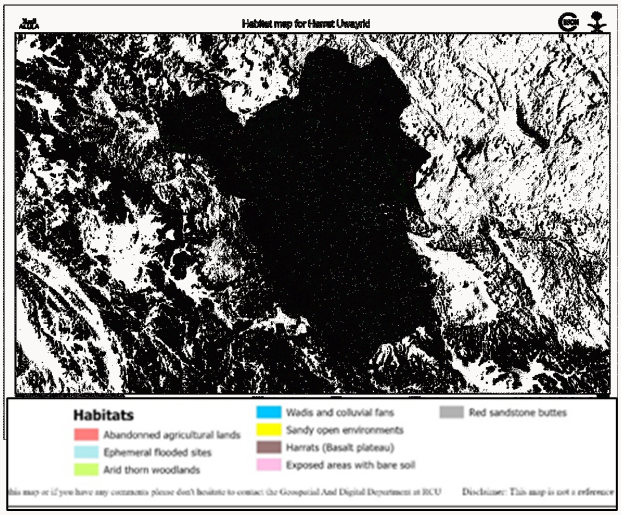
Figure 3.5-Deep and loosely sandy soil



Figure 3.6-HUBR

Habitats

HUBR is primarily covered with harrats, wadis and small part of sandy environments, mainly occurred in the north part of HUBR. Furthermore, a significant portion is degraded, mainly due to past and current anthropogenic activities such as grazing, off-road driving and agricultural activities. This habitat map broadens considerably our understanding of habitats distribution and will serve as an important resource for future ecological restoration initiatives (Annex 1).



3.3. HARRAT ALZABIN NATURE RESERVE (HZNR)

Soil Assessment

HZNR covers an area of 1677 km². The protected area's coverage consists of 91% soil and Harrat and 9% rocks. On HZNR, six soil map units (SMU) have been mapped, and 9 soil type units (STU) have been identified.

From a geomorphological point of view, this HZNR is constituted by a North-South oriented Harrat central basalt plateau. On either side towards the East and West of Harrat are the slopes and residual reliefs dissected by hydric erosion, extending into valleys and plains.

The major factors in soil formation on the site are essentially related to erosion processes (detachment, transport, deposition) related to water, wind and gravity, and conditioned by the stability of the parental material and the strength and speed of the erosion factors. The formed soils are essentially alluvial-colluvial.

Vegetation Communities

The analysis has identified and mapped four primary vegetation communities: plant community 1: Moringa – Ochradenus – Cymbopogon; plant community 2: Hibiscus – Lavandula – Aerva; plant community 3: Acacia tortilis – Acacia seyal – Maerua, and plant community 4: Acacia gerrardii – Acacia tortilis subsp. raddiana – Rhazia. These plant communities add substantially to our understanding of vegetation composition related to habitat occurrences and degradation level.



Figure 3.7-Cleome Chrysantha



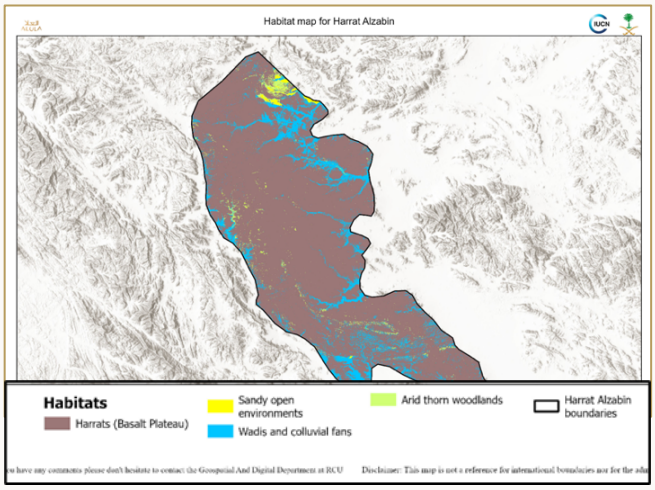
Figure 3.8-Wadis found in HZNR



Figure 3.9 -Stony gravelly soil from turbulent alluvial deposit in wadi

Habitats

HZNR is primarily covered with harrats, non-sedimentary arid mountains and wadis. Furthermore, a significant portion of HZNR is degraded, mainly due to past and current anthropogenic activities such as grazing. This habitat map broadens considerably our understanding of habitats distribution and will serve as an important resource for future ecological restoration initiatives (Annex 1).



3.4. GHARAMEEL NATURE RESERVE (GNR)

Soil Assessment

GNR covers an area of 2115 km². The protected area's coverage consists of 80% soil and 20% rocks and rocky outcrops. On the GNR, 7 soil map units (SMU) have been mapped, and 12 soil types units (STU) have been identified.

From a geomorphological point of view, GNR consists of dune areas, vast sandy-loamy plains, and rocky outcrops.

The major factors in soil formation on the site are essentially related to erosion processes (detachment, transport, deposition) related to water and gravity (alluvial-colluvial soils) and wind (aeolian soils), and conditioned by the stability of the parental material and the strength and speed of the erosion factors.

Vegetation Communities

The analysis has identified and mapped five primary vegetation communities: plant community 1: Artemisia – Ephedra – Acacia gerrardii; plant community 2: Haloxylon – Retama – Rhazia; plant community 3: Rhantherium – Kickxia – Rumex; plant community 4: Helianthemum – Gymnocarpos – Thymbra, and plant community 5: Morettia – Citrullus – Euphorbia. These plant communities add substantially to our understanding of vegetation composition related to habitat occurrences and degradation level.



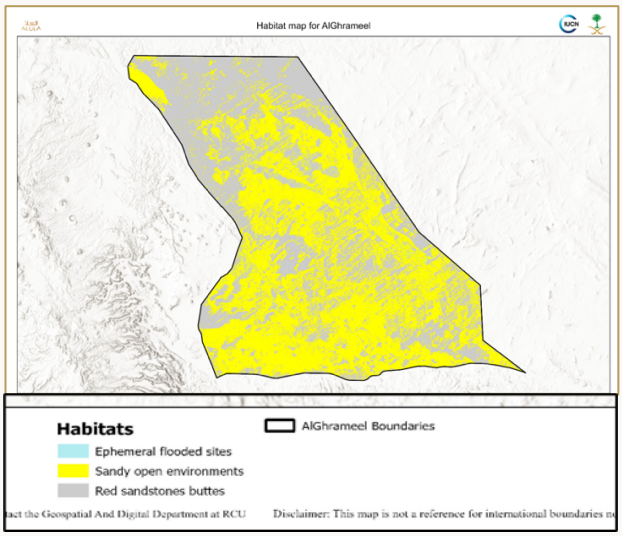
Figure 3.10 -Sandy open environments habitat



Figure 3.11-Very shallow sandy soil from plain

Habitats

GNR is primarily covered with sandy environments and red sandstone buttes. Furthermore, the mapping of the habitats highlighted a significant portion is degraded, mainly due to past and current anthropogenic activities such as grazing and off-road driving. This habitat map broadens considerably our understanding of habitats distribution and will serve as an important resource for future ecological restoration initiatives (Annex 1).



3.5. KHAYBAR WHITE VOLCANO GEOPARK (KWVG)

Soil Assessment

KWVG covers an area of 600 km². This protected area is a typical volcanic landscape with a coverage composed of 70% soil, and 30% rocks and lava. On the KWVG, six soil map units (SMU) have been mapped, and 12 soil type units (STU) have been identified.

From a geomorphological point of view, KWVG consists of volcanic reliefs, basaltic lava flows around craters and intersection related to the erosion of talweg and alluvial valleys (wadis).

The main types of soil found are derived from volcanic activity (pyroclastic soils) and secondarily under the action of erosion/deposition by water and gravity (alluvial-colluvial soils). The pyroclastic material results from the ashes and rocky fragments generated by volcanic eruptions. Alluvium and colluvium are materials displaced by gravity along a slope or watercourse, whose granulometric composition varies according to the eroded parent material and the displacement force generated by erosion factors.

Vegetation Communities

The analysis has identified and mapped five primary vegetation communities: plant community 1: *Achillea fragrantissima - Artemisia judaica – Pulicaria undulata*; plant community 2: *Ochradenus baccatus – Lycium shawii – Zilla spinosa*; plant community 3: *Ducrosia flabellifolia – Scrophularia deserti – Gypsophila capillaris*; plant community 4: *Malva parviflora – Farsetia aegyptia*, and plant community 5: *Acacia tortilis – Peganum harmala – Zygophyllum bruguieri.* These plant communities add substantially to our understanding of vegetation composition related to habitat occurrences and degradation level.



Figure 3.12-Artemisia Judaica L



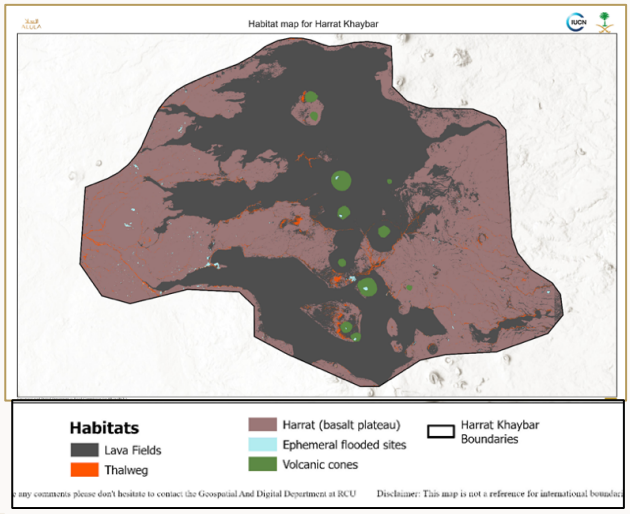
Figure 3.13-Sandy-silty shallow soil accumulated in micro-depression from lava formations



Figure 3.14-Sparse vegetation in lava fields

Habitats

KWVG is primarily covered with harrats and lava fields. Furthermore, a significant portion is degraded, mainly due to past and current anthropogenic activities such as grazing and off-road driving. This habitat map broadens considerably our understanding of habitats distribution and will serve as an important resource for future geotourism initiatives (Annex 1).



3.6. WADI NAKHLAH NATURE RESERVE (WNNR)

Soil Assessment

WNNR covers an area of 2427 km². The protected area's coverage consists of 30% soil and 70% rocks. On WNNR, 7 soil map units (SMU) have been mapped, and 7 soil type units (STU) have been identified.

From a geomorphological point of view, WNNR consists of a mesa plateau, narrow valleys, plains, dunes, wadis, and some rocky outcrops.

The major factors in soil formation on the site are essentially related to erosion processes (detachment, transport, deposition) related to water, wind and gravity, and conditioned by the stability of the parental material and the strength and speed of the erosion factors. The formed soils are essentially alluvial-colluvial.

Vegetation Communities

The analysis has identified and mapped five primary vegetation communities: plant community 1: *Moringa – Hibiscus – Abutilon; plant community* 2: *Acacia gerrardii – Haloxylon – Ephedra alata*; plant community 3: *Morettia – Asteriscus – Farsetia burtoniae*; plant community 4: *Heliotropium – Convolvulus – Centropodia*; and plant community 5: *Acacia tortilis – Acacia tortilis subsp. Raddiana – Ochradenus*. These plant communities add substantially to our understanding of vegetation composition related to habitat occurrences and degradation level.



Figure 3.15-Capparis Cartilaginea Decne.



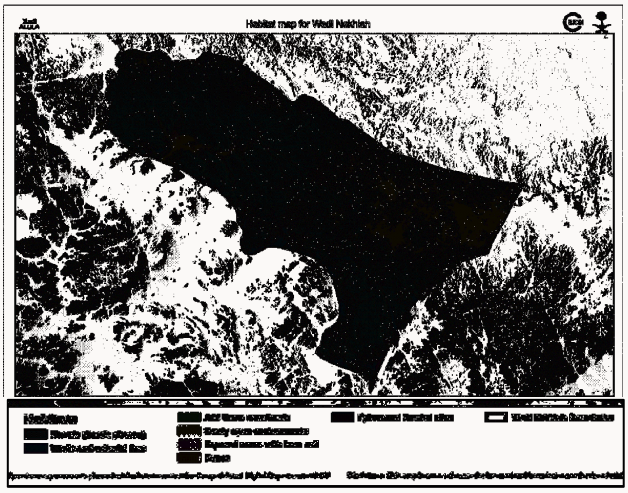
Figure 3.16 -Species rich open shrubland formation



Figure 3.17 -Compact sandy to sandy-loam soil with surface gravels

Habitats

WNNR is primarily covered with non-sedimentary arid land montane and Red sandstone buttes, sandy environments and wadis. Furthermore, a significant portion is degraded, mainly due to past and current anthropogenic activities such as grazing. This map will serve as an important resource for future ecological restoration initiatives (Annex 1).



3.7. SELECTION OF PRIORITY AREAS FOR RESTORATION AND NEXT STEPS FOR SCALING UP

3.7.1.THE RESULTS OF THESE ASSESSMENTS LEAD TO IDENTIFY 22 PRIORITY AREAS THAT REQUIRE ECOLOGICAL RESTORATION IN THOSE 6 PROTECTED AREAS.

The selection of these priority areas was built in a systemic approach based on the up mentioned results of the comprehensive ecological baseline assessment supported by Cassia® (https://cassia-technologies.com/), innovative technology based on artificial intelligence. To combat degradation and facilitate restoration, guidelines should be developed for each of the priority areas of the AlUla Protected Areas, tailored to their characteristics and habitats. These plans provided an overview of each Protected Area, outlining its principal challenges while proposing specific goals, objectives, and strategies for rehabilitation. They also should include habitat-specific recommendations, suggested planting densities, and a curated list of plant species. The selection of the priority areas for active ecological restoration is the critical phase for building the strategy to be implemented. A detailed study of these priority areas will make it possible to adapt and size the active ecological restoration to the reality of the habitats at the local scale, leading to the scale-up of ecosystem restoration on the AlUla County level (chapter 7), briefly described in figure 3.19. It is important to note that these are initial priority areas based on an ecological context, where further analysis described later in section 8 “Plan for Scale-Up of Ecosystem Restoration” were based on those initial priority areas and included ecological and socio-economic contexts.

3.7.2.PLANT SPECIES OF INTEREST FOR ECOLOGICAL RESTORATION

The species recorded in the Protected Areas were as follows: 295 plant species from 51 families in SNP, 255 plant species from 50 families in HUBR, 173 plant species from 45 families in HZNR, 176 plant species from 41 families in GNR. In WNNR, 235 plant species from 50 families were documented and in KWVG, 195 plant species from 38 families were noted. Figure 3.18 illustrates some key species of interest for ecological restoration.

As a transversal result of all the Protected Areas, a list of Plant species of interest for Ecological Restoration was developed (Annex 2). To obtain a list of priority species for ecological restoration purposes, a multiple traits approach was used. It was mainly based on the following four key criteria: ecological importance, interaction services, sociocultural perception and regeneration potential. Once the value (a score from 1 to

4) of these four key criteria has been obtained, for each plant species an SSI (species selection index) was calculated. The plant species list is then categorized into the following four groups: (i) Not a priority (SSI ≤ 5); (ii) Low priority (5 ≤ SSI ≤ 8); (iii) Priority (8 ≤ SSI ≤ 12); and High priority (13 ≤ SSI ≤ 16). Following this approach, a list of 131 plant species suitable for ecological restoration projects was proposed, with 51 species, mainly perennials, identified as high priority. Furthermore, these species were categorized based on their suitability for the specific habitats encountered throughout AlUla's six Protected Areas, providing valuable information for restoration planning and implementation.

3.8. CONCLUSION

Conserving AlUla's natural heritage is not only important to preserve its unique biodiversity, but also to protect its cultural heritage and provide sustainable livelihoods to its communities. Assessing and quantifying ecosystem services, following the detailed baseline assessment, in AlUla is crucial to support local stakeholders visualize the importance in conserving and help formulate guidelines for the restoration of this natural capital, developed in chapters 4 and 5.

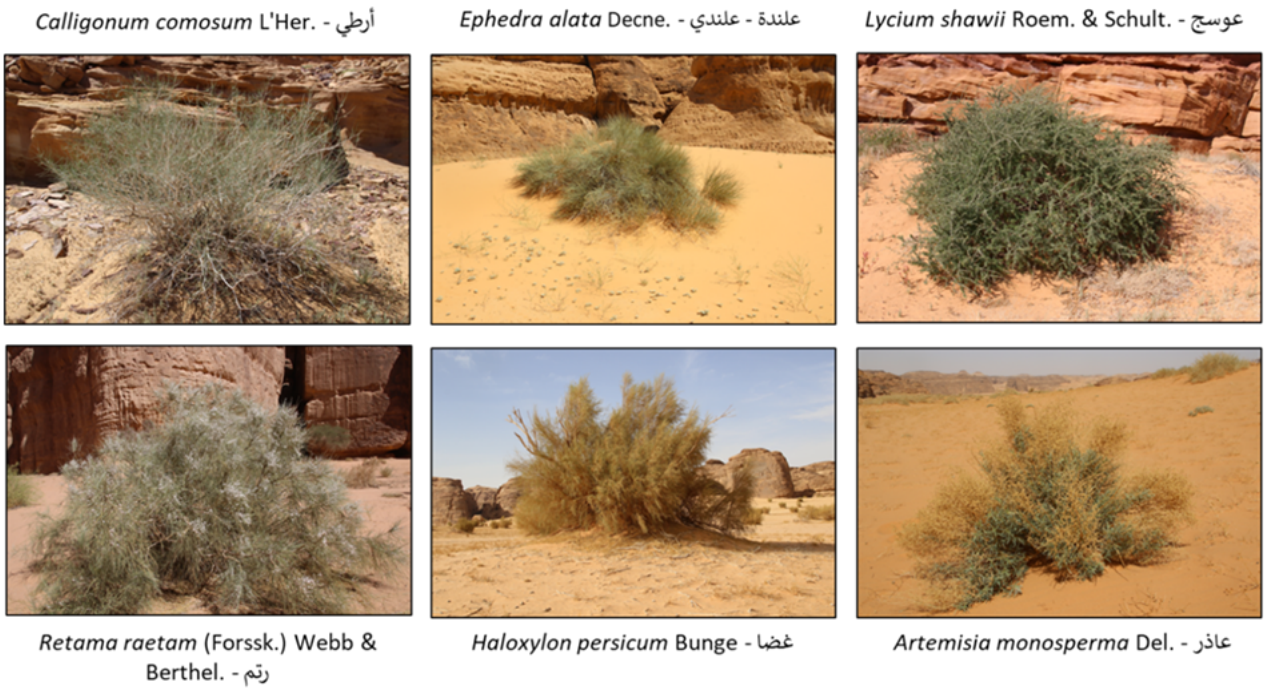


Figure 3.2- Illustration of examples of species of interest for ecological restoration for the six Protected Areas

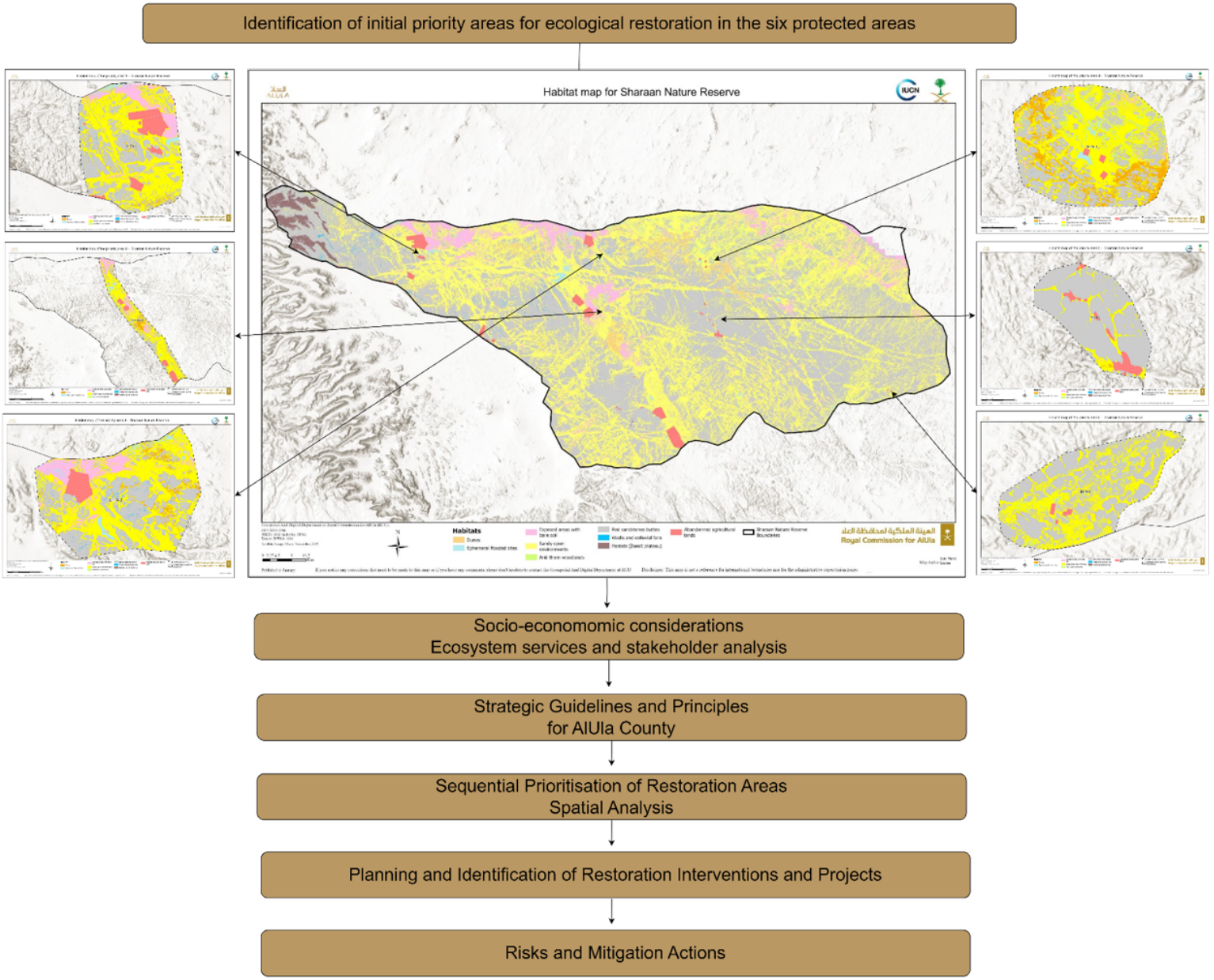


Figure 3.3-Next steps of the strategy based on the baseline assessment outcomes, based on SNP baseline assessment

4. VALUATION OF ECOSYSTEM SERVICES

Being aware of value of ecosystems is becoming increasingly important for their conservation. Therefore, there would be clear benefits in valuing ecosystems and increasing awareness of the importance of policies designed to protect them. Valuation of Ecosystem Services seeks to precisely quantify the economic and ecological worth of ecosystem services while concurrently evaluating the far-reaching consequences of their decline. The multiple ecosystem services provided by the natural ecosystems in AlUla have been quantified and estimates provided of their economic and social values. The valuation followed the standardized method based on the Millennium Ecosystem Assessment (MA) framework.

4.1. CATEGORISATION OF ECOSYSTEM SERVICES

A comprehensive review of all relevant reports, including those published by RCU, as well as research papers and other scholarly resources related to ecosystem services, ecosystem degradation, and degradation costs was conducted. This review of work to date is essential as it provides the basis for understanding the main ecosystems/habitats in AlUla, the ecosystem services they provide, their categorisation, their degree of degradation and the costs of restoration, with a view to establishing the key facts or areas that will enable RCU to have a baseline knowledge or understanding of the ecological-economic context. This study also aims to lay the groundwork for the next steps, namely the estimation of the economic and social values of ecosystem services in AlUla and the identification of restoration measures. Building on this review, this study 1) identifies and categorises the ecosystem services provided by ecosystems/habitats in AlUla following the Millenium Ecosystem Assessment Framework (MA 2005) and 2) establishes a sound basis for the subsequent estimation of the economic value of ecosystem services in the AlUla.

In 2005, the Millennium Ecosystem Assessment identified and categorised ecosystems and their resulting services. The Millennium Ecosystem Assessment framework identified ecosystem services within four categories (figure 4.1). Dynamic interactions exist between people and other parts of ecosystems, with the changing human condition serving to both directly and indirectly drive change in ecosystems that in turn lead to changes in human wellbeing. At the same time, many other factors independent of the environment modify the human condition, and many natural forces influence ecosystems (figure 4.1). Based on the 1) WWF Terrestrial Ecoregions, AlUla County belongs to the deserts and xeric shrublands biome and 2) IUCN Red List of Ecosystems the main biome in AlUla County is deserts and semi-deserts. Habitats were determined in the extensive baseline assessment, adding further ecological knowledge to be able to properly categorise and value services in AlUla, based on the Millennium Ecosystem Assessment (figure 4.1).

Ecosystem services outlined by the Millennium Ecosystem Assessment

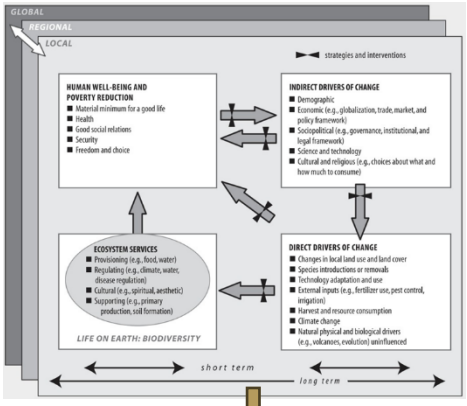
Provisioning Services
Products obtained from ecosystems
- Food
- Fresh water
- Fuelwood
- Fiber
- Biochemicals
- Genetic resources

Regulating Services
Benefits obtained from regulation of ecosystem processes
- Climate regulation
- Disease regulation
- Water regulation
- Water purification
- Pollination

Cultural Services
Nonmaterial benefits obtained from ecosystems
- Spiritual and religious
- Recreation and ecotourism
- Aesthetic
- Inspirational
- Educational
- Sense of place
- Cultural heritage

Supporting Services
Services necessary for the production of all other ecosystem services
- Soil formation
- Nutrient cycling
- Primary production

Millennium Ecosystem Assessment Conceptual Framework



Ecosystem services provided by each type of ecosystem or habitat		Ecosystem functional groups of AlUla **Habitats identified in the baseline assessment:** Abandoned agricultural lands, Sandy exposed environments, Ephemeral flooded sites, Red sandstone buttes, Dunes, Harrats, Exposed areas with bare soil, Wadi and colluvial fans, Arid thorn woodlands			
		Rocky areas	**Deserts** (Semi-desert steppes and hyper- arid deserts)	**Pastureland** (Dwarf-shrub steppes and arid grasslands)	**Plantations (Oases)**
Regulating services	Maintaining soil humidity and water flow regulation				
	Crop pollination				
	Erosion control				
	Maintaining soil fertility				
	Limit of the desert advance				
	Sandstorm prevention				
	Solar radiation reduction				
	Climate regulation				
	Temperature control				
	CO_2 storage				
	Air quality regulation				
	Urban refreshment				
Provisioning services	Compost production				
	Food (mainly livestock products)				
	Agricultural food sources				
	Wild food				
	Genetic and medicinal resources				
	Water for humans, livestock, irrigation and sanitation				
Cultural services	Inspiration, aesthetics, and landscape				
	Tourism (ecotourism) and recreation				
	Education and scientific discovery				
	Culture and heritage values				
Supporting services	Nutrient cycling				
	Habitat provision for species and biodiversity				
	Biomass production				

Figure 4.1- Categorisation of ecosystem services in AlUla based on MA 2005

4.2. QUANTITATIVE ASSESSMENT AND SPATIAL ANALYSIS

Following the categorisation of ecosystem services in AlUla, a methodology was developed to quantitatively assess the services leading to the identification of hotspots for ecosystem services provision will help delineate impact of management interventions to control or mitigate land degradation.

For the carbon storage model, different tools were used for spatial analysis of the data. One technique included downloading, editing and analysing vectors as raster cartographic layers using the QGIS and ArcGIS Pro software. A second technique used the Integrated Valuation of Ecosystem Services Trade-offs (InVEST) 3.8.0 modelling software (Sharp et al. 2016) to analyse the land uses and carbon storage in each of the six protected areas in AlUla county for the base year 2022. With an area of 468,000 hectares, Harrat Uwayrid Biosphere Reserve is the largest protected area. According to the InVEST model, it is also the protected area with the third highest current carbon storage capacity per hectare. Harrat AlZabin Nature Reserve has the highest storage capacity (64 tonnes per hectare) and Khaybar White Volcano Geopark the lowest (12 tonnes per hectare).

For the tourism model, the InVEST recreation model was used. It predicts the spread of person-days of recreation, based on the locations of natural habitats and other features that factor into people's decisions about where to recreate. The tool estimates the contribution of each attribute to visitation rate in a simple linear regression.

The quantitative assessment and spatial analysis helped identify hotspots for ecosystem service provision and areas of high priority. It also helped delineate sensitive areas. Priority zone mapping defined in the Baseline Assessment was used to identify the most important areas, considering parameters such as distance to agricultural lands, habitats, accessibility, soil vulnerability, vegetation, biodiversity, presence of camels and goats and tourism. Table 1 summarizes the hot spots identified and their main parameters characterized from the baseline assessment. The whole process is summarized in figure 4.2.

The identification of hotspots (figure 4.3) for ecosystem services provision will help delineate impact of management interventions to control or mitigate land degradation.

Table 4.1- Hot spots identified and their main characteristics

Site Name	Hotspot	Agric	Habitat	Access	Soil Vulne	Veg	Biodive	CamGoat	Tourism
SNP	SH_1	Close	Ab+Sexp+Du	Good	Mod	Yes	Yes	No Info	Close
	SH_2	Close	Ab+Sexp +RS	Good	Mod	Yes	Yes	No Info	Med
	SH_3	Close	Rs+Sexp	Good	Mod	Yes	Yes	No Info	Med
	SH_4	Close	Ab+Sexp +RS	Good	Mod	Yes	No	No Info	Med
	SH_5	Med	Rs+Sexp	Med	Mod	Yes	No	No Info	Far
HUBR	HU_1	Far	Sop+ExB+RS	Bad	Low	No Info	No Info	Far	Far
	HU_2	Far	Sop+ExB+RS	Bad	Low	No Info	No Info	Close	Close
	HU_3	Close	Sop	Good	Mod	No Info	No Info	Close	Far
	HU_4	Close	ExB	Good	Low	No Info	No Info	Close	Close
	HU_5	Close	AT	Good	Mod	No Info	No Info	Far	Close
	HU_6	Close	AT+RS	Good	Low-Mod	No Info	No Info	Close	Far
HZNR	HA_1	Far	WC	Bad	Mod-High	No Info	No	No	No Info
	HA_2	Far	WC+Ha	Med	Low-High	No Info	Yes	Close	No Info
	HA_3	Far	WC+Ha	Med	High	No Info	Yes	Close	No Info
	HA_4	Far	WC+Ha	Med	Low-High	No Info	No	Close	No Info
	HA_5	Far	WC	Good	High	No Info	Yes	No	No Info
	HA_6	Far	WC+Ha	Med	Low-High	No Info	Yes	Close	No Info
GNR	AG_1	Med	Sop	Good	High	Yes	Close	Close	Med
	AG_2	Med	Sop	Good	Low-Mod	Yes	Yes	Close	Med
	AG_3	Far	Sop	Bad	Mix	No	No	Far	Med
	AG_4	Far	Sop	Good	Low-Mod	Yes	Close	Close	Med
	AG_5	Med	Sop	Good	Low	No	No	Far	Med
WNNR	WK_1	Far	ExB	Med	High	No Info	No	Far	Far
	WK_2	Far	Sop+Ha	Bad	Low-Mod	No Info	No	Close	Far
	WK_3	Far	Sop+Ha	Bad	Low-Mod	No Info	No	Close	Far
	WK_4	Far	Sop+Ha	Bad	Mod	No Info	No	Far	Far
	WK_5	Far	Sop	Bad	Mod	No Info	No	Close	Far
KWVG	HK_1	Far	1+3 arcgis	Bad	Mod	No Info	No	No Info	Far
	HK_2	Far	1+2+4	Bad	Mod	No Info	No	No Info	Med
	HK_3	Far	3	Bad	Low-Mod	No Info	No	No Info	Far
	HK_4	Far	3+4	Bad	Mod	No Info	No	No Info	Far
	HK_5	Far	3+4	Bad	Mod	No Info	No	No Info	Far

Name	C_above	C_below	C_soil	C_dead
Crops_Dunes	0.5	1	5	0
Crops_Sandy exposed environments	0.5	1	5	0
Crops_Red sandstones buttes	0.01	0.01	2	0
Crops_Wadis and colluvial fans	3	3	10	1
Crops_Abandoned agricultural lands	10	5	10	2
Built area_Dunes	0	0	0	0
Built area_Sandy exposed environments	0	0	0	0
Built area_Arid thorn woodlands	0	0	0	0
Built area_Red sandstones buttes	0	0	0	0
Built area_Abandoned agricultural lands	0	0	0	0
Bare ground_Dunes	0.5	1	5	0
Bare ground_Ephemeral flooded sites	0.5	1	5	0
Bare ground_Exposed areas with bare soil	0	0	0	0
Bare ground_Sandy exposed environments	0.5	1	5	0
Bare ground_Arid thorn woodlands	4	4	12	3
Bare ground_Red sandstones buttes	0.01	0.01	2	0
Bare ground_Wadis and colluvial fans	3	3	10	1
Bare ground_Harrats (basalt plateau)	3	3	10	1
Bare ground_Abandoned agricultural lands	10	5	10	2
Rangeland_Dunes	0.5	1	5	0
Rangeland_Ephemeral flooded sites	1	1	5	0
Rangeland_Exposed areas with bare soil	0	0	0	0
Rangeland_Sandy exposed environments	1	1	5	0
Rangeland_Arid thorn woodlands	8	8	25	3
Rangeland_Red sandstones buttes	0.03	0.03	4	0
Rangeland_Wadis and colluvial fans	5	5	12	1
Rangeland_Harrats (basalt plateau)	5	3	10	1
Rangeland_Abandoned agricultural lands	15	5	15	2

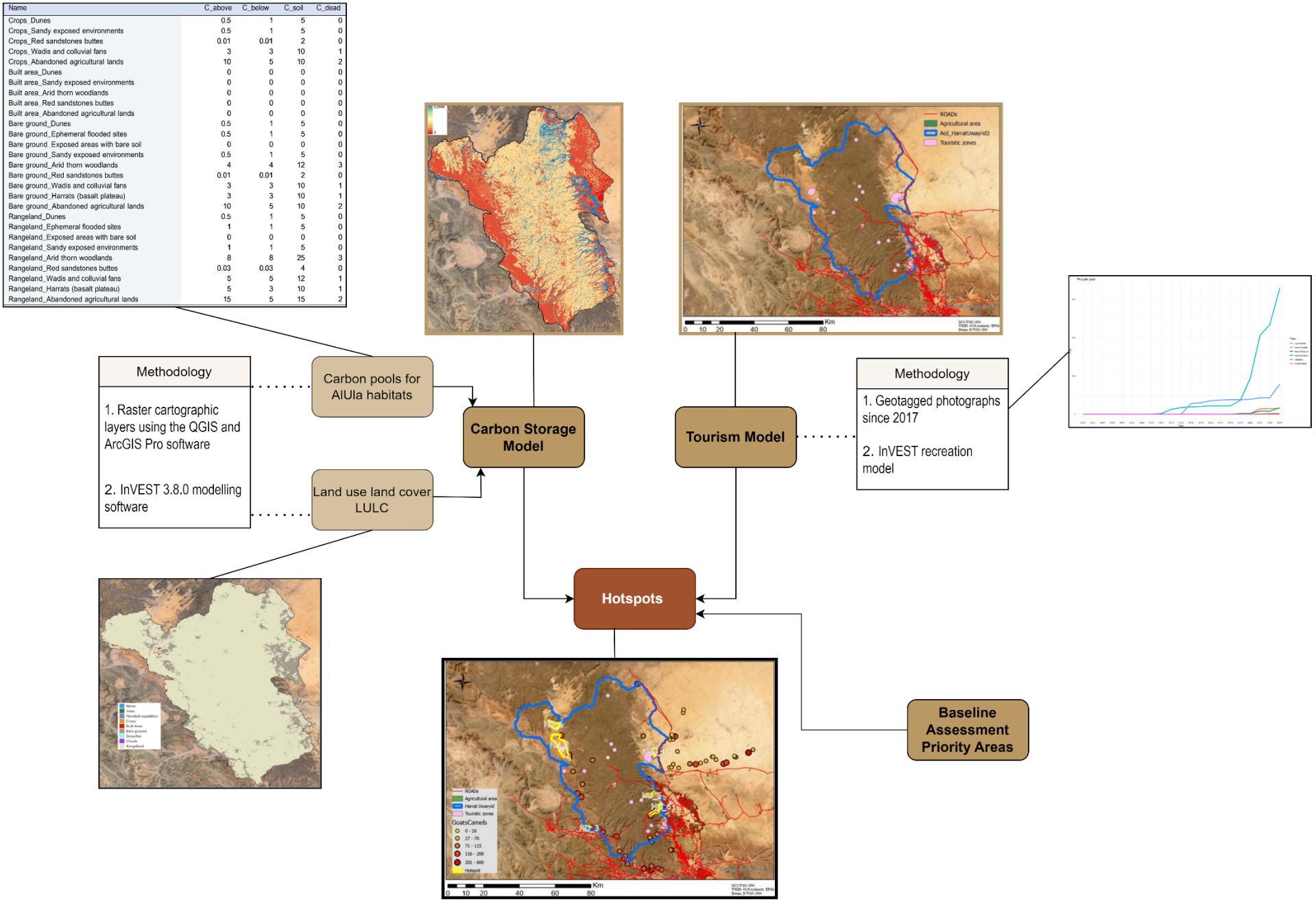


Figure 4.2-Summary of the quantitative assessment and spatial analysis

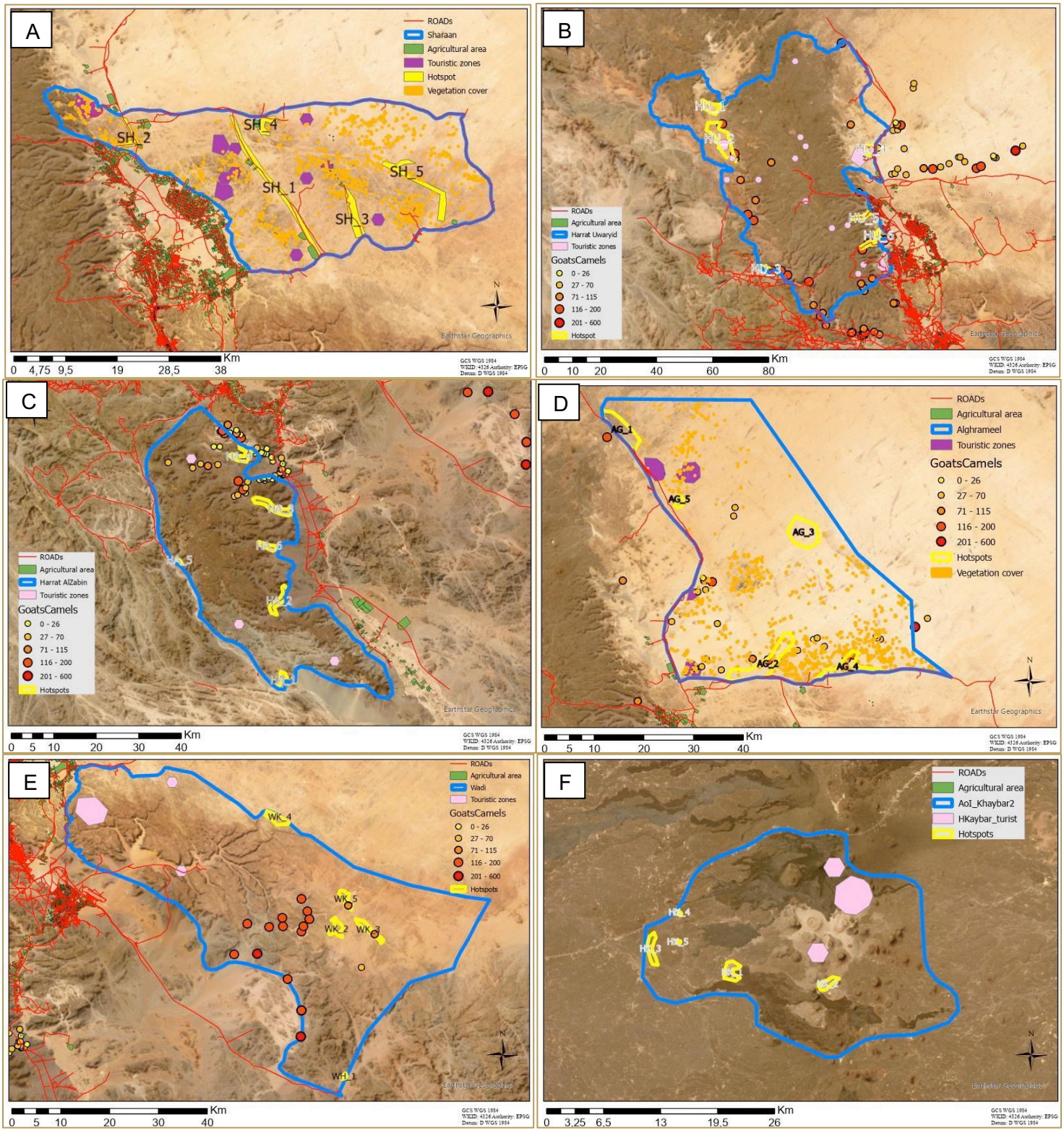


Figure 4.3-Hotspots in A) SNP, B) HUBR, C) HZNR, D) GNR, E) WNNR and F) KWVG

4.3. ECONOMIC VALUATION

Economic valuation can make it explicit to society and policymakers that environmental and natural resources are scarce and that their conservation has associated benefits. If these benefits are not accounted for, policy can be misguided, and society may be affected due to misallocation of resources. Therefore, valuing natural resources and the environment (i.e. measuring economic values of environmental and natural resources) can support decision making that has a positive effect on environmental and natural resources.

Following the categorisation and quantitative assessment of main ecosystem services, their economic value is estimated. In particular, the economic value of the following services was calculated: agricultural production, livestock production, carbon storage, crop pollination, tourism and recreation, cultural heritage, and biodiversity (table 4.2).

Table 4.2-Ecosystem services selected for economic valuation.

Ecosystem service	
Provisioning services	Agricultural food sources
	Livestock products
Regulating services	CO2 storage
	Crop pollination
Cultural services	Tourism and recreation
	Cultural heritage values
Supporting services	Habitat provision for species - biodiversity

The selected valuation methods and their alignment with those being discussed in the context of the System of Environmental Economic Accounting (SEEA) are assessed with an objective to determine whether the methodologies for estimating the economic value of ecosystem services in AlUla are in line with the monetary valuation principles for ecosystem accounting established by the SEEA. The analytical framework for carrying out this mapping is shown in table 4.3.

System of Environmental Economic Accounting (SEEA)

SEEA is a system for organizing statistical data for the derivation of coherent indicators and descriptive statistics to monitor the interactions between the economy and the environment and the state of the environment to better inform decision-making. It contains the internationally agreed standard concepts, definitions, classifications, accounting rules and tables for producing internationally comparable statistics. The SEEA framework follows a similar accounting structure as the System of National Accounts (SNA).

Table 4.3- Alignment of valuation methods with the SEEA

Ecosystem services		Method	Aligned with SEEA
Provisioning services	Agricultural food sources	Market prices	✓
	Livestock products	Market prices	✓
Regulating services	CO_2 storage	Market prices & social cost of carbon	✓
	Crop pollination	Market prices	✓
Cultural services	Tourism and recreation	Market prices	✓
	Cultural heritage values	Contingent valuation	✗
Supporting services	Habitat provision for species - biodiversity	Contingent valuation	✗

Results of the economic valuation for each ecosystem services selected, and all protected areas are summarized in table 4.4. It is important to note that:

- economic value of agricultural production is calculated by multiplying the net production of each type of crop (in kilograms) per year (in this case, year 2022) by the market price of that product (2022 values).
- economic valuation of livestock production is calculated by multiplying the quantity of meat produced (in kilograms) by the market price of that type of meat, for HUBR, HZNR, WNNR and GNR.
- economic valuation of carbon storage is estimated by multiplying the amount of carbon stored in each protected area by the Social Cost of Carbon (SCC) and the market prices in the voluntary market, which gives companies, non-profit organizations, governments, and individuals the opportunity to buy and sell carbon offset credits.
- the possibility of using InVEST to estimate the value of crop pollination in the six protected areas was explored. A systematic review of the literature was conducted to identify pollinator species and their pollination-related parameters that could be integrated into the model.
- for the economic valuation of cultural heritage, an econometric analysis based on the contingent valuation method was carried out.
- economic value of biodiversity is calculated the same procedure was followed as in the case of cultural values.

Table 4.4- Economic value of selected ecosystem services

Ecosystem services	Economic value in SAR	Economic value in USD
Agricultural food sources	672.29 Ma	181.66 Ma
Livestock products	51.35 Ma	33.74 Ma
CO_2 storage	1635.09 Ma	435.99 Ma
Crop pollination	57.15 Ma	15.24 Ma
Tourism and recreation*	1,105.95 Ma	295.44 Ma
Cultural heritage values	22.2 Ma	5.9 Ma
Habitat provision for species - biodiversity	21.2 Ma	5.7 Ma

**Based on gross revenue economic value*

4.4. SOCIAL VALUE ASSESSMENT

The stakeholder consultations undertaken as part of the social value assessment have provided several key insights into the threats and perceived value of the Protected Areas in AlUla County.

The discussions held highlighted that the protected areas are threatened by a variety of factors. The most concerning issue is uncontrolled grazing by livestock originating outside the protected areas, highlighting the need for stricter regulations. Further threats highlighted by stakeholders include poaching, climate change impacts, and windblown litter and refuse. Critically, the protected area rangers' lack of formal authority to enforce regulations hinders effective management.

Regarding the contribution of protected areas to community economic development and well-being: while local stakeholders perceive the protected areas positively and contributing to economic well-being through job creation, concerns exist. These include an uneven distribution of benefits, rising housing costs, and a sense of dispossession among some community members due to the fencing of land. Additionally, the general sentiment held by non-RCU stakeholders is that they are disconnected from the development process, lack information, and feel excluded.

These findings indicate that further work is required to protect the protected areas and integrate local communities into this process. Addressing external livestock grazing, strengthening enforcement authority, and fostering inclusive development practices that ensure equitable benefits and community ownership are critical for the restoration process. Open communication and collaboration between RCU and local stakeholders are essential for long-term sustainability.

4.5. CONCLUSION

Assessing ecosystems and ecosystem services is important to inform the development and implementation of related policies on climate, agriculture, forest, and regional planning. Thus, identifying key indicators and metrics to track enhancements in ecosystem service provision resulting from restoration efforts is important in the case of the Strategy for Ecosystem Restoration. This section is further developed in the Strategic Components (Chapter 8).

5. COST OF ECOSYSTEM DEGRADATION AND RESTORATION

5.1. INTRODUCTION TO COST OF ECOSYSTEM DEGRADATION

There are no national-scale studies that determine the level of degradation in KSA in physical terms. There is also no study that has analyzed ecosystem services, and the value provided by KSA's ecosystems. Considering all these gaps, the objective of this report has been formulated with the intention to bridge the existing gaps and understanding the cost of land degradation. The Economics of Land Degradation (ELD) Initiative has launched a key report at the 70th United Nations General Assembly. The ELD Initiative estimated that the global loss of ecosystem service values (ESV) costs between USD 6.3 and 10.6 trillion annually. The report points out that the effects of land degradation and desertification are distributed unevenly throughout human populations and often impact on the most vulnerable – the rural poor.

5.1.1.ESTIMATION OF LAND USE AND COVER CHANGES BETWEEN 2017-2022

Analysing land use and cover change involves observing how specific areas of Earth have changed in terms of their natural or human use. This analysis can be done using satellites that employ multispectral imaging technology to capture data across different bands of the electromagnetic spectrum, allowing for the analysis of variation in vegetation, water bodies, urban developments, and more. This type of technology is crucial for urban and regional planning, natural resource management, and monitoring the environmental impact of human activities (Rong, C.; Fu, W., 2023; Panuju, D.R et al., 2020). To analyse land use and cover changes in AlUla, satellite images provided by Sentinel-2 were used. Sentinel-2 is an Earth observation mission from the Copernicus Programme that systematically acquires imagery at high spatial resolution (10-60 m) over land and coastal waters (European Agency, 2024). Using the free and open data provided by Sentinel-2 at different points in time allowed the study team to identify the trends in land use and cover change in AlUla. Changes in land use from 2017-2022 in the six protected areas were analysed to quantify the rate of change, then projected trends to 2040. The cartography of 2017 was superimposed with that of 2022, and the area calculated that shows change from one to the other. Using this method, it is not possible to calculate uncertainty for specific land use changes. This has biases but is the best available approach given the context.

5.1.2.PROJECTED LAND USE AND LAND COVER CHANGES: 2040 SCENARIOS

Building on the changes over the five-year period of study (2017-2022), projections were made to 2040 using the Scenario Generator Package of InVEST. In this manner, an array of land-use change patterns (cropland, pasture, rangeland etc.) can be generated. Looking at how much area has changed in the last five years, the model takes into account the area that has to change in the next years and transform the land with the criteria that are defined. Based on the changes observed over the last five years, three potential future scenarios are proposed: an aggressive scenario in which changes are expected to continue at the same rate, with predictions made every five years; a moderate scenario, which foresees a 50% reduction in the rate of land use change every five years, and a conservative scenario which foresees a more substantial decrease, with 75% reduction in land use change every five years.

5.1.3.SUMMARY OF RESULTS

Considering the three main land uses or changes from 2017 to 2022, two primary patterns can be identified. Rangeland is the predominant land use in all protected areas (between 43% and 75% of the area) except in Gharameel Nature Reserve, where most of the land (73%) is covered by bare ground. Conversion of bare ground to rangeland during this five-year period ranged from 13%-34% of the land area across the protected areas (with an average of 18%).

Overall, preliminary analysis with limited available data suggests that there is not widespread evidence of degradation of the protected areas; however, it is acknowledged that a five-year span of data is limited in making generalizations about these areas without ground-truthing and a longer historical timespan for analysis. It should also be noted that the timeframe of the data utilized is the period since the establishment of the Protected Areas. Improvements in levels of degradation may therefore be as a result of improved land management. Using available data, it can be said that rangeland area has increased between 2017-2022 in all the protected areas, except Wadi Nakhlah Nature Reserve. This may create a slightly higher diversity and density of vegetation, although the overall improvement in the protected areas' natural habitats remains unknown without additional data. See the summary of historical trends across land uses in the six protected areas in figure 5.2.

Table 5.1- Summary of historical trends in percent land cover

Permanent areas	GNR	SNP	HZNR	HUBR	KWVG	WNNR
Rangeland	11.62	42.89	58.6	75.37	72.46	**57.86**
Bare ground	73.19	22.76	28.03	9.65	8.57	**27.36**
Built area	0	0	0.1	0.08	0	**0**
Crops	0	0.06	0	0.05	0	**0**
Changed areas	**GNR**	**SNP**	**HZNR**	**HUBR**	**KWVG**	**WNNR**
Bare ground to rangeland	15.18	34.16	13.09	14.73	17.55	**14.77**
Rangeland to built area	0	0	0.04	0.05	0	**0**
Rangeland to crops	0	0.03	0	0.03	0	**0**
Bare ground to crops	0	0.01	0	0.02	0.02	**0**
Bare ground to built area	0	0	0	0.01	0	**0**
Crops to rangeland	0	0.01	0	0	0	**0**
Rangeland to bare ground	**0**	**0**	**0**	**0**	**0.01**	**0**

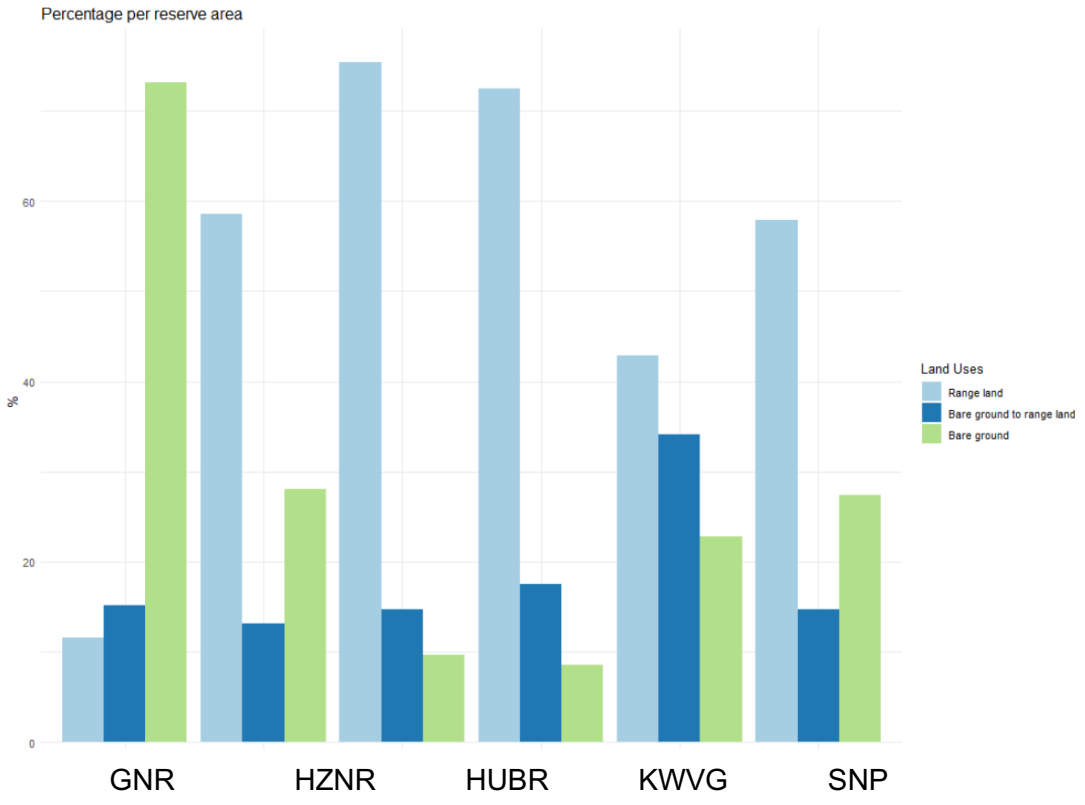


Figure 5.1- Summary of historical trends

Using the three potential severity scenarios, the number of hectares was estimated within each protected area that will be converted from bare ground to rangeland between now and 2040 (Table 5.2).

Based on the changes observed over the last five years, three potential future scenarios are proposed: an *aggressive scenario* in which changes are expected to continue at the same rate, with predictions made every five years; a *moderate scenario*, which foresees a 50% reduction in the rate of land use change every five years; and a *conservative scenario* which foresees a more substantial decrease, with a 75% reduction in land use change every five years.

Table 5.2- Hectares estimated to convert to rangeland by 2040

Scenarios			
	Aggressive	**Moderate**	**Conservative**
SNP	82,000	47,000	**25,000**
HUBR	37,000	23,000	**13,000**
HZNR	44,000	34,000	**22,000**
GNR	8,500	4,000	**2,500**
KWVG	34,000	26,000	**16,000**
WNNR	**54,000**	**35,000**	**20,000**

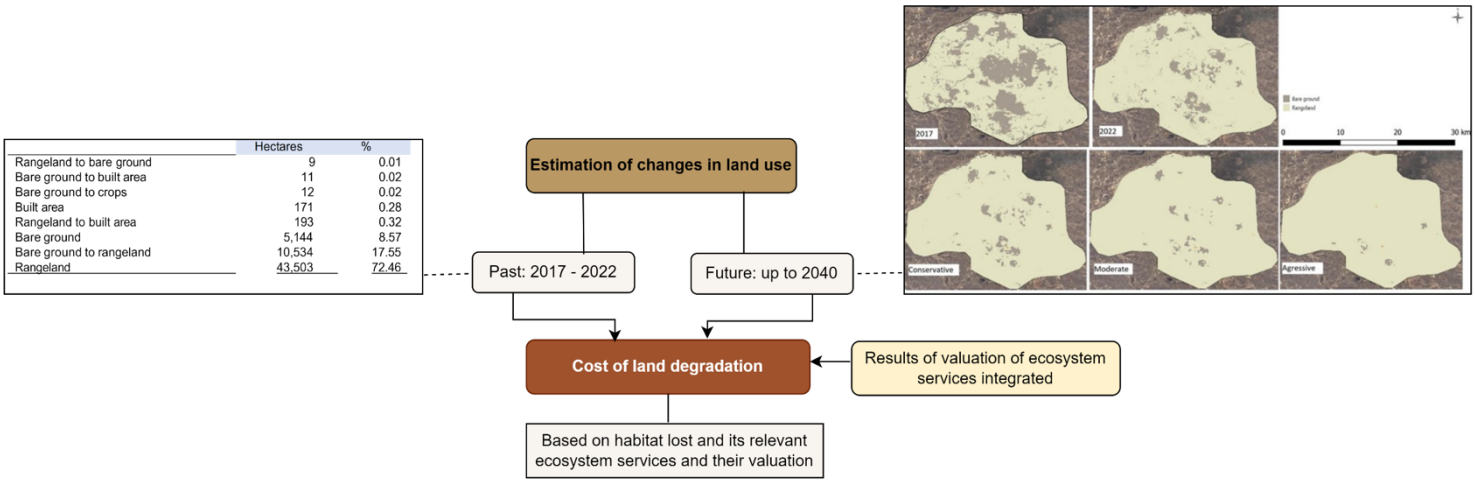


Figure 5.2- Summary of methodology to estimate cost of land degradation

5.2. CONCLUSION

Cost of land degradation and cost of ecosystem restoration are two important concepts to quantify in order to develop a concrete and data-based Strategy for Ecosystem Restoration.

The impacts of land use changes in monetary terms can be estimated by calculating the cost of land use changes using the detailed economic valuation of the main ecosystem services provided by ecosystems in AlUla to 2022, as summarized in figure 5.2. A more refined model to calculate cost of land degradation would be recommended in the near future. It is important to note that cost of land degradation should be based on land use changes and their projections caused by land degradation and not from conservation and restoration efforts. In the case of SNP, efforts between 2017 and 2022 were focused on protection, conservation and restoration, which would also lead to land use change. However, it would intend to decrease cost of degradation in this case.

Furthermore, more accurate interventions need to be identified, spatially and sequentially, to estimate the cost of restoration properly. The intensive work done on ecosystem services valuation and cost of land degradation and restoration has identified clear steps to be taken to develop a more context specific Strategy for Ecosystem restoration for AlUla, more specifically within the six protected areas.

Understanding ecosystem services and how to estimate their values and direct or indirect contributions to livelihoods will help in developing cost effective restoration action plans aligned with ecological, social and economic contexts. Restoration funding models will be based on economic benefits of restoration and actual cost of restoration intervention.

6. ECOSYSTEMS STRATEGIC GUIDELINES AND PRINCIPLES

Different drivers generate a wide range of pressures on natural and modified ecosystems, leading to large scale degradation of natural landscapes. For restoration projects to have a meaningful and sustainable impact on natural resource management, biodiversity conservation and human wellbeing, all drivers and pressures need to be taken into account, whether ecological, social or economic. Moreover, to be able to accurately estimate the cost of ecosystem degradation and cost of ecosystem restoration, a comprehensive ecosystem strategy has to be developed with quantifiable indicators. A thorough understanding of strategic guidelines and principles for ecosystem restoration is presented and explored in relevance to the AlUla context. It opens with an in-depth introduction to the concepts of ecological and ecosystem restoration and is especially focused on providing a foundation for applying standards-based restoration to the Strategy for Ecosystem Restoration.

Major restoration types range from reducing societal impacts that cause ecosystem degradation to the full recovery of natural ecosystems with all their key attributes. The restorative continuum includes a range of activities and interventions that can improve environmental conditions and reverse ecosystem degradation and landscape fragmentation. The continuum highlights interconnections among these different activities and recognises that the specific characteristics of the locality slated for restorative actions dictate the activities best suited for different landscape units. As one moves from left to right on the continuum, both ecological health and biodiversity outcomes, and quality and quantity of ecosystem services increase. Note that ecological restoration can occur in urban, agricultural, and industrial landscapes (FAO et al. 2024).

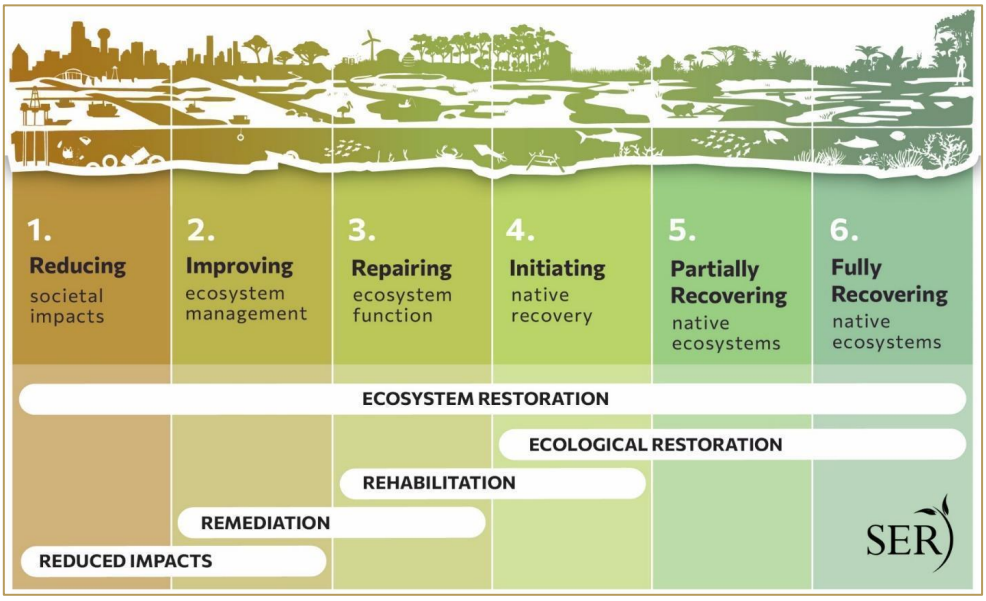


Figure 6.1-The SER Restorative Continuum

6.1. EXISTING RESTORATION GUIDANCE AND KEY PRINCIPLES

6.1.1.THE UN DECADE ON ECOSYSTEM RESTORATION GUIDANCE

The UN Decade, through its Best Practices Task Force in collaboration with SER and the IUCN Commission on Ecosystem Management, developed Principles (FAO et al. 2021) and Standards of Practice (SOPs; Nelson et al. 2024) for ecosystem restoration. The SOPs are tiered to the 10 UN Decade Principles, and are based on five major components (assessment, planning and design, implementation, ongoing management, and monitoring and evaluation), 45 subcomponents, and over 300 individual practices. Although many principles documents and SOPs were used to develop the UN Decade Principles, they are closely aligned with the principles previously published in the SER Standards. The UN Decade Principles and SOPs inform restoration activities along the entire Restorative Continuum

6.1.2.THE SOCIETY FOR ECOLOGICAL RESTORATION GUIDANCE

SER has produced several Standards and related products that underpin standards-based ecological restoration and inform ecosystem restoration more broadly around the world. They provide voluntary guidance on the restoration of natural and semi-natural landscapes. The SER Standards (Gann et al. 2019) are based on eight principles, four core standards of practice with detailed subcomponents for ecological restoration projects, and other key guidance including, e.g., the development of reference models, identifying appropriate restoration approaches, the role of ecological restoration in global restoration initiatives, and selecting seeds and other propagules for restoration.

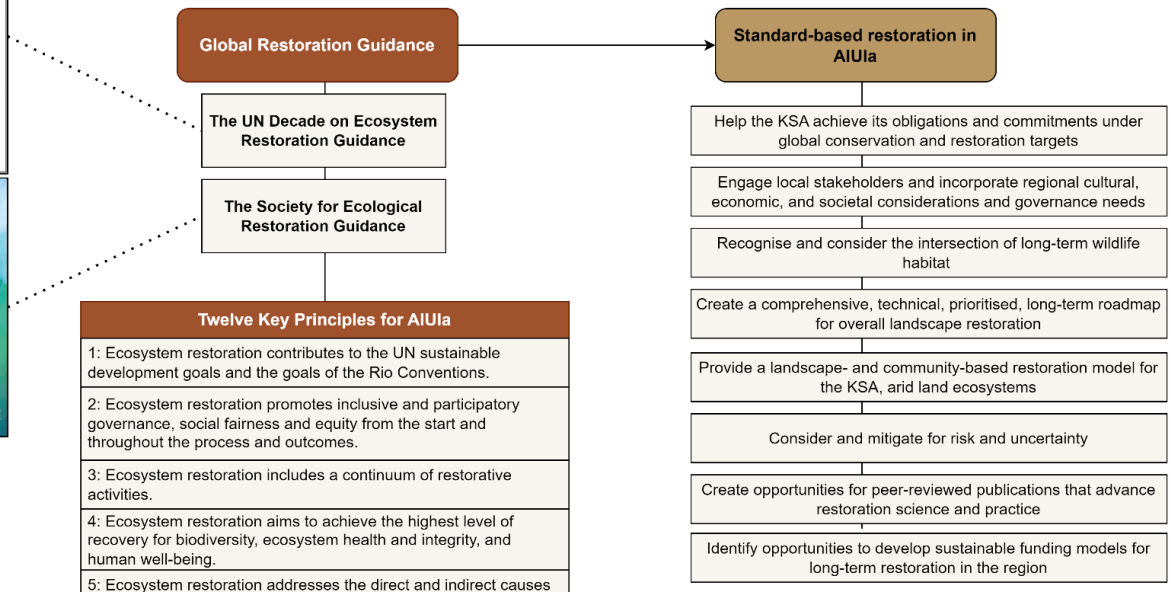
The SER Standards also introduced key concepts and tools useful for planning, implementing, monitoring, and communicating about ecological restoration, such as the Restorative Continuum, Five-star System including the Six Key Ecosystem Attributes, Ecological Recovery Wheel, and Social Benefits Wheel. These tools have been expanded since the publication of the SER Standards and are available online to support the implementation of standards-based ecological restoration. Of particular interest is the sub-attribute table, which allows practitioners to track progress across 18 or more variables linked to the six key ecosystem attributes. Additional SER standards-based resources include standards for the use of native seed in ecological restoration, and the specifically calibrated Five-star System sub-attributes table for ecological restoration in arid lands. The SER Standards align with the Conservation Standards, which are widely used by conservation practitioners and policymakers worldwide.

6.2. RCU PRINCIPLES FOR ECOSYSTEM RESTORATION

Tailored principles for the implementation of Ecosystem Restoration in AlUla have been developed utilsiing a combination of guidance from the UN Decade on Ecosystem Restoration and the SER Standrads. The RCU Principles for Ecosystem Restoration are provided in Figure 6.2.







Twelve Key Principles for AlUla
1: Ecosystem restoration contributes to the UN sustainable development goals and the goals of the Rio Conventions.
2: Ecosystem restoration promotes inclusive and participatory governance, social fairness and equity from the start and throughout the process and outcomes.
3: Ecosystem restoration includes a continuum of restorative activities.
4: Ecosystem restoration aims to achieve the highest level of recovery for biodiversity, ecosystem health and integrity, and human well-being.
5: Ecosystem restoration addresses the direct and indirect causes of ecosystem degradation.
6: Ecosystem restoration incorporates all types of knowledge and promotes their exchange and integration throughout the process.
7: Ecosystem restoration is based on well-defined short-, medium- and long-term ecological,and social-economic goals and objectives, including KPIs.
8: Ecosystem restoration is tailored to the local ecological, cultural and social-economic contexts, while considering the larger landscape.
9: Ecosystem restoration includes monitoring, evaluation and adaptive management throughout and beyond the lifetime of the project or program.
10: Ecosystem restoration is enabled by policies and measures that promote its long-term progress, fostering replication and scaling-up.
11: Ecological restoration, as a specific type of ecosystem restoration, is informed by natural reference ecosystems, while considering environmental change.
12: Ecosystem restoration supports ecosystem recovery processes.

Figure 6.2- Global guidance in relevance to AlUla context

6.3. STRATEGIC GUIDELINES FOR ECOSYSTEM RESTORATION

Building from the UN Decade SOPs and SER Standards, the Strategy for Ecosystem Restoration provides the following high-level guidance for application during the development and implementation of restoration in AlUla. As this Strategy for Ecosystem Restoration is designed for the six Protected Areas in AlUla and the majority of the restoration will take place within those areas, it will rely primarily on ecological restoration and will target stakeholders engaged in implementation of restoration projects in AlUla. The SER Standards are therefore emphasised as the main ecological guidance, while the UN Decade SOPs are emphasized for stakeholder guidance. Please note that both the SER Standards and the UN SOPs contain much more detailed guidance and the recommendations below elevate those things that are most critical for restoration in AlUla County.

6.3.1.IDENTIFYING RESTORATION TARGETS, GOALS, AND OBJECTIVES

In the planning phase of restoration projects, the project scope, vision, targets, goals, and objectives are identified, along with specific indicators to measure progress (Gann et al. 2019). Both ecological and social attributes of the project should be included. Indicators can then be used to monitor progress over time, applying adaptive management approaches.

Use of the Ecological Recovery Wheel

SER encourages the creative use of tools such as the Ecological Recovery Wheel (ERW) and appreciates the incorporation of the ERW into previously developed restoration guidance for AlUla from the baseline assessment analysis. However, SER recommends avoiding oversimplification. For example, the previously modified AlUla ERW focuses on plants and excludes animals (e.g., in the composition attribute). This is problematic, e.g., because the assignment of a Five-star System rating for “All trophic levels” for dunes in SNP is not possible given the absence of key faunal communities there. In HUBR, a Five-star System rating for “Absence of weeds” (modified from “No undesirable species”) in sandy open environments is inconsistent with records of species that are indicators of overgrazing. SER has now developed additional tools to help standardise and improve how the ERW is used for AlUla, specifically the sub-attributes table for arid lands available on the SER Standards tools page (Gann et al. 2024). In addition, the arid lands sub-attribute table can help align results when assessing sites and filling out the ERW using the Five-star System (figure 6.3).

6.3.2.KEY STANDARDS OF PRACTICE FOR APPLICATION IN ALULA COUNTY

Key ecological guidance and restoration interventions

Identifying target native reference ecosystem

A target native reference ecosystem, or habitat, is selected for each unique project area. In some cases, the target will be the same as the habitat identified in the mapping or corrected during the ground truthing (e.g., Arid thorn woodlands, Wadis and colluvial fans). In other cases, the target may not be the same as the current condition since the current condition represents a converted habitat (e.g., abandoned agricultural lands, Exposed areas with bare soil).

Attribute	Sub-attribute	Five-star system attribute rating
Species Composition	Desirable plants	SER Five-star System Sub-attribute Table Arid Lands https://docs.google.com/spreadsheets/d/1SGa1U37omDEy2_PySEG0BN1Alghfg6_Y/pubhtml?gid=1225455839&single=true
	Desirable animals	
	No undesirable species	
Structural diversity	All vegetation strata	
	All trophic levels	
	Spatial mosaic	
Ecosystem function	Production cycling	
	Habitats & interactions	
	Resilience/recruitment	
External exchanges	Habitat links	
	Gene flows	
	Landscape flows	
Absence of threats	Contamination	
	Invasive species	
	Over utilization	
Physical conditions	Water chemo-physical	
	Substrate chemical	
	Substrate physical	

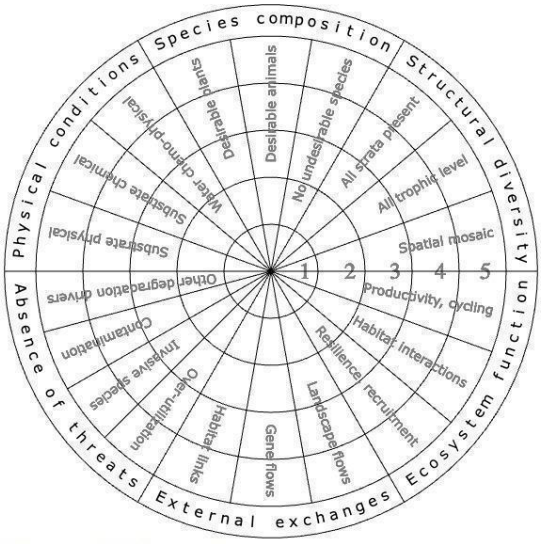


Figure 6.3-The ecological recovery wheel recommended for arid land with attributes and sub-attributes

In those cases, multiple choices of a target habitat are possible and data from ground truthing, stakeholder feedback, and expertise are used to make a selection of a target native habitat. Extreme degradation in sandy habitats may also make a determination difficult. Degraded dunes may represent historical native dunes and high-integrity native dunes may be an appropriate target for restoration. But degraded dunes may also represent a highly degraded condition that could be stabilised and another habitat, such as Arid thorn woodlands restored. Finally, Sandy open environments, which constitute thousands of square kilometres in AlUla, and ephemeral flooded sites, do not necessarily represent degraded conditions of those ecosystems. Until additional work can be conducted to determine reference conditions for undegraded sandy open environments and ephemeral flooded sites, these can be considered as temporary rehabilitation targets, rather than targets for ecological restoration.

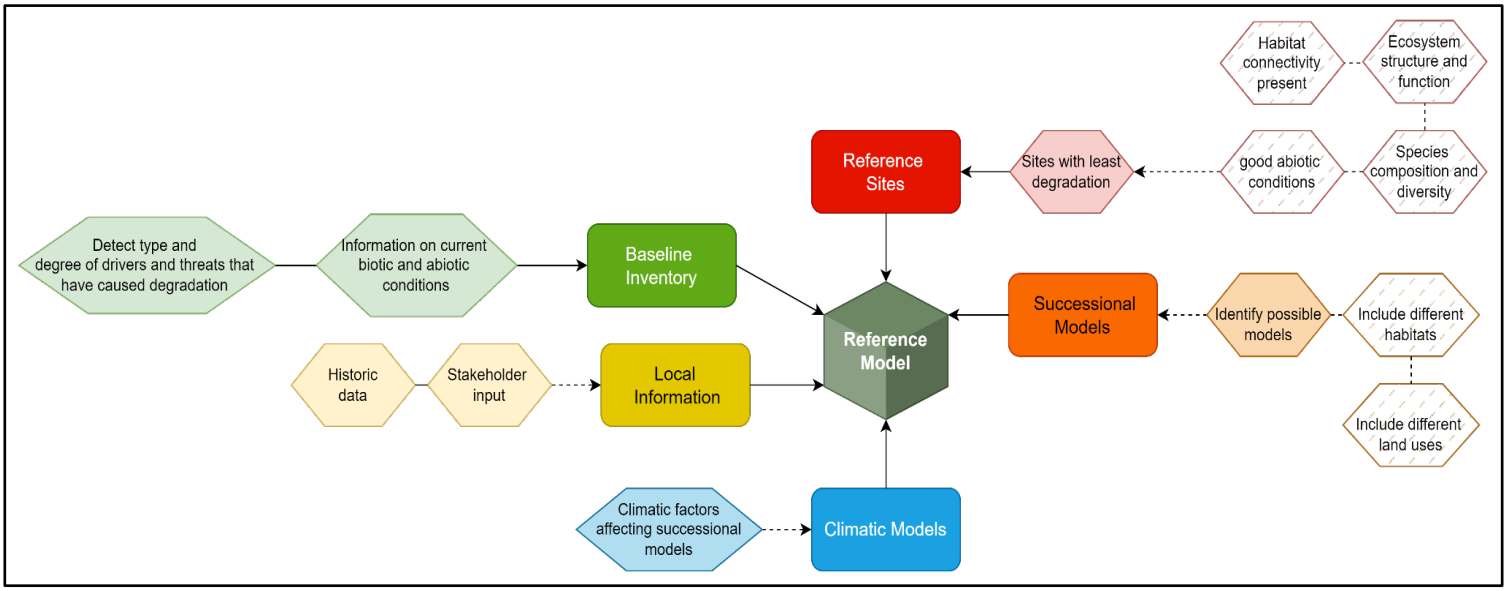


Figure 6.4- Information utilised for developing reference models in AlUla County.

Based on the SER Standards, the practice of ecological restoration involves removing or limiting sources of degradation and assisting the ecosystem in recovering, to the extent possible, to the condition it would be in had degradation not occurred, while also accounting for anticipated change. This requires a model to predict that condition, called a reference model (figure 6.4). Undisturbed conditions are rare or non-existent in AlUla, therefore reference models should be informed by the baseline inventory and 1) multiple environmentally similar reference sites, taking degradation into account, 2) ecological descriptions and successional models, 3) climatic models and 4) local site-specific information (both historical data and current stakeholder and local knowledge holder input).

The reference models can be supported by selecting reference sites using the following existing data from AlUla:

- All scores of 3 (or 2 for vegetation cover) for the eight ecological parameters used in the Priority Sites Report represent the highest ecological conditions. (For more information see chapter 7 “Plan for Scaling Up Ecological Restoration in AlUla”).
- Identify areas with the highest scores on maps
- Conduct ground truthing to verify the sites with the highest ecological conditions, which can be classified as reference sites, taking degradation into account
- Include these reference sites as sources of data for the reference model as described above

Regional sites can be included as reference sites, allowing for more data and thus a more accurate reference model, especially if related data is missing or minimal in AlUla. Such regional sites could be identified from:

- Nature Reserves and Protected Areas in Saudi Arabia
- Nature Reserves in Jordan that are managed by the Royal Society for The Conservation of Nature (RSCN)

Ground truthing

Spatial modelling (chapter 7) has limitations and must be augmented with ground truthing in order to 1) verify the spatial analysis or modify the data as needed to reflect real-world conditions, 2) conduct the baseline inventory, which informs the selection of the target native reference ecosystem, the development of a reference model, and the selection of restoration target.

Ground truthing allows for identification and assessments of current plant and animal community composition, including: functional groups of micro- and macroorganisms (including pioneer and late successional species); keystone or flagship species or species valued for economic or cultural reasons; soil seed banks or native species presumed absent; potential for seed colonization from adjacent areas; and invasive or non-native species either present or with potential to colonise the area. These on-the-ground assessments, paired with pre-determined social-economic conditions, will inform development of the restoration plan. Each distinct or mosaic project area chosen for restoration will be subject to appropriate ground truthing and be stratified across all identified habitats.

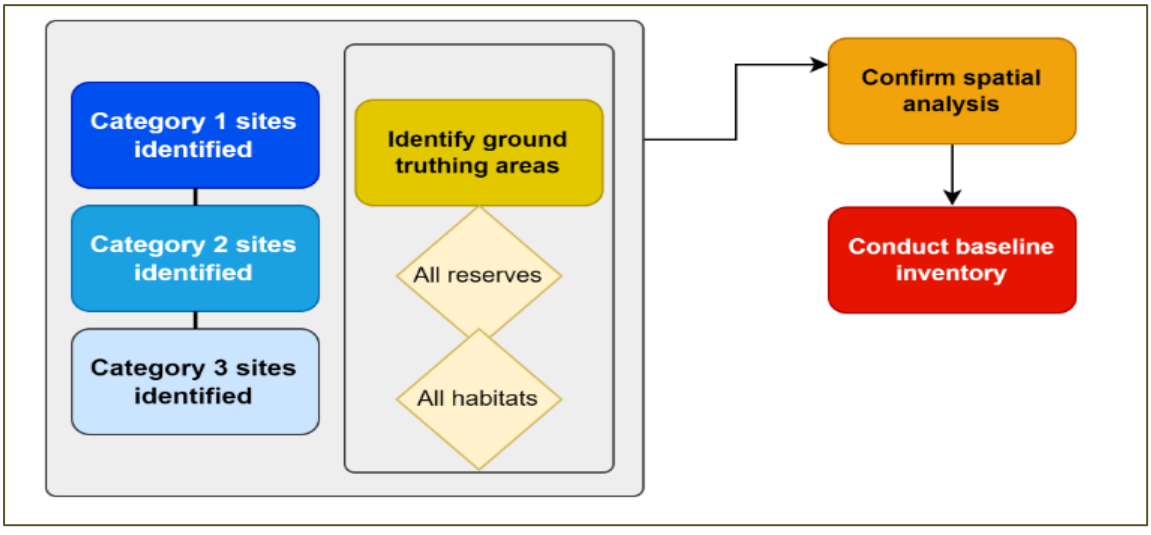


Figure 6.5 - Conceptualizing ground truthing. Categories 1, 2, and 3 refer to the mapping Categories in the spatial model that helps to identify priority areas for ecological restoration across AlUla Protected Areas under the Strategy (see the chapter 7 entitled

Assessment

Site assessments:
Ground-truthing and finer scale assessments (e.g., baseline inventories) after potential restoration sites are identified.

The Target Plant Concept:
Assess the objectives of and limiting factors affecting the site (biotic, abiotic, and anthropogenic) to support the proper selection of plant materials, species, and stocktypes (e.g., Dumroese et al. 2016, Davis and Pinto 2021).

Planning and design:
Effective planning is essential to achieve desired outcomes of ecosystem restoration and, therefore, the development of a restoration plan underpins the entire restoration process.

Stakeholder participation:
Effective restoration planning is a product of informed decision-making at all levels developed through a participatory process that includes all stakeholders and rights, and knowledge holders involved in, or affected by, the restoration, as well as experts in ecosystem degradation and repair.

Invasive and other undesirable species:
Additional assessments of presence and threats from invasive species and other undesirable species are needed. For animals, descriptions of species present and their impacts can be expanded (e.g., feral dogs and donkeys), and potential threats identified. For plants, few nonnative species are currently present, but some reports state that nonnative invasive plants are completely absent in priority restoration areas in Protected Areas, in error (e.g., *Cuscuta campestris*, which is present in three Protected Areas, has been identified as a nonnative invasive in Saudi Arabia). Documentation of potential weeds and invasive species known from the AlUla area (e.g., CMEP 2023) should be expanded. Some nonnative invasive species listed as potentially invasive but not present are in fact cultivated in AlUla and pose an immediate threat (e.g., *Leuceana leucocephala*). In addition, several species (e.g., *Datura metel, Lantana amara, Opuntia stricta*) that have been documented as invasive in other arid regions have been documented in surrounding areas near AlUla, and these should also be reviewed as potential threats and addressed as needed.

Use of appropriate plant species aligned with restoration targets:
Work to date on the prioritization of plant species for restoration has bee:n excellent (e.g., Valorhiz 2023, Valorhiz 2024). However, once robust reference models are

developed, and using the data generated during that process, the design of plant palettes for restoration will need to be further refined, e.g., related to species dominance, cover, density, and pattern. Work is also needed to determine designs for planting in areas of lower density and enrichment planting, and the identification of species missing from Protected Areas, but which are appropriate for restoration. While priority plants have been identified, a comprehensive list of plants that are not prioritised, together with the reasons why, is also needed. A comprehensive plant list will also identify species with high natural regeneration capacity that are priorities for restoration, especially if they do not require extensive planting, as well as weeds, including native undesirable species and other weedy species that are not specifically associated with overgrazing.

Conduct trials to generate knowledge to use in planning:
Make use of opportunities to conduct restoration trials to inform planning. When practical, design trials in a manner that they are scientifically valid (i.e., quantitative methods with adequate power of detection and valid qualitative methods) and that reliably separate the effects of restoration activities from background variation not caused by restoration activities (Nelson et al. 2024). This is especially important in areas that are difficult to restore such as abandoned agricultural landscapes, heavily overgrazed areas, and eroded landscapes. In abandoned agricultural landscapes, trials may indicate if natural regeneration or revegetation will be effective, or if there is an underlying issue with contamination that requires phytoremediation. It's imperative that RCU documents failures and lessons learned to improve future restoration projects.

Figure 6.6 summarizes the process to identify restoration plan design and interventions per habitat through proper planning.

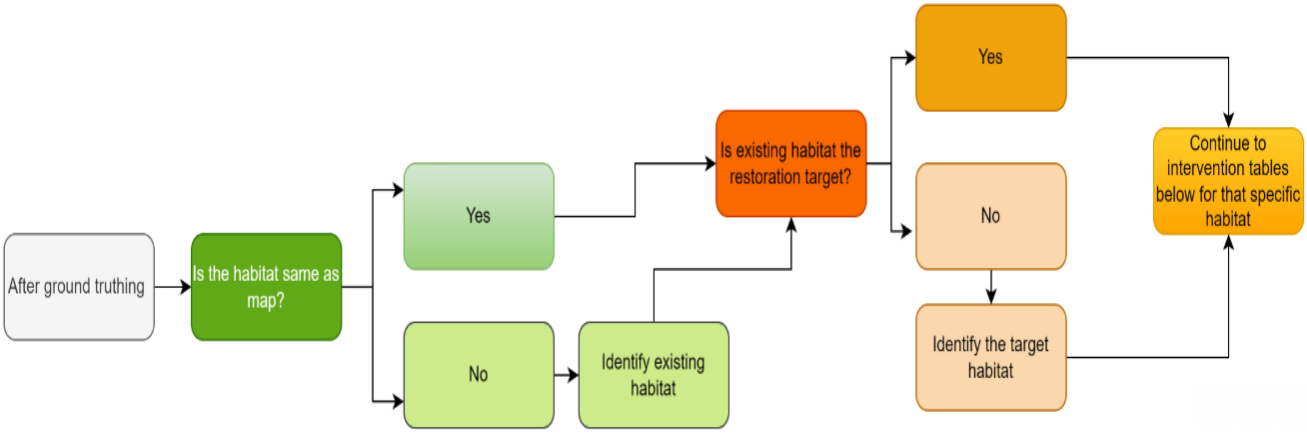


Figure 6.6- Process to identify restoration interventions per habitat.

Implementation

Use of appropriate plant material
It is critical to identify the most genetically appropriate plant material and stocktypes to increase survival rates, adapt to the identified limiting factors, and decrease cost of implementation and maintenance.

Timing of restoration
The implementation of restoration interventions should be timed when they are the most ecologically appropriate (e.g., timing planting to coincide with the rainy season). The supply of plant material must also be ready at the appropriate time. Longer-term planning must consider the sequence of recovery, such as waiting to implement certain activities until ecological conditions have recovered sufficiently to support the action (e.g., the introduction of predators after the habitat for prey has sufficiently recovered and not before).

Ongoing management

Develop and implement an ongoing management plan
Ecosystems are dynamic and respond to interventions over time. As such, ongoing management (often referred to as “maintenance”) of restoration sites, occurs after the primary project implementation has taken place, and is an essential part of successful restoration. Restoration projects are unlikely to succeed in providing a full range of benefits if the sites are not revisited after the completion of initial restoration activities. Because of this, ongoing management should begin as soon as a phase of project implementation is completed to minimise potential of regression back to a degraded state and maximise progress towards medium- and long-term restoration goals and objectives. However, there may not be a clear point of transition from implementation (e.g., the concept of continuous improvement) to ongoing management, especially in long-term restoration projects, where implementation phases continue until agreed upon levels of recovery are reached.

Monitoring and adaptive management

Implement robust and strategic monitoring systems:
Design short and long-term monitoring systems that assess implementation, effectiveness, and impacts of the restoration program. Use monitoring data season after season to identify the factors facilitating or hindering success (e.g., seed source, nursery practices and seedling quality, aftercare, seasonal weather) and adapt restoration interventions and ongoing management in response to monitoring results.

Record keeping as a quantitative tool to improve restoration:
In conjunction with planning, implementation, and ongoing management, develop robust and redundant record keeping systems to ensure effective tracking of project successes and challenges and to create opportunities for adaptive management based on monitoring results.

Alternative and non-invasive techniques to monitor fauna:
Explore emerging options to monitor animal populations (e.g., footprint AI, soil eDNA, camera traps).

Types of Standards-Based Monitoring:
This monitoring strategy focuses on ecological restoration, as most preliminary restoration interventions will take place within Protected Areas across AlUla County and the aim is to restore native ecosystems. This guidance can also be modified for rehabilitation projects. Additional guidance for monitoring rehabilitation projects can be found in the UN Decade SOPs, The Global Biodiversity Standard: Manual for Assessment and Best Practices (TGBS; Bartholomew & Mosyaftiani et al. 2024), and Table 6.1 of the KM-GBF T2 Guide.

To capture the information needed to thoroughly assess ecological restoration and implement a successful adaptive management program, three specific types of monitoring are recommended: implementation, effectiveness, and impact monitoring (figure 6.7).



Figure 6.7- The three types of monitoring for restoration activities.

Steps for Creating a Monitoring Plan for the Strategy for Ecosystem Restoration:

1. Ecological and social-economic indicators are chosen based on targets, goals, and objectives. Tools such as the SER Five-star System, ERW and SBW can be utilised.
2. Pre-restoration monitoring is conducted at sites prior to the initiation of restoration activities to document the baseline condition (baseline monitoring).
3. Restoration interventions are carried out.
4. Implementation monitoring is performed as appropriate.
5. Effectiveness and impact monitoring are performed at predetermined frequencies.
6. The project is assessed in reference to implementation, effectiveness, and impacts.

Based on monitoring results, the adaptive management process is used to modify plans or protocols and modify interventions as appropriate.

6.3.3.STAKEHOLDER ENGAGEMENT

Both the SER Standards and the UN Decade SOPs contain critical information on stakeholder engagement in relation to restoration (Gann et al. 2019, Nelson et al. 2024). Because the UN Decade SOPs have more dedicated content on stakeholder engagement, they provide the primary basis for this guidance. In summary, active engagement with stakeholders is imperative to long-term restoration success and recognizing the importance of this by including stakeholder engagement is a key principle underpinning ecosystem restoration, including ecological restoration). Strategic recommendations and guidelines are offered here to ensure broad, sustained, and participatory stakeholder engagement throughout different phases of ecological restoration efforts. The content of this guidance was compiled from a review of literature, input from stakeholders collected during virtual and in-person meetings, and in-depth discussions with RCU ecological restoration department and other project teams.

Key recommendations for successful stakeholder engagement.

Not only is participatory, inclusive stakeholder engagement critically important to standards-based restoration, but it is also the first step towards building trust and creating local social license to operate. With RCU investing in restoration over the long-term, building SLO will help increase the likelihood of achieving both the ecological and the social-economic/sociocultural outcomes from restoration investments. This will also be critically important in the context of wildlife

reintroductions. Numerous specific recommendations summarised into the following categories:

- **Enhance/improve communication**: Ensure transparent communication and provide clear and structured opportunities for participatory local involvement.
- **Fairly and transparently consider community input into restoration planning**: Community members made important recommendations that may require modifications to currently mapped priority areas. It will be important for RCU to communicate proactively and transparently with local communities about decisions to modify boundaries or not modify boundaries of priority restoration areas. Especially where those boundaries are not modified to address community concerns, it will be important to articulate why this is the case (see 6(a) immediately above).
- **Coordinate closely with other RCU departments**: Many of the considerations and recommendations above will require that the different internal departments at RCU coordinate together to recognise and act on community interests, needs, and concerns.
- **Address trade-offs**: Customise restoration plans for each priority site to address specific trade-offs and social-economic factors and communicate transparently about those customizations.
- **Invest directly in local capacity building and community needs**: Inclusive and community-centred models for eco-tourism and restoration should be developed to ensure fair economic opportunities and equitable benefit-sharing. For community members to benefit and participate in restoration, capacity building, training, and investment are critically needed, otherwise community members will not have the skills to compete for the new jobs and opportunities that restoration will create. In this context especially, it is important to develop specific programs to support women and girls in these activities.
- **Improve governance/policy frameworks**: In numerous instances, community members requested either legal or policy framework improvements that will provide preferential treatment for local grazers, local hiring, and local investment so that benefits are fairly shared with local communities, and young people, especially, have the ability to build lifelong careers (restoration, ecotourism, etc.) associated with RCU's long-term vision for the county.

6.4. CONCLUSION

Chapter 6 identifies key steps for developing a standards-based plan for scaling up ecosystem restoration in AlUla County, identifying and prioritizing sequentially and spatially restoration areas, allowing to develop the strategic components of the Strategy for Ecosystem Restoration based on a quantifiable and data-based mod

7. PLAN FOR SCALING UP ECOLOGICAL RESTORATION IN ALULA

An initial baseline assessment was completed in February 2024, identifying priority areas within each Protected Area (detailed in chapter 3). In the next phase, a multi-tiered spatial methodology was developed that:

- used the baseline assessment to conduct additional spatial analysis that prioritised restoration across the entirety of each Protected Area to illustrate ecological conditions of the Protected Areas.
- overlaid these results with additional criteria to create three different categories for future prioritisation and scaling up of restoration in AlUla County; the categories are intended to optimise both ecological and social-cultural approaches and outcomes.
- divided the prioritisation into two phases (2025-2030 and 2031-2035) and identified the minimum number of hectares to be brought under restoration in each phase in order to meet RCU's intended 2035 KPI of treating 65,000 hectares of land across the six Protected Areas. For both phases, the maps provided include more land than will be restored by 2035, as ground-truthing and additional analyses are needed to determine the exact areas of restoration:
  1. Phase one will result in at least 23,500 hectares under restoration through 2030
  2. Phase two will result in at least 41,500 hectares under restoration through 2035

7.1. DETERMINING RESTORATION PRIORITIES

7.1.1.INITIAL PRIORITISATION

The parameters used in this prioritisation model were processed from data layers generated through studies and projects previously commissioned by RCU. The analysis primarily relied on the Baseline Assessment. To support this analysis, additional data was generated through remote sensing (e.g., fraction of vegetation cover for Spring 2022), or through data processing using tools in ArcGIS Pro (e.g., generation of flow accumulation layers). In this first phase of the modelling, each of these parameters was reclassified into three scores reflecting low moderate, and high importance (Table 7.1) and then overlaid and multiplied together using the Raster Calculator tool in ArcGIS Pro to reflect the final scoring of each location based on all parameters. Where viable, existing vegetation samples from prior work outlined earlier in the Strategy for Ecosystem Restoration were used to determine data thresholds, rather than adopted values from the literature.

Table 7.1- Scoring levels per ecological parameter.

Parameter	Score 3	Score 2	Score 1	Notes on score 3
Vegetation health	Moderate to good	-	Low	Healthy vegetation indicates good conditions for planting success.
Species diversity	High to moderate	-	Low	High species diversity supports natural regeneration and restoration success.
Vegetation cover	Moderate	High	Low	Moderate cover facilitates plant establishment and recovery.
Vegetation degradation by grazing	Low	Moderate	High	Remnant decreasers contribute to success.
Soil available water capacity	High	Moderate	Low	Higher available soil water facilitates success.
Soil compaction	Moderate	-	High and low	Moderate soil compaction facilitates success. Too high or too low (excess drainage) offers more challenging conditions.
Soil erosion susceptibility	Low	Moderate	High	Low soil erosion susceptibility (not actual) contributes to success.
Flow accumulation	Highest	-	Lowest	Access to water flow increases chances of success.

The model described above, therefore, was used to generate the classification for priority ecological condition zones in which to conduct ecological restoration interventions in the six Protected Areas. All Protected Areas were modelled using the eight parameters previously listed except for KWVG and HUBR, which were each missing 1-2 layers which were, therefore modelled using the available layers.

The priority ecological condition zones were then assigned to one of three classes based on the scoring range of the cells in the GIS model output:

- Areas with highest priority ecological conditions for restoration (red)
- Areas with moderate to high priority ecological conditions for restoration (green)
- Areas with lower priority ecological conditions for restoration (yellow)

In addition, in Protected Areas where abandoned farmlands exist, those that have vegetation cover and span an area of one hectare and above were overlaid onto the map of priority ecological conditions to identify opportunities for diversification of restoration interventions.

This first part of the spatial modelling resulted in maps for each Protected Area as shown in the example of Gharameel NR ecological conditions zoning. Gharameel NR covers an area of 2115 km^2 (figure 7.1). Results from this first level modelling show a concentration of the highest priority ecological condition class in the southwestern 2024 Priority Area.

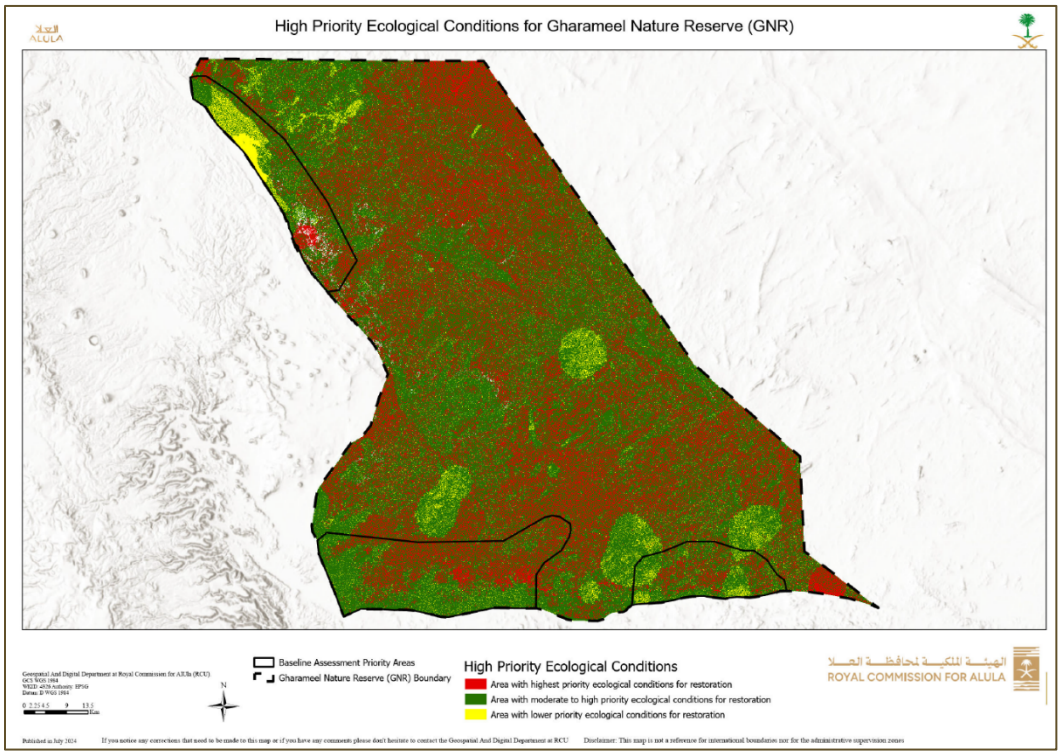


Figure 7.1- Gharameel NR ecological conditions zoning

7.1.2.Categorisation of potential restoration areas

Building from the initial prioritisation, the next step defined three mapping Categories: mapping Category 1 with higher water availability in red and green zones; mapping Category 2 with moderate water availability in red and green zones; and mapping Category 3 with high to moderate water availability in yellow zones (figure 7.2). All three Categories have moderate to low vegetation cover, as high cover was assumed to be of higher integrity and not appropriate for medium to high density revegetation. Other important restoration interventions are recommended for those areas in the full intervention tables provided to RCU.

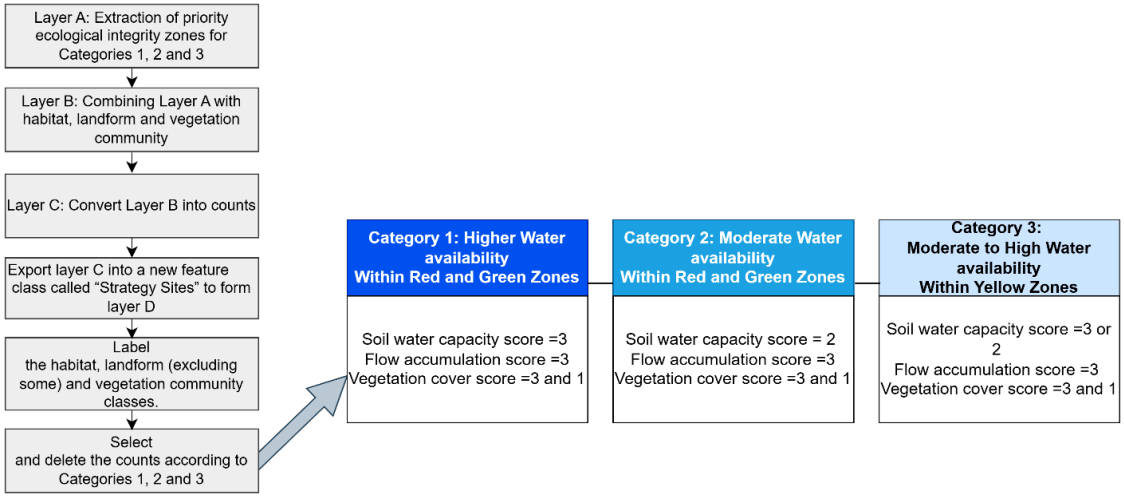


Figure 7.2- Mapping Category development and description.

As shown in the example of GNR in figure 7.3 below, a map was produced for each Protected Area to illustrate the ecological conditions zoning produced by this model. In addition, Fig. 6.3 below illustrates an example of the results of the three different restoration mapping Categories in GNR per habitat. All mapped units are 50 hectares or larger per distinct habitat.

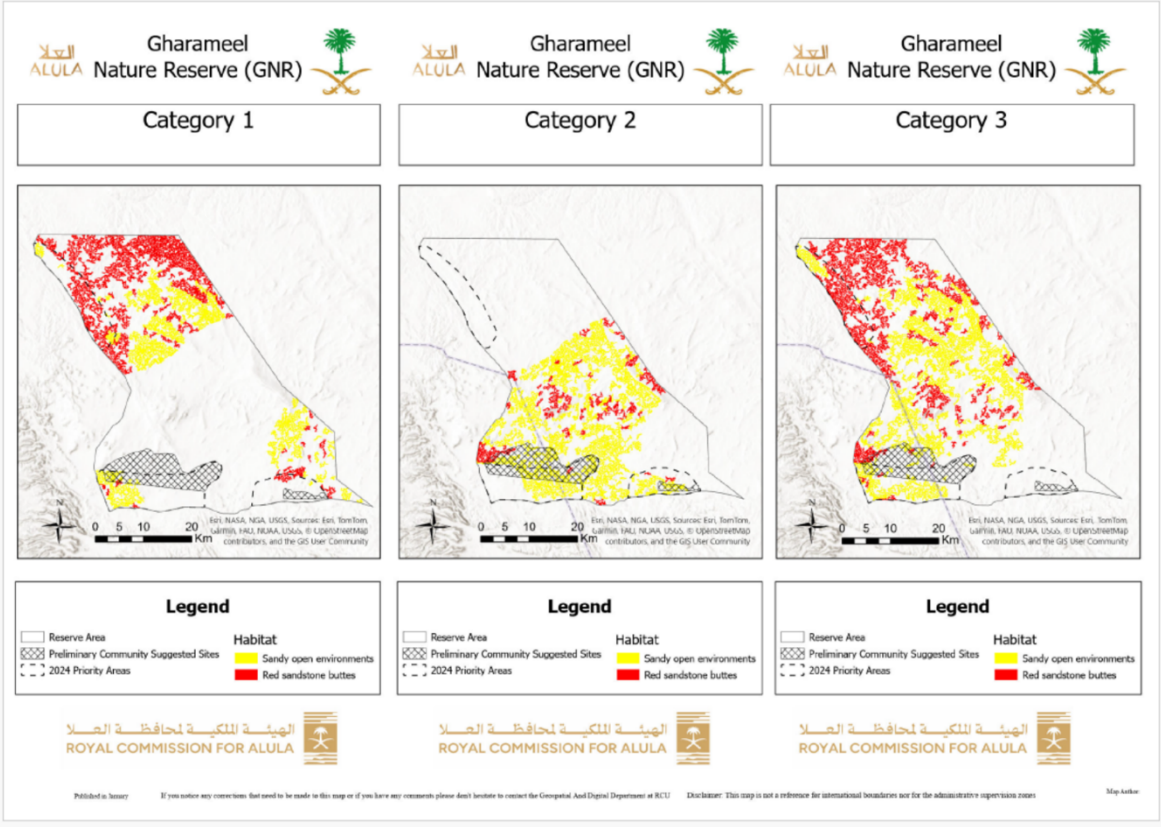


Figure 7.3- Gharameel Nature Reserve areas per habitat under Categories 1, 2, and 3.

Tables 7.2 provide summaries of spatial extent of mapping Categories by Protected Area, presence in 2024 Priority Areas, and presence in preliminary community suggested restoration areas. All habitats mapped in this part of the modelling are the priority areas for restoration to be taken forward for further assessment by RCU; this categorisation underlies the information provided in the final phased maps.

Table 7.2 - Mapped project areas per Protected Area by overlap with 2024 Priority Areas and preliminary community suggested restoration sites (excluding harrat sites).

Reserve	Category	Total area	Total 2024 Priority Areas	Overlap with 2024 Priority Areas	Total community suggested sites	Overlap with community suggested sites	Overlap between community suggested sites and 2024 Priority Areas	Overlap with 2024 Priority Areas without community sites	Overlap with community suggested sites without 2024 Priority Areas
GNR	C1	42194.17	34943.23	7315.61	14223.19	603.88	573.00	6742.61	30.88
	C2	44011.48		6807.86		5014.58	2773.44	4034.42	2241.14
	C3	62963.53		10094.34		1991.09	700.25	9394.09	1290.84
KWVG	C1	225.24	9387.984	43.57	1458.31	38.77	38.70	4.87	0.07
	C2	14859		124.75		418.72	34.14	90.61	384.58
	C3	5433.25		0.00		0.00	0.00	0.00	0.00
HUBR	C1	9379.38	63512.84	5325.92	5338.85	266.91	266.91	5059.01	0.00
	C2	46706.68		4993.67		507.17	476.86	4516.81	30.31
	C3	1495.85		111.38		0.00	0.00	111.38	0.00
HZNR	C1	1840.75	18837.21	422.03	12851.65	1330.84	422.03	0.00	908.81
	C2	0		0.00		0.00	0.00	0.00	0.00
	C3	782.57		727.13		401.05	401.05	326.08	0.00
SNP	C1	2395.52	23074.03	1794.81	0.00	0.00	0.00	1794.81	0.00
	C2	7013.02		2280.68		0.00	0.00	2280.68	0.00
	C3	1197.76		327.64		0.00	0.00	327.64	0.00
WNNR	C1	14010.93	33576.19	5489.65	0.00	0.00	0.00	5489.65	0.00
	C2	2348.46		301.94		0.00	0.00	301.94	0.00
	C3	3823.84		101.24		0.00	0.00	101.24	0.00
Total		**260681.43**	**183331.484**	**46262.22**	**33872.00**	**10573.00**	**5686.38**	**40575.84**	**4886.62**

7.2. SEQUENTIAL PRIORITISATION (PHASING) OF RESTORATION

Phase one is intended to deliver at least 23,500 hectares of restoration, while phase two will deliver the remaining 41,500 hectares. The determination for where actual restoration will take place will be done through the Detailed implementation plan for standards-based restoration in AlUla, the Ecosystem Restoration Action Plan (chapter 9). The polygon maps included below in figure 7.4 show only the two phases; they do not show the Categories or the habitat types. Those individual maps, for each Protected Area, are included in the full analysis separately provided to RCU, and they can be overlain with the phase maps as a restoration implementation planning protocol is undertaken. It is important to note that table 7.3 and maps below (figure 7.5) include a far greater number of hectares than are likely to be restored. The methodology for selecting sites for each of the two phases is as follows:

- **Phase 1:** all areas within preliminary community suggested sites whether inside or outside the 2024 Priority Areas for GNR, HUBR, HZNR, and KWVG that intersect with Categories 1, 2, and 3 + 0.65% of SNP areas + all 2024 Priority Areas in WNNR that intersect with Categories 1, 2, and 3.
- **Phase 2:** all areas outside the preliminary community suggested sites whether inside or outside the 2024 Priority areas for GNR, HUBR, HZNR, and KWVG that intersect with Categories 1, 2, and 3 + 0.35% of SNP areas + all 2024 Priority areas in WNNR that intersect with Categories 1, 2, and 3.

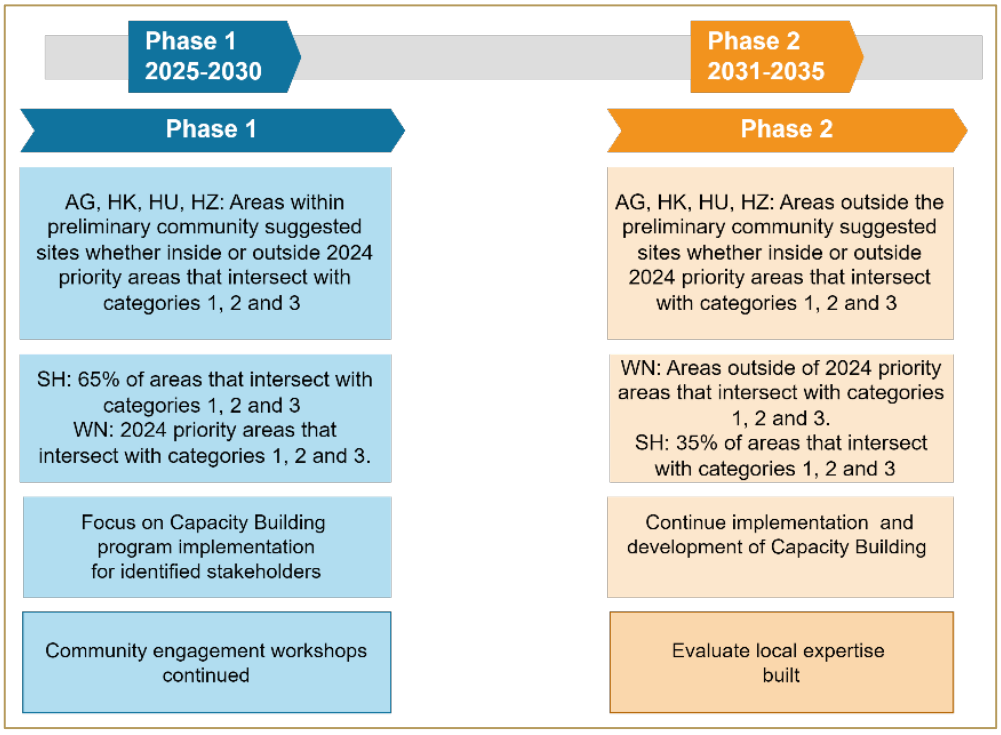


Figure 7.4-Sequential restoration prioritisation and implementation timeline.

The breakdown of the total area from which restoration will be selected in Phases 1 and 2 is outlined in table 7.3. Following that, the individual final phase map for each Protected Area is included (figure 7.5).

Table 7.3-Phased approach for restoration implementation where Phase 1 and Phase 2 show the total area where final restoration sites of 65,000 ha will be selected from

Protected Area	Phase 1 total area	Phase 2 total area
GNR	8,387	136,793
HUBR	1,314	99,421
HZNR	1,477	2,398
KWVG	534	6,042
SNP	9,526.4	5,129.6
WNNR	8,820	21,196
Total	**32,057.4 ha.**	**270,979.6 ha.**

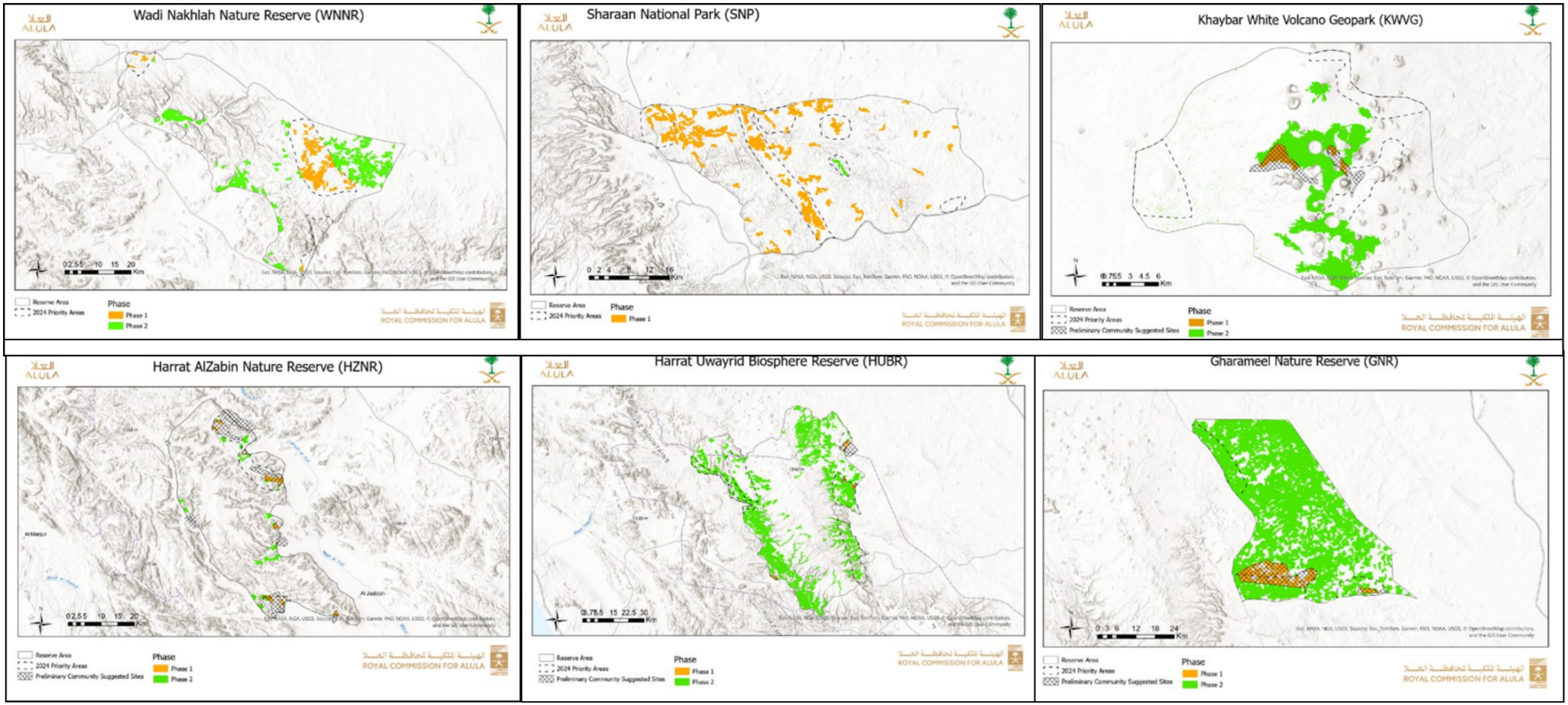


Figure 7.5- Final Maps Showing Phased Restoration Approach in upper left WNNR, upper mid SNP, upper right KWVG, lower left HZNR, lower mid HUBR and lower right GNR

7.3. CASE STUDIES

The below case studies illustrate the sequence of steps for modelling high priority ecological conditions to identify best restoration interventions. Following the classification of zones through modelling and acknowledged by ground truthing, additional relevant social and economic parameters (including results from existing and future stakeholder engagement) should be added and overlaid on the proposed priorities, with restoration interventions refined or updated accordingly.

7.3.1.CASE STUDY 1

Subject: Multiple categories embedded within one project area in Gharameel Nature Reserve.

The identified area in GNR corresponds to the southwest 2024 Priority Area as shown in the below figure 7.6 including areas from Category 1, Category 2 and Category 3.

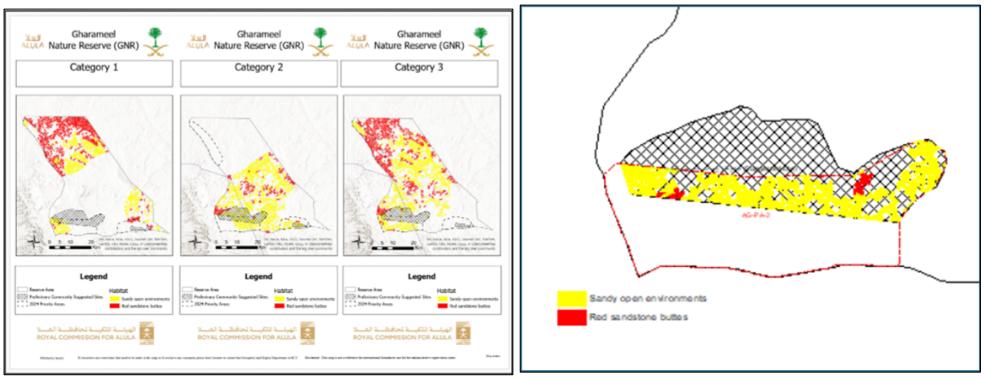


Figure 7.6- Project area mosaic identified in Gharameel NR, with two habitats: red sandstone buttes and sandy open environments

Following ground truthing, the final area will be delineated under two possible scenarios:

1. all of the area will be designated for restoration polygon if the blank spaces between the identified areas from the mapping are primarily the same habitats with similar conditions for restoration. In this case, the total area would be 6988 hectares, as shown in the figure 7.7:
2. the final area designated will be similar to the proposed areas from the mapping model, with a total surface area of 3607 hectares., including sandy open environments and red sandstone buttes.



Figure 7.7- Full area designated as mosaic project area

After delineating the final mosaic project area, the steps shown below (figure 7.8) are taken to identify restoration interventions for each distinct project area in a single habitat or sub-habitat.

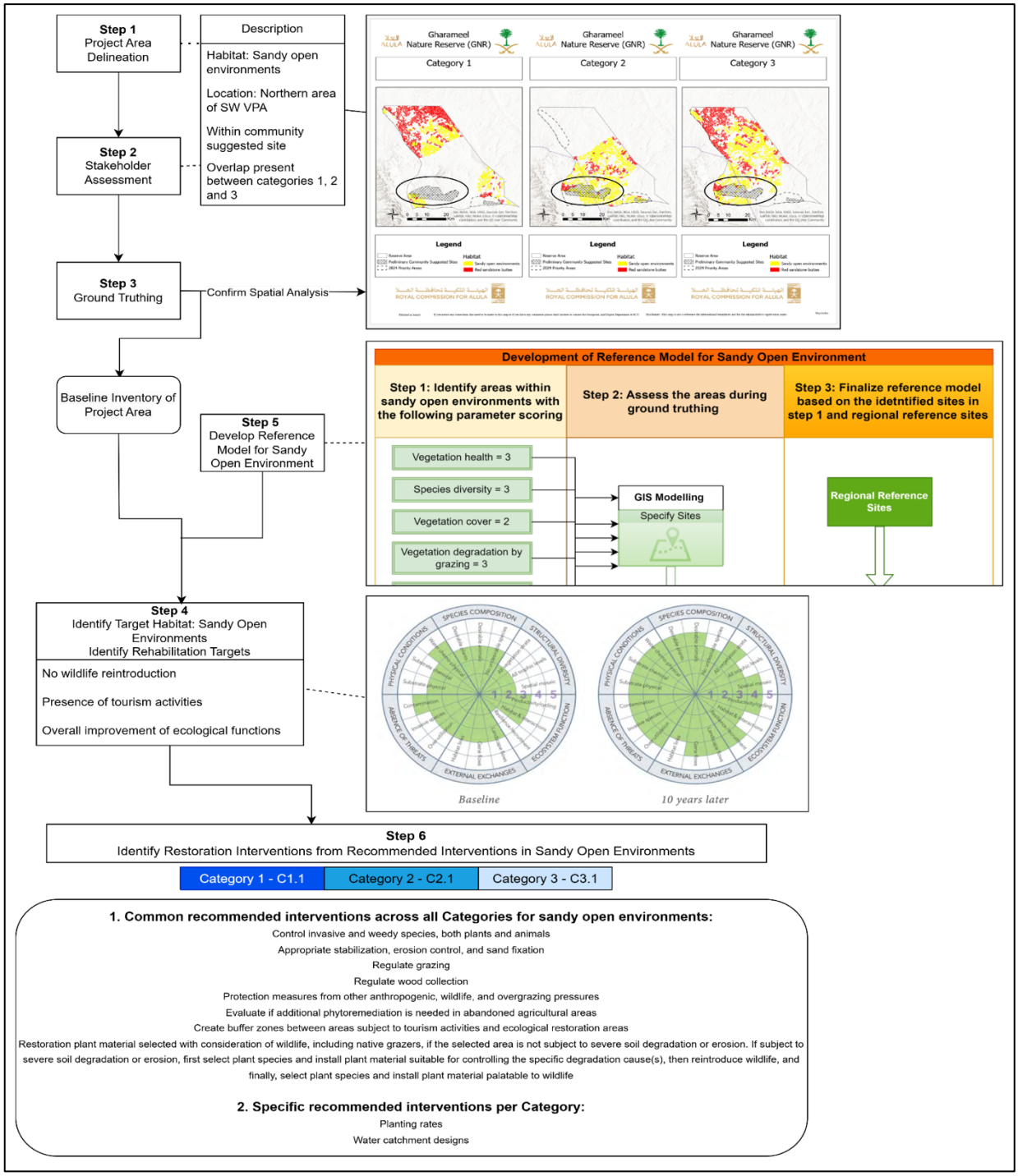


Figure 7.8- Steps for case study 1.

7.3.2.CASE STUDY 2

Subject: Planning for blank areas within an identified project area in SNP in abandoned agricultural lands (figure 7.9).

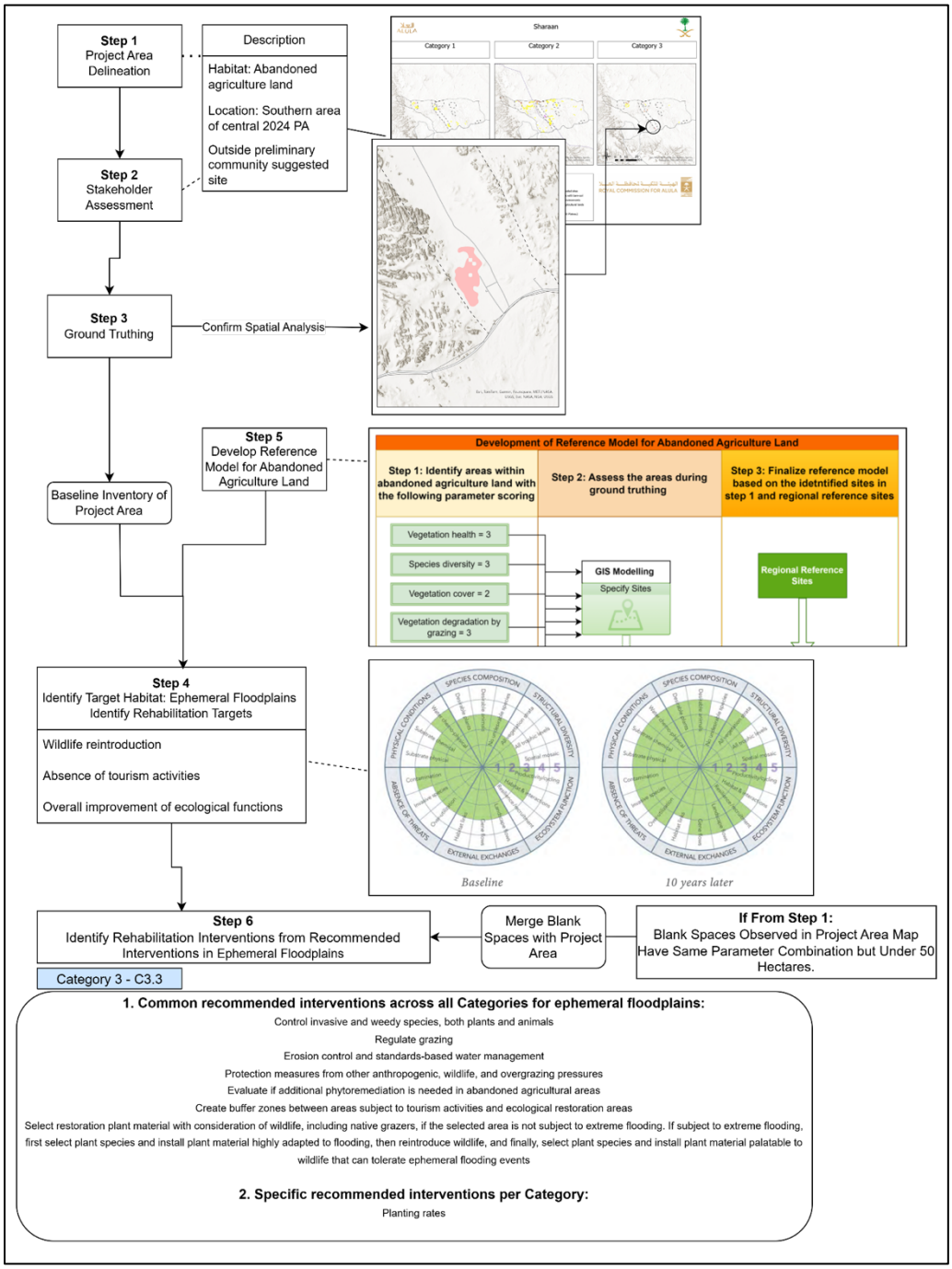


Figure 7.9-Steps for case study 2.

7.4. CONCLUSION

The presented model to sequentially and spatially prioritise restoration areas in the six Protected Areas, based on ecological parameters and their scoring, allows more detailed and accurate identification of restoration interventions. Table 7.4 presents a summary of overall recommended restoration interventions; however, more detailed interventions are presented in the full chapter for Ecosystem Strategic Guidelines and Principles. Specific interventions and projects are presented in chapter 9 “Ecosystem Restoration Action Plan”. Table 7.5 summarizes the recommended interventions per current habitat and target habitat. Table 7.6 summarizes the recommended planting densities based on Category 1, 2 and 3, water availability and ecological condition zoning. The following chapter identifies key steps based on international standards for the development of a complete and comprehensive Strategy for Ecosystem Restoration, including all phases of an ecosystem restoration project. Chapter 8 introduces Strategy-specific vision, mission, pillars and strategic objectives that are directly tied to RCU’s existing vision, mission and objectives.

Table 7.4- Recommended Overall Restoration Interventions Based on Parameter Scoring

Parameter	Score 1	Score 2	Score 3
Vegetation health	Improvement of planting material quality		Improvement of planting material quality
Species diversity	Identification and planting of missing important native species		Increase native species production and planting
Vegetation cover	Medium density planting requirements	Enrichment planting requirements	Higher density planting requirements Improvement of planting material quality
Vegetation degradation by grazing	Native decreasers species used for any density planting (species that decrease in abundance after grazing)	Control of increasers (species that increase in abundance after grazing) and increase of native decreasers (species that decrease in abundance after grazing) Control grazing in the area	Removal of increasers (species that increase in abundance after grazing) and increase of native decreasers (species that decrease in abundance after grazing) Limit grazing in the area
Soil available water capacity	Improvement of planting material quality with a focus on suitable stocktype for site limiting factors Selection of species genetically adapted to site conditions (e.g., use more drought tolerant species)	Design water catchment structures to increase water availability Improvement of planting material quality with a focus on suitable stocktype for site limiting factors Selection of species genetically adapted to site conditions (e.g., use more drought tolerant species)	Design water catchment structures to increase water availability Improvement of planting material quality with a focus on suitable stocktype for site limiting factors Selection of species genetically adapted to site conditions (e.g., use more drought tolerant species)
Soil compaction	Improvement of planting material quality with a focus on suitable stocktype for site limiting factors		Improvement of planting material quality with a focus on suitable stocktype for site limiting factors
Soil erosion susceptibility	Selection of species genetically adapted to site conditions (e.g., planting with faster growing species and fast root development/establishment)	Selection of species genetically adapted to site conditions (e.g., planting with faster growing species and fast root development/establishment) Adopt site engineering measures to control erosion (e.g., light terracing of site)	Selection of species genetically adapted to site conditions (e.g., planting with faster growing species and fast root development/establishment) Adopt site engineering measures to control erosion (e.g., light terracing of site)
Flow accumulation	Limit all anthropogenic stresses such as grazing, tourism, etc. Selection of species genetically adapted to site conditions (e.g., use more drought tolerant species)		Prevent all anthropogenic stresses such as grazing, tourism, etc. Improvement of planting material quality with a focus on suitable stocktype for site limiting factors Design water catchment structures to increase water availability

Table 7.5-Summary of interventions per current habitat and target habitat

Current Habitat	Restorative Continuum	Target Habitat
Arid Thorn Woodlands, Sandy Open Environments, Abandoned Agricultural Lands	**Ecological Restoration**	**Arid Thorn Woodlands**
Simple reference model (adapted from Valorhiz 2023, 2024): Arid thorn woodlands are characterised by a diverse range of soils, varying from sandy to silty clay loam in texture. The vegetation community is rich and diverse, including species like *Vachellia gerrardii*, *Retama raetam*, *Lycium shawii*, *Ochradenus baccatus*, *Panicum turgidum*, *Ephedra foliata*, *Haloxylon salicornicum*, and *Ziziphus numularia*. In shaded areas, you can also find *Lavandula coronopifolia* and *Aerva javanica*. Some of the most prominent species are *Vachellia gerrardii*, *Retama raetam*, *Lycium shawii*, and *Ochradenus baccatus*. This habitat displays a relatively dense vegetation cover for arid conditions. The APAN Rehabilitation Report used the term *Species rich open shrublands* for this habitat. Locations: HUBR (Category 3), HZNR (Categories 1-3). Arid thorn woodlands can also be the target for the restoration of abandoned agricultural sites, sandy open environments, and possibly exposed areas with bare soil. The APAN Rehabilitation Report recommended restoration of arid thorn woodlands only for SNP, but the *Spring Vegetation Report* listed priority species for arid thorn woodlands also for GNR, HUBR, HZNR, and WNNR. Preliminary specifications: Assume the preliminary desired minimum plant density during initial stages of recovery at 2,500 plants/ha. (4 sq. m/plant).		
Common recommended interventions across all Categories for arid thorn woodlands: ● Control invasive and weedy species, both plants and animals ● Regulate grazing ● Regulate wood collection ● Protection measures from other anthropogenic, wildlife, and overgrazing grazing pressures ● Evaluate if additional phytoremediation is needed in abandoned agricultural areas ● Select restoration plant material with consideration of wildlife, including native grazers, if the selected area is not subject to severe soil degradation or erosion. If subject to severe soil degradation or erosion, first select plant species and install plant material suitable for controlling the specific degradation cause(s), then reintroduce wildlife, and finally, select plant species and install plant material that are palatable to wildlife ● Create buffer zones between areas subject to tourism activities and ecological restoration areas		
Dunes	**Ecological Restoration**	**Dunes**
Simple reference model (adapted from Valorhiz 2023, 2024): This habitat is characterised by unstable sand dunes dominated by annual or ephemeral plant species that bloom following periods of rainfall. Dunes comprise loose and fragile sandy soil on relatively steep slopes, without any rock fragments. Valorhiz (2023) reported two distinct vegetation communities with overlapping primary species pools: *Haloxylon salicornicum*, *Ephedra alata*, *Artemisia monosperma*, *Calligonum comosum*, *Heliotropium dignum*, *Centropodia forskalii*, *Stipagrostis plumosa*, and *Convolvulus spicatus*; 2) *Haloxylon persicum*, *Centropodia forskalii*, *Stipagrostis plumosa*, *Monsonia nivea*, *Molkiopsis ciliata*, and *Convolvulus spicatus*. In both cases, the presence of high and low shrub strata is sparse, but the herbaceous stratum is dense. Different successional stages are present. Ephemeral species with wind-dispersed seeds include *Ifloga spicata*, *Silene villosa*, *Eremobium aegyptiacum*, *Neurada procumbens*, *Schismus barbatus* and *Monsonia nivea*. Key perennial species missing from degraded dunes include *Haloxylon persicum*, *Haloxylon salicornicum*, *Ephedra alata*, *Convolvulus spicatus*, *Calligonum comosum*, and *Artemisia monosperma*. In less degraded areas, a low shrub stratum can be found, including species like *Haloxylon salicornicum*, *Ephedra alata*, *Convolvulus spicatus*, and *Artemisia monosperma*. In the late successional stages and in undegraded dunes, *Haloxylon persicum* can be found. Locations: SNP (109 ha. in Category 2). The APAN Rehabilitation Report recommended restoration of dunes only for SNP, but the *Spring Vegetation Report* listed priority species for dunes also for GNR, HUBR, and WNNR. Some areas mapped as dunes could be degraded arid thorn woodlands or other native ecosystems. Preliminary specifications: Assume early successional conditions over 50% of the area and revegetation over the remaining 50%. Of the 50%, assume the preliminary desired minimum plant density during initial stages of recovery at 2,500 plants/ ha. (4 sq. m/plant) or 1,250 per ha. total area.		
Common recommended interventions across all Categories for exposed areas with bare soils: ● Control invasive and weedy species, both plants and animals ● Prohibit wood collecting ● Prohibit grazing ● Appropriate dune stabilisation, erosion control, and sand fixation ● Protection measures from other anthropogenic, wildlife, and overgrazing pressures ● Restoration plant material selected with consideration of wildlife, including native grazers, if the selected area is not subject to soil erosion. If subject to soil erosion, first select plant species and install plant material suitable for controlling the specific degradation cause(s), then reintroduce wildlife, and finally, select plant species and install plant material palatable to wildlife. Note that undegraded dunes are characterised by unstable sand and successional processes. ● Create buffer zones between areas subject to tourism activities and ecological restoration areas.		
Ephemeral Flooded Sites; Abandoned Agriculture Land	**Rehabilitation**	**Ephemeral Floodplains**
Simple reference model (adapted from Valorhiz 2023, 2024): Ephemeral flooded depressions are described as primarily characterised by halophilic shrubs, including species such as *Suaeda* sp., *Traganum nudatum*, *Salsola imbricata*, *Anabasis setifera,* and *Seidlitzia rosmarinus*. Ruderal species can also be observed in association with these shrubs, but their presence is indicative of degradation. Certain areas of ephemeral flooded depressions may also be devoid of vegetation due to the harsh environmental conditions created by flooding after a rain event, or due to pedological conditions. Until additional work can be conducted to determine reference conditions for undegraded ephemeral flooded sites, we treat these as temporary rehabilitation targets, rather than targets for ecological restoration. Locations: HUBR, KWVG, SNP. The APAN Rehabilitation Report did not recommend restoration through revegetation of ephemeral flooded sites in any Protected Area, but the *Spring Vegetation Report* listed priority species for ephemeral flooded depression for all Protected Areas. Most of the area mapped as ephemeral flooded sites (93%) are Category 3 sites in HUBR, representing many scattered sites totalling 4,841 ha. Preliminary specifications: Ground truthing of this habitat and the development of an evidence-based reference model are needed prior to the establishment of specifications for revegetation.		
Common recommended interventions across all Categories for ephemeral flooded sites: ● Control invasive and weedy species, both plants and animals		

Current Habitat	Restorative Continuum	Target Habitat
• Regulate grazing • Erosion control and standards-based water management • Protection measures from other anthropogenic, wildlife, and overgrazing pressures • Evaluate if additional phytoremediation is needed in abandoned agricultural areas • Select restoration plant material with consideration of wildlife, including native grazers, if the selected area is not subject to extreme flooding. If subject to extreme flooding, first select plant species and install plant material highly adapted to flooding, then reintroduce wildlife, and finally, select plant species and install plant material palatable to wildlife that can tolerate ephemeral flooding events. • Create buffer zones between areas subject to tourism activities and ecological restoration areas		
Harrats & Thalwegs	**Ecological Restoration**	**Harrats & Thalwegs**
Simple reference models (adapted from Valorhiz 2023, 2024): harrats include patchy dense herbaceous and shrub layers mainly concentrated in sandy pockets, but this concentration may be an artefact of overgrazing. It is worth noting that a rich shrub vegetation community occurs in the thalwegs, which are low-lying season watercourses within the harrats. The typical vegetation includes shrubs and herbs such as *Achillea fragrantissima*, *Gymnocarpos decander*, *Zilla spinosa*, *Astragalus spinosus*, *Farsetia aegyptiaca*, *Haloxylon salicornicum*, *Stipagrostis sp.*, *Aerva javanica*, *Artemisia sieberi*, *Gymnocarpos decander*, *Lycium shawii* and tree species, mainly *Vachellia tortilis* subsp. *raddiana*, and *Vachellia gerardii* locally in sandy areas. Locations: HUBR, HZNR, KWVG, SNP, and WNNR. The APAN Rehabilitation Report did not recommend restoration through revegetation of harrats in any Protected Area, but the *Spring Vegetation Report* listed priority species for rocky outcrops and arid land montane, which includes harrats, for all Protected Areas. Harrats are not included as priority habitats for revegetation in the APAN Rehabilitation Report. However, harrats are important habitats for native biodiversity, including wildlife, and can benefit from lower intensity interventions as reviewed below.		
Common recommended interventions across all Categories for harrats: • Control invasive and weedy species, both plants and animals • Regulate grazing • Regulate wood collection • Assisted natural regeneration including al Hima grazing and enrichment planting • Protection measures from other anthropogenic, wildlife, and overgrazing pressures • Select restoration plant material with consideration of wildlife, including native grazers, if the selected area is not subject to severe soil degradation or erosion. If subject to severe soil degradation or erosion, first select plant species and install plant material suitable for controlling the specific degradation cause(s), then reintroduce wildlife, and finally, select plant species and install plant material palatable to wildlife. • Create buffer zones between areas subject to tourism activities, and ecological restoration areas. • Community-RCU collaboration for alternative intervention plans		
Red Sandstone Buttes	**Ecological Restoration**	**Red Sandstone Buttes**
Simple reference model (adapted from Valorhiz 2024): This sub-habitat consists of natural rock outcrops at the foot, on the slopes and on the top of the sandstone escarpments. It tends to remain stable and relatively undisturbed by human activities, except overgrazing. Harsh climate conditions, such as extreme temperatures and limited water availability, are common in this sub-habitat. Soil is formed through erosion on rock falls, resulting in the exposure of underlying rocks. These outcrops typically have a limited soil cover, but still sufficient for sparse vegetation. Vegetation is predominantly composed of ephemeral plants that heavily rely on the seasonal rainfall patterns. Species commonly found in this sub-habitat are: *Blepharis ciliaris*, *Gymnocarpos decander*, *Zygophyllum bruguieri*, *Zygophyllum mole* and *Zygophyllum paulayanum*. Locations: HUBR. The APAN Rehabilitation Report did not recommend restoration through revegetation of red sandstone buttes in any Protected Area, but the *Spring Vegetation Report* listed priority species for rocky outcrops and arid land montane, which includes red sandstone buttes, for all Protected Areas. Red sandstone buttes are not included as priority habitats for revegetation in the APAN Rehabilitation Report. However, they are important habitats for native biodiversity, including wildlife, and can benefit from lower intensity interventions as reviewed below.		
Common recommended interventions across all Categories for exposed areas with bare soils: • Control invasive and weedy species, both plants and animals • Regulate grazing • Regulate wood collection • Assisted natural regeneration including enrichment planting • Protection measures from other anthropogenic, wildlife, and overgrazing pressures • Restoration plant material selected with consideration of wildlife, including native grazers, if the selected area is not subject to severe soil degradation or erosion. If subject to extreme severe soil degradation or erosion, first select plant species and install plant material suitable for controlling the specific degradation cause(s), then reintroduce wildlife, and finally, select plant species and install plant material palatable to wildlife. • Create buffer zones between areas subject to tourism activities and ecological restoration areas.		
Sandy Open Environments; Dunes; Abandoned Agriculture Land	**Rehabilitation**	**Sandy Open Environments**
Simple reference model (adapted from Valorhiz 2023, 2024): The soil primarily consists of deep sand, sometimes featuring small sand mounds. The typical vegetation in this reference habitat comprises *Haloxylon salicornicum*, *Haloxylon persicum*, *Artemisia monosperma*, *Calligonum comosum*, *Ephedra alata*, *Panicum turgidum*, *Stipagrostis plumosa* and *Zygophyllum bruguieri*. Locations: Large areas of degraded open sand environments are found nearly throughout except for HZNR and KWVG. Sandy open environments can also be the target for the rehabilitation of abandoned agricultural sites and possibly exposed areas with bare soil. Conversely, areas mapped as sandy open environments, which constitute thousands of square kilometers in AlUla, do not necessarily represent degraded conditions of that ecosystem. Like dunes, areas mapped as sandy open environments could represent the degraded condition of arid thorn woodlands or another native ecosystem. Until additional work can be conducted to determine reference conditions for undegraded sandy open		

Current Habitat	Restorative Continuum	Target Habitat
environments, SER treats these as temporary rehabilitation targets, rather than targets for ecological restoration. The APAN Rehabilitation Report recommended restoration of sandy open environments for all Protected Areas except for HZNR and KWVG, but the *Spring Vegetation Report* listed priority species for all Protected Areas except KWVG. Preliminary specifications: Assume the preliminary desired minimum plant density during initial stages of recovery at 2,500 plants/ ha. (4 sq.m/plant).		
Common recommended interventions across all Categories for sandy open environments: ● Control invasive and weedy species, both plants and animals ● Appropriate stabilization, erosion control, and sand fixation ● Regulate grazing ● Regulate wood collection ● Protection measures from other anthropogenic, wildlife, and overgrazing pressures ● Evaluate if additional phytoremediation is needed in abandoned agricultural areas ● Restoration plant material selected with consideration of wildlife, including native grazers, if the selected area is not subject to severe soil degradation or erosion. If subject to severe soil degradation or erosion, first select plant species and install plant material suitable for controlling the specific degradation cause(s), then reintroduce wildlife, and finally, select plant species and install plant material palatable to wildlife ● Create buffer zones between areas subject to tourism activities and ecological restoration areas.		
Wadis & Colluvial Fans	**Ecological restoration**	**Wadis & Colluvial Fans**
Simple reference models (adapted from Valorhiz 2023, 2024): The soil primarily consists of rocky substratum with non-consolidate material composed of layered colluvial deposits. The typical vegetation in this reference habitat comprises *Vachellia gerardii*, *Vachellia tortilis* subsp. *raddiana* and *Vachellia tortilis* subsp. *tortilis*, *Vachellia seyal* in association with numerous shrub species such as *Retama raetam*, *Zilla spinosa*, *Leptadenia pyrotechnica*, *Senegalia hamulosa*, *Lycium shawii*, *Maerua crassifolia*, *Zygophyllum bruguieri* and *Ephedra foliata* in the sandy zones. The herbaceous stratum is rather dense due to the presence of water, and includes *Panicum turgidum* and *Stipagrostis sp*. [more detail to be added]. Locations: HUBR, HZNR, and WNNR. The APAN Rehabilitation Report recommended restoration of wadis and colluvial fans for all Protected Areas except for GNR and SNP, which is consistent with the *Spring Vegetation Report*. Preliminary specifications: Assume the preliminary desired minimum plant density during initial stages of recovery at 2,500 plants/ha. (4 sq. m/plant).		
Common recommended interventions across all Categories for wadis & colluvial fans: ● Control invasive and weedy species, both plants and animals ● Regulate grazing ● Regulate wood collection ● Erosion control and standards-based water management ● Protection measures from other anthropogenic, wildlife, and overgrazing pressures ● Evaluate if additional phytoremediation is needed in abandoned agricultural areas ● Select restoration plant material with consideration of wildlife, including native grazers, if the selected area is not subject to severe soil degradation or erosion. If subject to severe soil degradation or erosion, first select plant species and install plant material suitable for controlling the specific degradation cause(s), then reintroduce wildlife, and finally, select plant species and install plant material palatable to wildlife. ● Create buffer zones between areas subject to tourism activities, vector points, and ecological restoration areas		

Table 7.6-Summary of planting densities based on categories 1, 2 and 3.

Category	Ecological condition zoning	Water availability	Planting densities recommended
C1	Red and Green Zones	Higher water availability	625 to 2,000 seedlings/ha depending on vegetation cover
C2	Red and Green Zones	Moderate water availability	300 to 625 seedlings/ha depending on vegetation cover
C3	Yellow Zones	High to moderate water availability	Average of 200 seedlings/ha in 10 nucleated patches (100 sq. m.) Direct seed 20 additional nucleated patches between planted patches

8. STRATEGIC COMPONENTS OF THE STRATEGY

The Strategy for Ecosystem Restoration is intended to be implemented over a ten-year period, ending in 2035 and to be consistent with and tiered to previously adopted relevant departmental components of RCU's vision, mission, objectives, and KPIs. This chapter outlines pre-existing RCU strategic components as well as the Strategy-specific content, including a specific mission and vision for the Strategy, pillars, objectives, KPIs, initiatives, and projects. These Strategy-specific components are aligned to, and embedded within, RCU's overall vision, mission, and objectives. Importantly, the objectives and KPIs are also aligned with national and international policy. For example, the Ecosystems Strategic Guidelines and Principles chapter introduces the definition of effective restoration adopted for implementation of the Kunming-Montreal Global Biodiversity Framework. That definition specifically recognises only standards-based restoration that meets certain criteria as effective restoration. Pillar 1 of this strategy, as outlined below, is dedicated to standards-based restoration, while Pillars 2-3 include initiatives related to the additional criteria. Because the KSA is a signatory to the KM-GBF, this enables the work implemented under the Strategy for Ecosystem Restoration to help fulfil the KSA's eventual commitments under the KM-GBF. Similarly, the entire Strategy, as outlined in the pillars below, is designed to help the KSA under the Saudi and Middle East Green Initiatives.

8.1. VISION, MISSION, AND PILLARS OF THE STRATEGY WITH NESTED INITIATIVES AND PROJECTS

RCU has adopted an overarching vision, along with a mission and four strategic objectives for the Strategy for Ecosystem Restoration. This section reiterates the existing RCU vision, mission, and primary objectives, along with a selection of the most relevant strategic objectives for restoration, as provided by RCU. This is followed by the proposed vision and mission for the Strategy for Ecosystem Restoration, along with four key pillars and nested proposed initiatives and projects. Together these provide a foundation for the overall delivery of the Strategy for Ecosystem restoration.

Table 8.1 provides a breakdown of the vision, mission, the four pillars, and strategic objectives, along with the initiatives and projects that are nested underneath each one, and further discussed in the Action Plan (Chapter 9).

Table 8.1-RCU Mission, Vision, and Objectives

RCU Vision	
We preserve, protect, and develop AlUla, an area of rich culture, heritage, and outstanding natural beauty in Saudi Arabia. • AlUla is firmly on the map from a global wildlife & ecotourism perspective • Wildlife is once more thriving in restored habitats, including large predators, both within and beyond protected areas • Habitat restoration and wildlife reintroduction create a blossoming ecotourism sector that diversifies the economy and provides opportunities for local communities	
RCU Mission	
To enable AlUla development for its communities and visitors through regenerating and protecting its cultural landscape and providing quality of life.	
Primary RCU Objectives	
• To create nature reserves to conserve the region's ecosystems, fragile habitats, and biodiversity • To restore and enhance degraded ecosystems, ecological processes through protection, management, research and community engagement, for the benefit of present and future generations • To conserve and reintroduce native species of outstanding universal value	
Strategic RCU Objectives	
Tourism	**Develop a successful and responsible global tourism destination** • Ensure global awareness of AlUla • Offer diverse and authentic experiences for visitors' continuous interest and delight • Drive sustainable growth of AlUla's tourism sector for social-economic impact
Heritage and culture	**Discover and activate and conserve heritage** • Discover and activate heritage • Conserve and safeguard heritage **Develop Arts & Culture offerings and communities** • Develop and promote Arts & Culture offerings • Build communities for Arts & Culture
Nature and wildlife	**Conserve nature and wildlife** • Create and activate Nature Reserves to conserve ecosystems, fragile habitats, and biodiversity • Restore and enhance degraded ecosystems and ecological processes • Conserve and reintroduce native species
Economic and social development	**Develop a vibrant, prosperous and engaged community** • Ensure social-economic prosperity and engagement of AlUla's community • Develop the skills and capabilities of AlUla's community • Improve quality of life for AlUla's residents **Develop a sustainable economy** • Develop priority sectors' value chains • Ensure sustainable growth of SME sector in AlUla • Ensure local content development across sectors in AlUla
Institutional excellence	**Attain organizational excellence** • Plan, implement, and monitor successful delivery leveraging reliable and trusted technology solutions • Ensure effective and efficient policies, business processes and procedures • Develop accurate financial planning, compliance, and governance mechanisms • Foster innovation • Nurture innovation in AlUla • Cultivate innovation at RCU

Table 8.2- RCU's vision, mission, pillars, and strategic objectives, and initiatives for the Strategy for Ecosystem Restoration.

VISION	**Ecosystem restoration, including ecological restoration, has positively transformed and enhanced the extraordinary natural heritage of AlUla County, including through playing a role in the successful reintroduction of the Arabian leopard in its rightful place as a keystone predator in the region. Ecosystem restoration of AlUla's protected areas has contributed to AlUla County being recognized as a unique and high-quality destination, known as an example of successful sustainable development.**									
MISSION	**Restore the natural treasures of AlUla County and support KSA's global climate, biodiversity, and land degradation neutrality global commitments by applying standards-based ecological and ecosystem restoration in partnership with local communities.**									
PILLARS	**1: Standards-based ecosystem restoration implemented locally with a global impact**		**2: Planning, design, monitoring and evaluation**			**3: Community participation and capacity building at the core of restoration**		**4: Partnerships for restoration success**		
STRATEGIC OBJECTIVES	**Restore and enhance degraded ecosystems and ecological processes**		**Planning and monitoring to ensure high quality ecosystem restoration and enhance outcomes**			**Enshrine AlUlas local communities' valuable participation throughout the restoration process and ensure communities receive tangible benefits.**		**Partner and collaborate with national and international experts and organisations to enhance RCUs work and share learnings globally**		
INITIATIVES	**1.1: Phase 1 implementation of standards-based restoration to achieve ecological and socio-cultural objectives (2025-2030)**	**1.2: Phase 2 implementation of standards-based restoration to achieve ecological and socio-cultural objectives (2030-2035)**	**2.1: Planning and design for implementation phases**	**2.2: Research and development**	**2.3: Data management and monitoring**	**3.1: Local capacity building for restoration**	**3.2: Elevate community-based ecosystem restoration and sustainable land management**	**4.1: RCU capacity building and intradepartmental cooperation**	**4.2: Partner with local, national and international stakeholders**	**4.3: Promote the results of the Strategy**
PROJECTS	1.1a: Vegetation development and planting of 500,000 trees in Sharaan NP	1.2a: Phase 2 implementation of ecosystem restoration in Sharaan NP	2.1a: Detailed Implementation Plan for standards-based restoration in AlUla	2.2a: Ecosystem restoration pilot site, Sharaan National Park	2.3a: Design framework for ecological restoration ata management and monitoring system	3.1a: AlUla Ecosystem Restoration Training Academy	3.2a: Revive al Hima and traditional knowledge-based management of livestock	4.1a: RCU Habitat Regeneration and Landscaping team capacity building	4.2a: Local partnerships for restoration success	4.3a: Application for UN Decade Flagship programme
	1.1b: Harrat Uwayrid Biosphere Reserve ecosystem restoration and vegetation development	1.2b: Phase 2 implementation of ecosystem restoration in Harrat Uwayrid Biosphere Reserve	2.1b: Long-term progress planning, evaluation and adaptive management	2.2b: Rangeland degradation and recovery assessments in AlUla: A satellite and field approach across landscapes	2.3b: Long-term monitoring of ecosystem restoration in AlUla Protected Areas	3.1b: Prioritise women in the workforce	3.2b: Native plant materials for restoration	4.2b: RCU intradepartmental cooperation to achieve integrated ecological and social objectives	4.2b: National partnerships for restoration success	4.3b: Ecological Restoration of Arid Ecosystems Conference in AlUla
	1.1c: Water harvesting and flood risk reduction implementation in AlUla Protected Areas	1.2c: Phase 2 implementation of ecosystem restoration in Gharameel NR	2.1c: Sustainable finance planning	2.2c: Estimating carbon stocks and enhancing carbon sequestration potential in AlUla Protected Areas	2.3c: Data management system for ecosystem restoration in AlUla Protected Areas	3.1c: Ecosystem restoration as an opportunity for entrepreneurship	3.2c: Community led honeybees and geographic indications products		4.2c: International partnerships for restoration success	4.3c: RCU Habitat regeneration and landscaping communication plan
	1.1d: Nature based solutions for ecosystem restoration at Harrat AlZabin NR	1.2d: Phase 2 implementation of ecosystem restoration in Wadi Nakhlah NR		2.2d: Direct seeding experimental research project						
	1.1e: Restoration of degraded lands and combating desertification in Gharameel NR	1.2e: Phase 2 implementation of ecosystem restoration in Harrat AlZabin NR		2.2e: Long term research programme						
	1.1f: Adopting direct reseeding as tool for improving natural vegetation	1.2f: Phase 2 implementation of ecosystem restoration in Harrat Khaybar Volcano Geopark		2.2f: Water resources assessment for habitat restoration and vegetation development in AlUla Protected Areas						
	1.1e: Phase 1 implementation of ecosystem restoration in Wadi Nakhlah NR									
	1.1g: Phase 1 implementation of ecosystem restoration in Harrat Khaybar Volcano Geopark									

8.2. KEY PERFORMANCE INDICATORS

The pillars for the Strategy for Ecosystem Restoration include nested initiatives and projects. The initiatives provide overarching categories for groups of projects. The projects are explained in more detail in the narrative and through a series of project cards included in chapter 9 entitled Ecosystem Restoration Action Plan. Table 8.2 below outlines both existing and proposed KPIs. At the time of writing, the KPIs attached to Pillar 1 have been adopted under the RCU Strategy; the KPIs listed below are proposed for the three remaining pillars. The project cards in chapter 9 also outline expected outcomes that provide additional KPIs, should that be determined necessary.

KPIs of Pillar 1 will contribute to measuring success of ecosystem restoration locally and its impact globally. They are based on global KPIs measuring global impact of ecosystem restoration. Under Pillar 2, the KPIs will contribute to measuring generated quantifiable data from ecosystem restoration projects crucial for the standardized measuring of restoration impacts locally and their contribution globally. Under Pillar 3, the KPIs focus on measuring the integration of local communities into the projects and how local communities are contributing to the sustainability of impacts and to the established local governance model. Finally, under Pillar 4, the KPIs will measure the increase in local expertise built in AlUla and how it will lead to international recognition through established local and international partnerships.

8.3. CONCLUSION

With comprehensive strategic components identified and developed under the AlUla context and aligned with national and international strategies, standards-based and detailed interventions and projects are presented in the next chapter “Ecosystem Restoration Action Plan”.

Table 8.3– Strategic and operational KPIs of the Strategy for Ecosystem Restoration.

Pillar	KPI	2025 Baseline	2030 Target	2035 Target
Pillar 1: Standard-based ecosystem restoration implemented locally with a global impact	Area of restored rangeland within AlUla*	5100 ha.	23,500 ha.	65,000 ha.
	Number of planted trees in AlUla protected areas*	530,000	2.5 million**	13 million**
	Number of flora species revegetated in AlUla*	56	130	200
Pillar 2: Planning and monitoring to ensure high quality ecosystem restoration and enhance outcomes	Number of ecosystem restoration research publications	5	25	50
	Restoration database developed, consistent with the ISF and FERM	Design complete	Database operational	Interoperable with the FERM
	Area of Protected Areas covered by the ecosystem restoration monitoring framework	5000 ha.	200,000 ha.	1,250,000 ha.
Pillar 3: Community participation and capacity building at the core of restoration	Number of students trained through RTA	0	240	540
	Percentage of women in technical roles in the restoration workforce	N/A	20	30
	Number of native seedlings produced by local community nurseries	N/A	200,000	1,300,000
Pillar 4: Partnerships for restoration success	Core restoration staff successfully achieving CERP/CERPIT status	N/A	3	7
	Number of partnership agreements with national and international institutions	4	10	15

*Existing KPIs adopted under the RCU Strategy.
**Based on rate of minimum 200 seedlings per hectare needed to restore 65,000 ha.

9. ECOSYSTEM RESTORATION ACTION PLAN

The Ecosystem Restoration Action Plan is directly built from the mission, pillars, objectives, KPIs, initiatives, and projects previously explained in chapter 8. This Ecosystem Restoration Action Plan is presented specifically through a detailed series of “Project Cards” for each of the four pillars, and for each initiative within the pillars. The project cards address both existing and proposed activities, creating a roadmap for RCU to implement the Strategy for Ecosystem Restoration over the next 10 years. They are intended to help RCU meet its overall KPIs and deliver a holistic restoration program that benefits both people and nature, contributing to broader RCU and Vision 2030 Strategic Objectives related to sustainable economic development and capacity building of multi-stakeholders (i.e. local communities and women in the workforce).

The recommended projects included in this chapter focus on both ecological and social-economic interventions prioritised for local communities and social groups that are adjacent or associated with the protected areas. Each project card includes the title of the project, its rationale, objectives, anticipated outputs, and a tentative project plan comprising main actions and interventions, priority-level, duration, and targeted stakeholders.

The project cards align the planning format with the high-level approach and the execution modalities adopted by RCU and enable RCU to choose which approaches within the Strategy for Ecosystem Restoration to implement.

Under Pillar 1, the project cards address the two phases of restoration implementation across the different protected areas. Pillar 2 includes three important planning project cards that will support full implementation of the overall Strategy for Ecosystem Restoration. This includes a comprehensive project card for a detailed implementation plan for standards-based restoration in AlUla, which will enable RCU to choose specific sites for restoration implementation for each of the two restoration implementation phases. In addition, many of the new projects, especially under Pillar 3, focus on engaging, supporting, and building capacity for local communities and local restoration implementation, particularly in terms of social-economic development, sustainable use of natural resources, restoration training, and community-based management of protected areas. These activities are also important for helping RCU build long-term social license to operate (SLO) across AlUla County. Finally, Pillar 4 focuses on project cards outlining internal and external partnerships and promotion of the Strategy for Ecosystem Restoration. It is important to note that the projects across

all fours pillars are not be completed sequentially, and will be undertaken at appropriate times through the 10-year programme.

The full project cards are included in Ecosystem Restoration Action Plan deliverable and provide detailed information on timeline, geographic scope, project rationale, general description of project interventions, recommended RCU Departmental partners, estimated budget and anticipated results. Table 9.1 summarizes the project cards developed and table 9.2 the timeline suggested for each of the project cards.

Table 9.1- Action Plan Summary.

Initiative/Project		Description
Pillar 1: Standards-based Ecosystem Restoration Implemented Locally with a Global Impact		
1.1 Phase 1 implementation of standards-based restoration to achieve ecological and socio-cultural objectives (2025-2030)		
1.1a	Vegetation development and planting of 500,000 trees in Sharaan NP	The main objective of this project is to plant and maintain 500,000 native seedlings across 5,000 hectares in SNP to rehabilitate degraded rangelands and improve vegetation quantity and quality as well as biodiversity.
1.1b	Harrat Uwayrid Biosphere Reserve ecosystem restoration and vegetation development	Restoration in Harrat Uwayrid Biosphere Reserve (HUBR) will be the first restoration project conducted by RCU outside of the fenced Sharaan National Park. This offers an opportunity for RCU to test methods for restoration in a different habitat and also develop a project with participation from local communities.
1.1c	Water harvesting and flood risk reduction implementation in AlUla Protected Areas	The RCU KPI to restore 65,000 hectares of land in AlUla Protected Areas needs to be designed and implemented responsibly to ensure enhancement of ecosystem services, including enhancing the local water resources.
1.1d	Nature based solutions for ecosystem restoration at Harrat AlZabin NR	Through projects 1.1a, 1.1b, and 2.2a, RCU will bring 10,000 hectares under restoration. To achieve the goal of 23,500 hectares, a further 13,500 hectares must be under restoration by 2030, and projects 1.1d-g combined are intended to address the remainder.
1.1e	Restoration of degraded lands and combating desertification in Gharameel NR	
1.1f	Phase 1 implementation of ecosystem restoration in Wadi Nakhlah NR	
1.1g	Phase 1 implementation of ecosystem restoration in KWVG	
1.2 Phase 2 implementation of standards-based restoration to achieve ecological and socio-cultural objectives (2031-2035)		
1.2a	Phase 2 implementation of ecosystem restoration in Sharaan NP	These combined projects will form Phase 2 of ecosystem restoration in AlUla. The first phase will result in 23,500 hectares of land in the Protected Areas being under restoration. This second phase will therefore cover 41,500 hectares to ensure that RCU's 2035 KPI of 65,000 hectares restored can be achieved.
1.2b	Phase 2 implementation of ecosystem restoration in Harrat Uwayrid Biosphere Reserve	
1.2c	Phase 2 implementation of ecosystem restoration in Gharameel NR	
1.2d	Phase 2 implementation of ecosystem restoration in Wadi Nakhlah NR	
1.2e	Phase 2 implementation of ecosystem restoration in Harrat AlZabin NR	
1.2f	Phase 2 implementation of ecosystem restoration in Harrat Khaybar Volcano Geopark	
Pillar 2: Planning and Monitoring to Ensure High Quality Ecosystem Restoration and Enhance Outcomes		
2.1: Planning and design for implementation phases		
2.1a	Detailed Implementation Plan for standards-based restoration in AlUla	This project provides specific restoration recommendations for all sites, including plant material, densities, irrigation and maintenance requirements, etc.
2.1b	Long-term progress planning, evaluation and adaptive management	This project will cover the strategic management of implementation of the Strategy. This will require ongoing planning, evaluation and adaptive management through adjusting to changes in RCU priorities and budget allocations.
2.1c	Sustainable finance planning	This project is needed to develop a long-term (minimum 10 years) sustainable funding and finance plan for ecosystem restoration in AlUla County.
2.2: Research and Development		
2.2a	Ecosystem Restoration Pilot Site, Sharaan National Park	To ensure efforts and investment in restoration results in the desired benefits to biodiversity, research into the most effective methods for restoring arid ecosystems in AlUla is required. Research will focus on soil rehabilitation, weed control, and approaches to planting initiatives to understand the ecological outcomes of a variety of restoration interventions.
2.2b	Rangeland degradation and recovery assessments in AlUla: A satellite and field approach across landscapes	This project will look at historical data to understand patterns of change in the landscape over time, which will be important for understanding future landscape changes in response to restoration interventions. This project should also be designed to integrate with projects 2.1b and 2.3b.
2.2c	Estimating carbon stocks and enhancing carbon sequestration potential in AlUla Protected Areas	The main purpose of this project is to provide an estimate for the current carbon stocks within the AlUla Protected Areas ecosystems, assessing the carbon sequestration in the main trees and shrubs within the AlUla Protected Areas including above-ground biomass, below-ground biomass, and soil carbon. This provides an understanding of how restoration will contribute to RCUs goals to be carbon net-zero by 2035.

Initiative/Project		Description
2.2d	Direct seeding experimental research project	Direct seeding would involve sowing seeds collected from the Protected Areas directly into the soil. Research should be undertaken across all habitats suitable for direct seeding in the AlUla Protected Areas to ascertain if certain habitats and plant species show more success than others. This will inform how direct seeding may best be integrated into restoration interventions.
2.2e	Long term research programme	This programme will create opportunities for RCU to partner with both KSA and international universities and to provide opportunities for university students, especially masters/PhD students to conduct academic research in conjunction with the Strategy. This research focus on improving methods for restoration to be implemented in AlUla.
2.2f	Water resources assessment for habitat restoration and vegetation development in AlUla Protected Areas	The RCU KPI to restore 65,000 ha. of land in the AlUla protected areas needs to be designed and implemented responsibly to ensure enhancement of ecosystem services, including securing and enhancing local water resources through this project.
2.3: Data Management and Monitoring		
2.3a	Design framework for ecological restoration data management and monitoring system	This project will focus on the design of a data management and monitoring system for ecological restoration in AlUla.
2.3b	Long-term monitoring of ecosystem restoration in AlUla Protected Areas	Ecosystem restoration is inherently long term, as ecosystems take time to respond to restoration interventions. This project focuses on long-term monitoring for assessing how the ecosystem responds over time and for understanding the long-term successes and challenges.
2.3c	Data management system for ecosystem restoration in AlUla Protected Areas	The RCU Protected Areas operate across 12,500km^2, and long-term monitoring will generate a significant volume of data for research, assessment, adaptive management, national reporting, and other related activities. The data management system will be designed as part of project 2.3a: Design framework for ecological restoration data management and monitoring system.
Pillar 3: Community Participation and Capacity Building at the Core of Restoration		
3.1: Local Capacity Building for Restoration		
3.1a	AlUla Ecosystem Restoration Training Academy	The project involves the identification and development of curricula and other training materials, both classroom and field-based, for ecosystem restoration vocational training, initially provided to the AlUla local community.
3.1b	Prioritise women in the workforce	The project involves supporting local communities, especially women, in developing small-scale businesses that support or derive from ecological restoration. This project will also ensure women receive opportunities for technical training and career development.
3.1c	Ecosystem restoration as an opportunity for entrepreneurship	To ensure RCU's restoration projects are sustainable long term, it is vital that local communities receive tangible benefits. This project will facilitate the establishment of businesses that support or derive from ecological restoration and will work to support long-term success.
3.2: Elevate Community-Based Ecosystem Restoration and Sustainable Land Management		
3.2a	Revive al Hima and traditional knowledge-based management of livestock	The project includes the establishment of community conserved areas and co-managed protected areas based on the al Hima approach.
3.2b	Native plant materials for restoration	This project comprises the selection, design, development, and operationalization of 10 hyperlocal native plants nurseries across AlUla County.
3.2c	Community led honeybees and geographic indications products	NA
Pillar 4: Partnerships for Restoration Success		
4.1: RCU Capacity Building		
4.1a	RCU Habitat Regeneration and Landscaping team capacity building	A systematic process of enhancing and expanding the skills, knowledge, and overall abilities of individuals with the team will be developed. The project will be implemented in three phases.
4.1b	RCU intradepartmental cooperation to achieve integrated ecological and social objectives	The Strategy outlines a holistic approach to restoration that is designed to appropriately balance both ecological and community outcomes. As part of the Strategy, a governance structure has been developed that provides guidance on which RCU departments should be involved under each of the pillars. This will therefore guide the Habitat Regeneration and Landscaping Team with which departments to coordinate for each project and to create mutually supportive goals and partnerships wherever viable.
4.2: Partner with Local, National, and International Stakeholders		
4.2a	Local partnerships for restoration success	In order to achieve RCU's goals in ecosystem restoration, local support will be essential. One mechanism to secure such support is partnerships with local organisations and local private sector entities, including local volunteer groups, farmers associations, or wildlife groups.
4.2b	National partnerships for restoration success	The project will facilitate knowledge exchange and collaboration that will enhance results for biodiversity between national agencies, companies and other groups.
4.2c	International partnerships for restoration success	The project will focus on partnering with international organisations working in ecosystem restoration globally and will create opportunities for collaboration with experts, knowledge exchange, and funding diversification.
4.3: Promote the Results of the Strategy		
4.3a	Application for UN Decade Flagship programme	The UN Decade on Ecosystem Restoration hosts a Restoration Flagship programme that elevates high impact restoration projects globally. Because the Strategy is standards-based, with an emphasis on the UN Decade Standards of Practice as well as the SER Standards, RCU can provide an important example of standards-based restoration.
4.3b	Ecological Restoration of Arid Ecosystems Conference in AlUla	Arid environments cover approximately a third of terrestrial land area and are some of the most vulnerable both to habitat degradation and climate change impacts. As such, restoration in these areas is vital to protect sensitive habitats, enhance biodiversity, and improve climate change resilience. RCU is planning a global gathering on arid lands restoration that will feature high level invited experts from around the world.
4.3c	RCU Habitat regeneration and landscaping communication plan	RCU is undertaking landscape level restoration across the entirety of AlUla County, starting in Protected Areas. A project of this ambition and scope is important to promote and share globally as a learning opportunity. The plan should include local engagement, events, publications, and other activities that will help RCU share the successes (and the challenges that we learn from) with both the broader restoration community, but also the general public.

Table 9.2- Action plan timeline (Green indicates completed project)

		2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
1.1a	Vegetation development and planting of 500,000 trees in Sharaan NP											
1.1b	Harrat Uwayrid Biosphere Reserve ecosystem restoration and vegetation development											
1.1c	Water harvesting and flood risk reduction implementation in AlUla Protected Areas											
1.1d	Nature based solutions for ecosystem restoration at Harrat AlZabin NR											
1.1e	Restoration of degraded lands and combating desertification in Gharameel NR											
1.1f	Adopting direct reseeding as tool for improving natural vegetation											
1.1g	Implementation of ecosystem restoration in Wadi Nakhlah NR											
1.1h	Implementation of ecosystem restoration in Harrat Khaybar Volcano Geopark											
1.2a	Implementation of ecosystem restoration in Sharaan NP											
1.2b	Implementation of ecosystem restoration in Harrat Uwayrid Biosphere Reserve											
1.2c	Implementation of ecosystem restoration in Gharameel NR											
1.2d	Implementation of ecosystem restoration in Wadi Nakhlah NR											
1.2e	Implementation of ecosystem restoration in Harrat AlZabin NR											
1.2f	Implementation of ecosystem restoration in Harrat Khaybar Volcano Geopark											
2.1a	Detailed Implementation Plan for standards-based restoration in AlUla											
2.1b	Long-term progress planning, evaluation and adaptive management											
2.1c	Sustainable finance planning											
2.2a	Ecosystem restoration pilot site, Sharaan National Park											
2.2b	Rangeland degradation and recovery assessments in AlUla: A satellite and field approach across landscapes											
2.2c	Estimating carbon stocks and enhancing carbon sequestration potential in AlUla Protected Areas											
2.2d	Direct seeding experimental research project											
2.2e	Long term research programme											
2.2f	Water resources assessment for habitat restoration and vegetation development in AlUla Protected Areas											
2.3a	Design framework for ecological restoration data management and monitoring system											
2.3b	Long-term monitoring of ecosystem restoration in AlUla Protected Areas											
2.3c	Data management system for ecosystem restoration in AlUla Protected Areas											
3.1a	AlUla Ecosystem Restoration Training Academy											
3.1b	3.1b: Prioritise women in the workforce											
3.1c	Ecosystem restoration as an opportunity for entrepreneurship											
3.2a	Revive al Hima and traditional knowledge-based management of livestock											
3.2b	Native plant materials for restoration											
3.2c	Community led honeybees and geographic indications products											
4.1a	RCU Habitat Regeneration and Landscaping team capacity building											
4.1b	RCU intradepartmental cooperation to achieve integrated ecological and social objectives											
4.2a	Local partnerships for restoration success											
4.2b	4.2b: National partnerships for restoration success											
4.2c	4.2c: International partnerships for restoration success											
4.3a	4.3a: Application for UN Decade Flagship programme											
4.3b	4.3b: Ecological Restoration of Arid Ecosystems Conference in AlUla											
4.3c	4.3c: RCU Habitat regeneration and landscaping communication plan											

9.1. CONCLUSION

The project outlined in this section are intended to provide a roadmap for RCU as it implements the Strategy for Ecosystem Restoration. The projects cover all required components across all four pillars and over the projected 10-year time frame of the Strategy for Ecosystem Restoration. They are intended to help RCU meet its overall KPIs and deliver a holistic restoration program that benefits both people and nature. They are directly aligned with the Strategic Components, as outlined in chapter 8. To sustain efforts and ensure proper implementation and impact on the long term, there is a need for proper governance and funding models. In the following section, primary models for governance and funding are presented.

10. GOVERNANCE AND FUNDING MODEL

10.1. GOVERNANCE MODEL

Overall implementation of the Strategy for Ecosystem Restoration requires a coordinated internal RCU governance model that applies not only to the Habitat Regeneration and Landscaping Team leading the Strategy, but also that supports effective internal collaboration with the other teams in the Wildlife and Natural Heritage Department, other RCU sectors, departments, and teams, as well as external RCU stakeholders and partners. The governance model focuses on the roles and responsibilities of RCU, as well as internal and external stakeholders and partners.

The proposed governance model for the Strategy for Ecosystem Restoration incorporates both internal and external roles and responsibilities, while also maintaining consistency with RCU's overall governance framework. In addition, the overall governance of the strategy must address the capacity building needs that will empower meaningful, participatory, informed stakeholder engagement and community buy-in.

RCU generally applies four roles to internal or external stakeholders or partners. For the purposes of the Strategy for Ecosystem Restoration, they are defined as:

- **Accountable:** lead entity responsible for ownership, oversight, and final decision-making on that pillar, initiative, program, or project
- **Responsible:** Entity with responsibility related to any individual or collective components of a pillar, initiative, program, or project
- **Consulted:** Entity engaged to provide input, feedback, and relevant content related to a pillar, initiative, program, or project
- **Informed:** Entity with whom RCU or its representatives, communicates to ensure they are aware of relevant details related to a pillar, initiative, program, or project

Table 10.1 outlines the key governance roles for each pillar of the strategy, starting with internal and then moving to external stakeholders. Because pillars include many initiatives, roles may vary within an individual pillar; in cases with more than one role listed, the order of listing indicates the likely greater relevance of the first listed role. For RCU internal stakeholders, Sector level is indicated by brown, bold font; Department level is indicated by brown font; and Team level is indicated by standard black font. Table 10.2 summarizes stakeholder engagement priorities, presented across the phases of restoration including priority internal and external stakeholders, objectives, and potential approaches/considerations.

Table 10.1- Key governance roles for internal and external entities and stakeholders for each pillar of the Strategy.

Entity	Pillar 1: Standards-based restoration	Pillar 2: Planning, design, monitoring, and evaluation	Pillar 3: Community participation and capacity building	Pillar 4: Partnerships	Notes
Internal and other governmental stakeholders/partners					
Tourism: Wildlife & Natural Heritage					
Habitat regeneration & landscaping	Accountable, Responsible	Accountable, Responsible	Accountable, Responsible	Accountable, Responsible	HR&L is the overall owner of the Strategy, and as such is Accountable for all aspects of the design, delivery, and implementation of all pillars. HR&L is also directly Responsible for the implementation or for ensuring implementation of the different initiatives occurs as planned and delivers intended results.
Nature Reserves	Consulting, Responsible	Consulting, Responsible	Consulting, Responsible	Consulting	Because many activities are taking place in Nature Reserves, staff need to be considered a key partner for information sharing and coordination through Consultation. In addition, Nature Reserves may be directly Responsible, especially regarding some of the restoration interventions and community engagement opportunities planned for each Nature Reserve.
Wildlife & natural heritage research and advisory	Consulting, Responsible	Responsible, Consulting	Consulting, Responsible	Responsible, Consulting	Largely focused on Consultation, but especially may be Responsible in the context of national and international research (Pillar 2) research partnerships (Pillar 4)
Conservation breeding & reintroduction	Consulting	Consulting	Consulting	Consulting	Because one of the long-term, visionary goals of the Strategy is to support the successful reintroduction of the Arabian Leopard, Consultation is critical to ensure restoration interventions are achieving the results on projects intended to support reintroduction in some manner.
Tourism: Destination Management & Marketing	Informed	Informed	Consulting, Responsible	Consulting	As implementation of the restoration strategy delivers more high integrity, high functioning ecosystems and other associated outcomes, HR&L will need to work increasingly closely with Marketing to promote the improved ecosystem and the associated ecotourism. As the restoration achieves intended objectives and increases the interest of both Saudi and international tourists to visit AlUla County. It will also be imperative to driving visitation that will support future local community-based ecotourism companies.
Tourism: Culture	Consulting	Consulting	Consulting, Responsible	Consulting, Responsible	Consultation is important, especially in the context of promoting things like artisanal handicrafts, traditional foods, and many other components of AlUla County's cultural heritage. Marketing will also be Responsible for helping promote ecotourism and supporting these new local businesses as a result.
Legal Affairs & Regulations	Responsible, Consulting	Responsible, Consulting	Consulting	Consulting	Legal Affairs will be at least partially Responsible for contracts, disputes, and potentially regulations to support implementation of the actual restoration programs. In many instances, they will need to be Consulted regarding other practices (and may need to provide contracting support for consultants related to Pillar 3 as well.
Communications & PR	Consulting	Consulting	Consulting	Consulting, Responsible	As the Strategy is implemented and outcomes are achieved, it will be important to Consult with Comms regarding effectiveness; Comms may be Responsible for developing or supporting promotion of the innovative approaches, successes, and lessons learned across all pillars, and especially for Pillar 4 comms plan about the strategy.
Operations	Informed	Informed	Informed	Informed	While E&SD, as described immediately below, will play a responsible role in several pillars, the Operations Sector should also generally be Informed across all Pillars throughout the entirety of the Strategy.
Economic and social development	Consulting	Consulting	Responsible, Consulting	Responsible, Consulting	Especially in Pillars 3 and 4, E&SD will be critical implementing partners Responsible for helping develop ecosystem restoration as a multi-faceted economic and community development tool. They will also be critically important for success of programs like, e.g., the Restoration Training Academy, which will help train qualified workers for both lower-skilled and higher-skilled restoration jobs. To effectively do this work, it will be important that they are Consulted on projects and programs implemented through Pillars 1 and 2.
Agricultural	Consulting	Informed	Informed	Consulting	The Agricultural Planning team will be a key stakeholder in the implementation of restoration across the reserves, particularly how it

Entity	Pillar 1: Standards-based restoration	Pillar 2: Planning, design, monitoring, and evaluation	Pillar 3: Community participation and capacity building	Pillar 4: Partnerships	Notes
Planning					pertains to reduction of drivers of degradation (grazing) and rehabilitation of agricultural areas.
Development & Construction	Consulting, Responsible	Consulting	Consulting, Responsible	Informed	D&C will have direct Responsibility for supporting implementation of, e.g., the development of micro-nurseries associated with capacity building programs in Pillar 3. They may also be needed to support, e.g., irrigation or fencing construction in Pillar 1. They will be Consulted in regard to Pillar 2, but only play an Informational role in Pillar 4.
Strategy & Digital	Informed	Responsible, Consulting	Informed	Informed	S&D will be directly involved, and therefore partly Responsible in the development of databases and data management in Pillar 2. In all other pillars, they will need to be Informed.
Strategy and Performance	Informed	Consulting	Consulting	Informed	Pillar 2 will require the most significant Consulting with Strategy and Performance, as it includes the further planning of both the remaining restoration work as well as the sustainable finance plan; Pillar 3 is also likely to require Consulting, while HR&L should also keep Strategy and Performance Informed about the work done under Pillars 1 and 4, especially performance outcomes.
Strategic Partnerships	Informed	Informed	Informed	Accountable, Responsible	The majority of long-term partnerships are outlined in Pillar 4, requiring formal Accountability and Responsibility from the Strategic Partnerships Team. For all other pillars, HR&L will keep this team Informed.
Finance	Responsible, Consulting	Responsible, Consulting	Responsible, Consulting	Consulting	Successful implementation of all aspects and all components of the Strategy require effective budgeting, financial management, and secure funding. Finance will be Responsible for supporting this component, especially of Pillars 1-3, while they will be largely Consulted on Pillar 4. Pillar 2 includes the development of a long-term sustainable, public-private fundraising plan and Finance will be Responsible for supporting that work.
Shared Services	Consulting, Responsible	Consulting, Responsible	Consulting, Responsible	Consulting, Responsible	Nearly all aspects of Shared Services apply to all pillars of the Strategy and HR&L will Consult and coordinate closely with these Shared Services, including those that require their direct implementation/Responsibility.
Agriculture	Consulting	Responsible, Consulting	Responsible, Consulting	Consulting	The Agriculture Sector is an important intragovernmental partner, given the role agriculture plays in degradation of the land, as well as the opportunity to use carefully managed and controlled agriculture as a restoration tool (once vegetation has recovered enough to support such efforts). As such HR&L will Consult with Agriculture regarding implementation of restoration activities under Pillar 1, and Agriculture will have shared Responsibility regarding the application of al Hima and traditional knowledge approaches to grazing as applied in Pillar 3. Agriculture will largely play a Consulting role in Pillars 2 and 4, though several projects in Pillar 2 might provide opportunities for a Responsible role.
Ministry of Environment, Water, and Agriculture	Responsible, Consulting	Responsible, Consulting	Informed	Informed	The Ministry will be an important partner, especially as a Responsible party related to Agricultural Management and reducing degradation in conjunction with Pillars 1&2. Keeping the Ministry Informed about activities associated with Pillars 3&4 will benefit that work as well, including potentially identifying additional partnerships.
National Center for Vegetation Cover	Consulting	Consulting	Consulting	Consulting	NCW need not be engaged with the Strategy throughout to ensure it meets national commitments.
National Center for Wildlife	Consulting	Consulting	Consulting	Consulting	NCW need not be engaged with the Strategy throughout to ensure it meets national commitments.
Special Forces for Environmental Security	Responsible	Responsible	Responsible		The Special Forces will be Responsible for providing security patrols, enforcing both legal and illegal grazing activities in conjunction with Pillars 1-3, and for ensuring the safety and legal compliance of other activities associated with the Strategy.

Entity	Pillar 1: Standards-based restoration	Pillar 2: Planning, design, monitoring, and evaluation	Pillar 3: Community participation and capacity building	Pillar 4: Partnerships	Notes
External Stakeholders and Partners					
International and National					
AfAlula	Consulting	Consulting, Responsible	Consulting	Responsible, Consulting	Afalula is a French agency that partners closely with RCU to support development in AlUla County; they are likely to be a Responsible Party for planned activities in Pillar 4 and to support implementation of some activities in Pillar 2, while they are expected to play a Consulting role associated with Pillars 1 and 3.
Universities	Consulting	Responsible, Consulting	Consulting, Responsible	Responsible, Consulting	International and national universities will act as Responsible partners associated especially with monitoring and evaluation and long-term research programs related to the Strategy (Pillar 2). Through that, they have the potential to be Consulting partners to support improved implementation of the Strategy (Pillars 1 and 2). International Universities may also act in a Consulting or Responsible role to support, e.g., development of curricula and trainings associated with the Restoration Training Academy (Pillar 3), and will be key International Partners (Pillar 4). Ideally many students, especially Saudi students, will get directly involved in the Strategy as part of their studies.
Restoration and social-cultural consultancies	Consulting	Consulting	Consulting	Responsible	Many of the project cards listed in the Ecosystem Restoration Action Plan envision both international and national consultancies as Responsible for some components of delivery. HR&L will likely develop calls for proposals for qualified ecological or social-cultural consultancies. For ecological (especially Pillars 1-2), priority should go to entities with CERPs or CERP equivalent on the project teams. In some instances, consultancies may be engaged as reviewers/advisors instead of implementers, thus playing a Consulting role.
Local					
Local community groups (including, e.g., livestock owners, farmers)	Consulting, Responsible	Consulting, Responsible	Responsible, Consulting, Accountable	Responsible, Consulting	As part of standards-based restoration, all aspects of the Strategy will require active, sustained, and participatory stakeholder engagement. The outcomes of that stakeholder engagement will shape the level of activity that Local Community groups will engage in, e.g., Consulting as citizen scientists supporting monitoring in Pillar 2, or Responsible, and perhaps even Accountable, as adopters and implementers of al Hima and Traditional knowledge grazing approaches as a restoration tool in Pillar 3. Pillar 4 also includes local partnerships, which will obligate Responsibility on the part of local community groups.
Local community leaders (including, e.g., Sheiks, religious leaders)	Consulting, Responsible	Consulting	Responsible, Consulting	Informed	Local community leaders are incredibly important for supporting community engagement in the Strategy, especially in a Consulting role across all four pillars. In addition, local community leaders can take Responsibility to support and promote community members to attend courses at the Restoration Training Academy, or to implement al Hima grazing approaches as part of Pillar 3. Similarly, respected elder women in the community can take Responsibility to support younger women to participate in the Restoration Training Academy and to set up nurseries or become seed collectors. Local leaders are also important in a Consulting role for improving communication opportunities between local NGOs and RCU to ensure local voices are being considered, similar to Local NGOs, below.
Local businesses	Informed, Responsible	Consulting, Responsible	Accountable, Responsible	Consulting	In addition to existing local businesses, ideally new local businesses (e.g., ecotourism; artisanal and traditional handicrafts, seed collecting, micro-nurseries), will be created to help implement the Strategy creating opportunities for Responsibility and Accountability based roles, especially in different initiatives associated with Pillars 1-3. Local businesses that are contracted to implement components of the Strategy (e.g., hyperlocal nurseries) will be both Accountable for meeting their contractual obligations, and Responsible for developing and implementing the activities needed, in a high-quality manner, to meet those obligations. Local businesses can provide important Consulting support for Pillar 4.
Local NGOs	Consulting	Consulting, Responsible	Consulting, Responsible	Responsible	Similar to the role of local businesses, but with a more Consulting-oriented role across all four pillars. Local NGOs might take a Responsibility role to help support women who are building artisanal/handicraft businesses associated with Pillar 3, or they might support the development of citizen science monitoring projects associated with Pillar 1. Local NGOs are also important in a Consulting role for improving communication opportunities between local NGOs and RCU to ensure local voices are being considered, similar to Local leaders, above.

Table 10.2- Summary of stakeholder engagement priorities.

Phase	Stakeholders		Objectives	Means, approaches, & communication
	Internal	External		
Assessment	Nature Reserves, Agriculture (AG), Water Management (WM), Environment and Sustainability (ES)	Local communities	• Identify full range of stakeholders, knowledge and stake owners • Analyse stakeholders and identify their potential interests and contributions • Ensure enabling conditions and encourage various stake- and knowledge holders to participate • Assess synergies and trade-offs related to restoration projects	• Full identification of stakeholders • Identify stakeholders' interests and needs and their potential impact or support to restoration projects • Empower stakeholders to be engaged effectively • Consider compromises between synergies and tradeoffs among various stakeholders
Planning	Nature Reserves, Agriculture (AG), Water Management (WM), Strategy and Performance (SP), Environment and Sustainability (ES), Financial Planning and Analytics (FPA), Operations, Hotels and Resorts – Planning & Guidelines Development (HRPGD), Destination Development (DD), Culture – Sector Planning (C-SP), Breeding and Reintroduction (CBR)	Local communities	• Build relations with stakeholders • Establish enabling environment and align restoration objectives with local needs and aspirations • Identify capacity development needs and required programmes • Develop deep understanding of social-economic and inter-intra stakeholder dynamics • Develop partnerships with various stakeholder, rights and knowledge holders • Develop consensus agreements with shared vision for restoration projects • Develop restoration plans by adopting various sources of knowledge, including scientific, traditional and local • Consider a variety stakeholder values and issues and develop long-term stakeholder engagement strategies • Work closely with stakeholders to avoid and mitigate conflicts between restoration objective and cultural values • Develop inclusive agreements outlining roles and responsibilities of stakeholders • Develop data collection and processing policies respecting rights of stakeholders and ensure FPIC • Develop and adopt participatory stakeholder engagement mechanisms • Invest in awareness raising, capacity development to foster long-term behavioral change	• Form governance structure engaging key stakeholders and develop communication means reach all stakeholders • Developed shared and consensus objectives through participatory approaches • Developed stakeholders capacity to ensure their meaningful engagement • Develop and sign arrangements documenting stakeholders' agreements • Engage stakeholders and various types of knowledge to develop restoration project plans • Conduct meetings with stakeholders on a regular basis and enable shared decision making process
Implementa-tion	Nature Reserves, Agriculture (AG), Water Management (WM), Environment and Sustainability (ES), Breeding and Reintroduction (CBR)	Local communities, private vendors	• Develop monetary and non-monetary incentives and opportunities • Develop required enabling environment and effective communication to ensure active engagement • Address disputes promptly using mechanisms developed during the planning phase • Adopt effective practices for stakeholder, knowledge, and right holders' engagement • Respect FPIC while collecting and processing data provided by stakeholders • Integrate knowledge, including local and traditional knowledge during restoration	• Develop incentive and economic opportunity schemes to address social-economic aspects and support stakeholders' engagement and support • Develop stakeholders' capacities for active and meaningful engagement • Conduct periodic meetings with stakeholders and adopt transparent approaches • Utilise governance structure and mechanism; boards, committees, to continue effective engagement of stakeholders • Respect and adopt local and traditional knowledge practices to improve technical interventions

			• Ensure balanced implementation of technical activities and consideration of social-economic aspects	
Ongoing manage- ment	Nature Reserves, Agriculture (AG), Water Management (WM), Environment and Sustainability (ES)	Local communities	• Develop participatory and inclusive management plan involving stakeholders, knowledge and stake owners • Develop innovative customised management plans integrating various knowledge and expertise • Ensure wide participation of stakeholders including marginalised communities and community groups • Adopt adaptive management plans, review and modify as required • Revisit restoration projects governance and ensure the implementation of agreements • Ensure protection of restoration sites • Foster stewardship programmes to ensure long term sustainability	• Build on the developed governance structure to engage stakeholders in the ongoing management activities • Integrate local and traditional knowledge to develop accepted and appreciated innovative, customised and adaptive management plans • Engage wide range of stakeholders in the management plans • Support awareness raising and knowledge sharing to developed broad and meaningful stakeholder engagement and stewardship
Monitoring and Evaluation		Local communities	• Invest in stakeholders' involvement and support to monitoring, evaluation, and adaptive management • Develop citizen science approaches to facilitate stakeholder engagement in monitoring and evaluation efforts • Ensure FPIC process while collecting and processing data from local communities	• Develop inclusive and transparent to support stakeholder engagement in monitoring and evaluation activities • Ensure FPIC during data collection and analysis

10.1.1.CAPACITY BUILDING PROGRAMME FOR IMPROVED GOVERNANCE

From a governance perspective, stakeholder engagement will also require capacity development with stakeholders. Targeted development starts with a capacity assessment to assess the desired competences compared to existing capacities in order to inform the formulation of a capacity development process (UNDP, 2008). Capacity development interventions aim to strategically strengthen individual and organizational competencies.

The capacity development programme should consider functional and technical capacities and operate at all dimensions: individual, organization and enabling environment (figure 10.1). The approach for designing and implementing capacity development programme varies between internal and external stakeholders. Therefore, it is essential to ensure that the capacity development programme enables:

- Smooth, productive and sustainable collaboration within and between internal and external stakeholders
- Stronger local expertise in ecosystem restoration and related fields
- Strong local governance prioritizing equity between all stakeholder groups, especially underrepresented groups

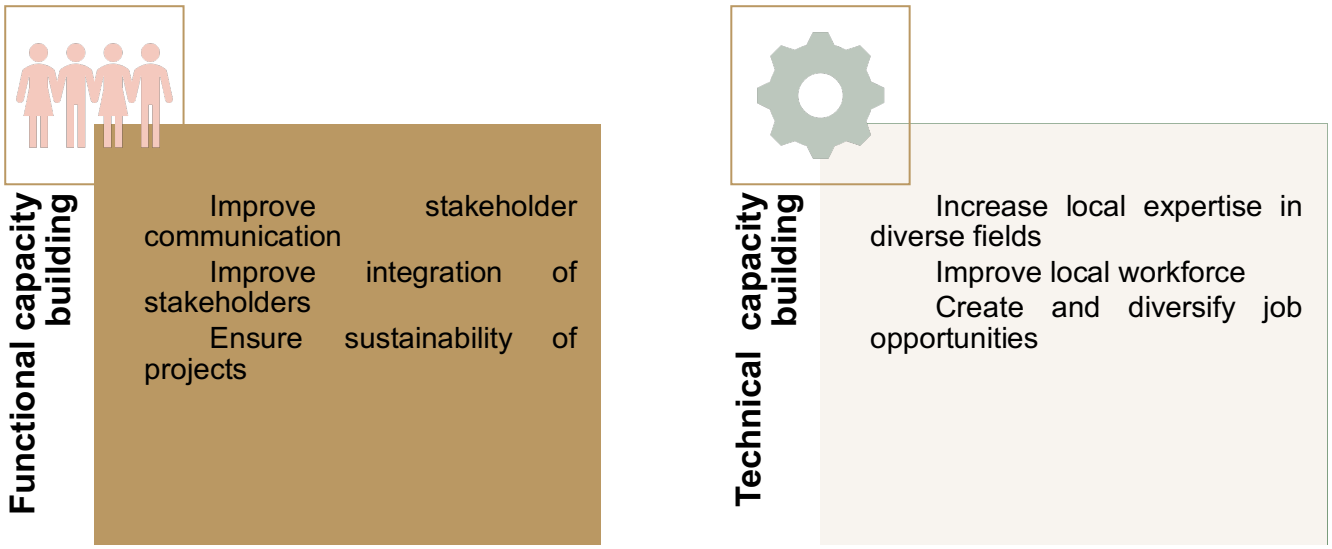


Figure 10.1- Functional and technical capacity building.

Figure 10.2 outlines the steps for developing and implementing a comprehensive capacity building programme. It is important to note that for post-implementation

evaluation of capacity-building programs to be meaningful, it will be important to collect baseline data regarding each of the parameters to be measured.

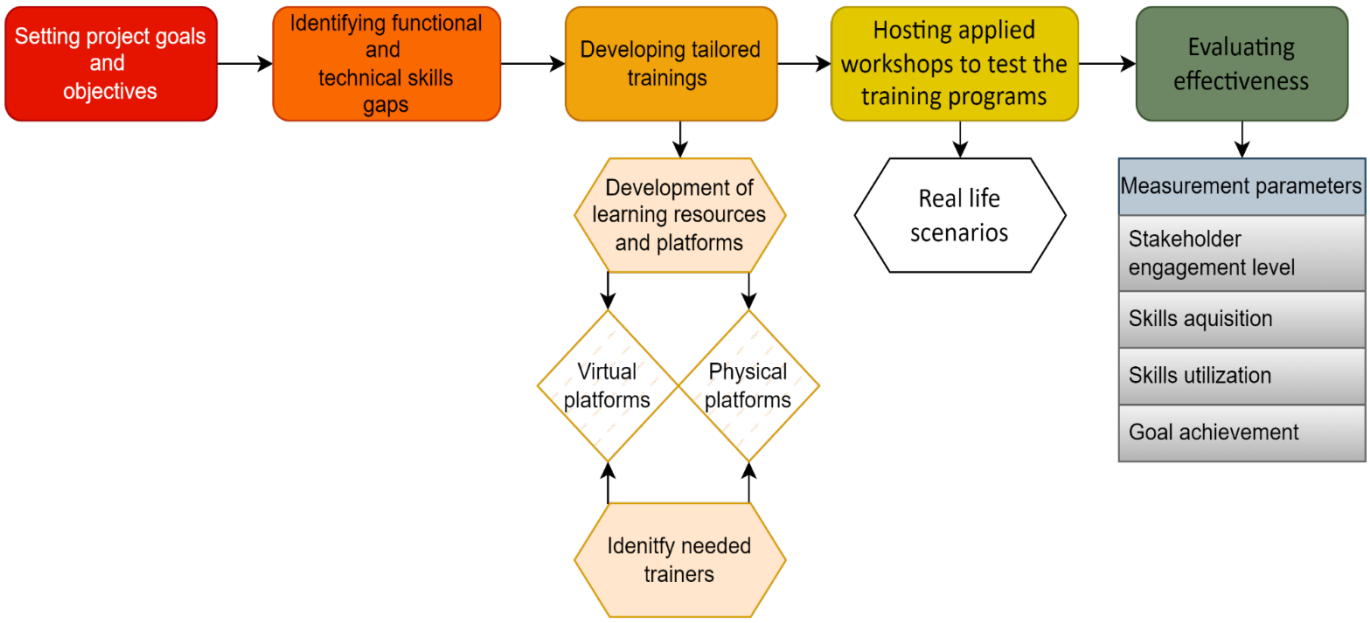


Figure 10.2- Steps for developing and implementing a capacity building programme.

Stakeholder engagement includes both internal and external stakeholders and requires associated capacity building to support a higher degree of competencies among stakeholders. In development of the Strategy for Ecosystem Restoration, a small number of stakeholder meetings were held, but the level of stakeholder engagement completed to date is not sufficient either to ensure representative input or to create social license to operate (SLO). RCU will undertake significant additional stakeholder engagement, including extensive capacity building, to create the enabling conditions for meaningful and participatory stakeholder engagement in the development and delivery of the strategy. The Ecosystem Restoration Action Plan chapter includes numerous recommendations to support these efforts. Table 10.3 summarizes key capacity building by pillar, divided into technical and functional capacity building.

Table 10.3- Capacity building recommendations by pillar.

Pillar	Technical capacity building to consider	Functional capacity building to consider
Pillar 1 Standards-based ecosystem restoration implemented locally with a global impact	• Natural resource management • Ecosystem restoration (e.g., planting, seed collection, ground truthing) • Native plant materials	• Internal-external stakeholder communication • Project management • Protected Area management

	• Seed management • Monitoring	
Pillar 2 Planning, design, monitoring, and evaluation	• Nature resource management • Ecosystem restoration • Native plant materials • Seed management • Monitoring • Water harvesting • Research design and implementation	• Strategic restoration planning • Project management • Volunteer coordination • Community and stakeholder engagement • Youth and gender integration
Pillar 3 Community participation and capacity building at the core of restoration	• Agroecology • Natural resource management • Ecosystem restoration • Native plant material • Seed management	• Internal-external stakeholder communication • Project management • Protected Area management • Youth and gender integration
Pillar 4 Partnerships for restoration success	• Communications and public relations delivery • National/international policy • Conference planning and delivery	• Strategic partnership development and management • Project management • Internal-external stakeholder communication • Intradepartmental communication and coordination • Strategic communications

10.2. FUNDING MODEL

The global conservation and restoration funding gap is due to a wide variety of factors, including ongoing challenges related to the valuation of nature and of services and products derived from nature. Chapter 4 “Valuation of Ecosystem Services” will be critical to supporting a sustainable funding model for ecosystem restoration. But restoration investment should not be reliant on creating economic valuations for nature. Other factors include but are not limited to the lengthy time horizons for restoration success (and the associated incompatibility with the often short time

horizons that many investors operate within), the risk of failure for restoration projects, and the voluntary nature of most restoration interventions.

Sustainable funding for restoration and associated activities typically changes over time. For example, government funding is often the earliest source of funding, when risks are highest, while private funding tends to be more viable at later phases of a project, when risks are lower and the potential for investment returns might increase. Utilizing a diversity of funding sources can help reduce risk and increase long-term funding stability by limiting reliance on any one individual funding source.

Conservation and restoration funding comes from a variety of sources, as illustrated in Figure 10.3 (Deutz et al., 2020). Not all funding sources are appropriate or available for all types of restoration projects. For example, some global funding sources are limited only to low-income countries or entities within those countries, while other funding sources are dependent on having products to sell (e.g., carbon or biodiversity credits) which many restoration projects do not produce.

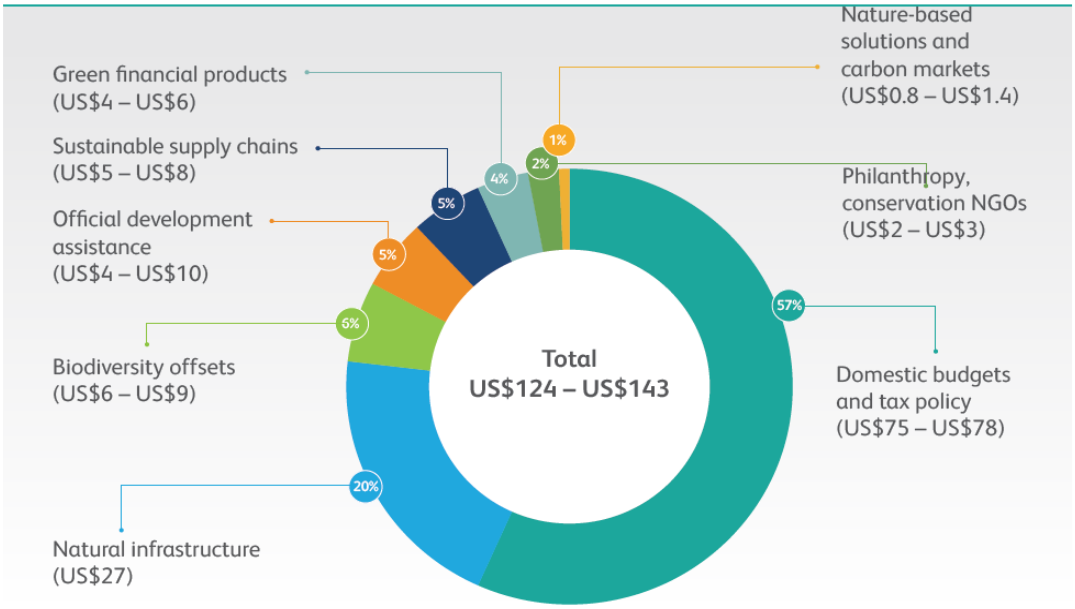


Figure 10.3- Global biodiversity conservation financing in 2019.

Table 10.4 provides a listing of prospective types of funding for the strategy, whether that funding is public or private, a description, and the pillars for which that funding is most likely to be applicable. It is important to note that this is not exhaustive, and depending on the specific funding, it may be applicable to different pillars than listed here.

Table 10.4- Prospective funding types for the Strategy.

Funding Type	Source	Description	Relevant pillars
Direct governmental funding	Public	Current funding is dependent on direct funding from the government for RCU or other similar agencies. Direct funding is subject to shifting governmental priorities. Please note that different direct government funding may be relevant to different pillars (e.g., funding from government research entities would be relevant for P2 long-term monitoring and research, funding from economic and social development entities might be relevant for P3).	P1-P4 All phases will require direct government funding at start up.
Alternative governmental funding	Public	Alternative governmental funding for restoration can include, for example, proceeds from lotteries and municipal bonds. (In some states in the USA, for example, lottery proceeds are a primary source of funding for restoration.)	P1-P4
Resource extraction impact fees	Private (industry)	Resource extraction and development impact fees can be used to create funding sources for ecosystem restoration and community development. For example, a percent of proceeds from the sale of extracted resources can be used to build a restoration fund in KSA. This fund can be additive to any mandatory mitigation and offsets that the industry is obligated to perform. (The underpinning assumption of ecological restoration, for example, is that restoration should not ever be used as a justification for degradation (Gann et al., 2019). As such, compensatory mitigation should be obligatory, whereas impact fees could be used to pay for non-obligatory restoration).	P1-4
Eco-tourism/nature-derived product impact fees	Private (individual)	The “consumers” of ecotourism and of local handicrafts/nature-derived products can be charged a fee or tax to generate additional funds to support these programmes. If nature-based products are developed and exported, a tax or fee could also be associated with those products to further support the economic development or ecosystem programmes associated with the programme. Such impact fees would be charged to tourists/visitors; local community members should be explicitly excluded from paying such fees/taxes.	P3
Green investment	Private, including corporate	Green investments can include a wide variety of tools and mechanisms, including government issued bonds, green stocks, solar bonds, and corporate sponsorship. In some instances, green investments (e.g,. pension fund investments) would require repaying the investment and providing a return on investment. Because the Strategy is not designed to create a financial return, opportunities for green investment may be limited and should be carefully considered to prevent the creation of perverse incentives.	P1, P3, P4
Carbon, biodiversity, environmental, or renewable energy credits/offsets markets	Private and possibly public	The carbon market is relatively advanced but has experienced numerous challenges; biodiversity and environmental credit markets are rapidly emerging. It is imperative to avoid the creation of any perverse incentives in association with funding tied to credit-based markets. Renewable energy credits are not necessarily a source of capital but help reinforce the demand for sustainable investing.	P1, P2
Micro-loans	Private and possibly public	Small loans for businesses that need a non-traditional way to get funding. This is a valued option for entrepreneurs from underrepresented communities. These could be highly relevant, especially for creating women-led initiatives (e.g., handicrafts, nature-derived products) in the local communities adjacent to the reserves. A micro-loan program could be set up by RCU or by a private investor. Micro-loans would be intended to not only be paid back, but to provide a small return on investment. The sustainable finance consultant can provide more details on whether or not this is a viable option for RCU.	P3
Philanthropic giving	Private	Private philanthropy may not be a highly viable approach for RCU/AlUla County, but it should be included as an option, especially for community capacity building.	P3

10.2.1.CONSIDERATIONS FOR FUNDING KPIS

Final KPIs should be determined in conjunction with the finance consultant who will help develop the finance plan. These KPIs should be tied to the specific approaches that the plan will follow. Assuming that the baseline/current funding scenario for RCU is 100% governmental, some sample KPIs that RCU may consider and discuss with potential sustainable funding consultants include:

2030
At least three new funding mechanisms in place and providing ecosystem restoration or community development funds for the Strategy
10% of ecosystem restoration programme expenses financed through non-governmental mechanisms
20% of eco-tourism/community development programme expenses generated through non-governmental mechanisms
2035
At least five funding mechanisms in place and providing ecosystem restoration or community development funds for the Strategy
20% of ecosystem restoration programme expenses financed through non-governmental mechanisms
35% of eco-tourism/community development programme expenses generated through non-governmental mechanisms

10.3. CONCLUSION

It is critical to consider the risks of failure of restoration strategies and projects, especially when funding is limited. The next section will assess the main risks considerations and propose mitigation measures to minimize risk of losing funding for restoration.

11. RISKS AND MITIGATION

Ecosystem restoration is inherently uncertain for a wide variety of reasons. Most significantly, ecosystems are dynamic, and they do not always react to restoration interventions in the expected manner. This uncertainty means that it is not uncommon for restoration projects to fail, for a wide variety of reasons. Reasons for failure can include, e.g., poor project design; good project design, but poor implementation (implementation inconsistent with approved project plan); low quality plant materials or unsuitable species; poor timing of restoration activities during the implementation phase; extreme weather (e.g., unexpected or extreme heat, cold, drought, or rain). Arid lands restoration is uniquely challenging, which only increases the levels of uncertainty. Specific challenges in arid lands restoration relate not only to limited water availability, but soils often have limited nutrients, organic matter, and water-holding capacity and the microclimates can be extremely harsh with very high temperatures as well as very low temperatures. Revegetation, in particular, is extremely challenging in arid land ecosystems, but it is also a priority for RCU. Planting drought tolerant native plants and carefully planning restoration to align with water availability is one tool for mitigating the risk of project failure due to water limitations.

Standards-based restoration is an important tool for reducing risk and increasing the likelihood of success, as it helps control and reduce the number of risk factors (e.g., standards-based project design and implementation will mitigate against poor project design and ideally also against poor implementation). While standards-based restoration cannot ever address the dynamic nature of ecosystems, nor can it predict how ecosystems will respond to restoration interventions, it can reduce risk and uncertainty by addressing controllable factors. Stakeholder engagement is an excellent example. Projects implemented without strong stakeholder engagement are more likely to fail than projects implemented with robust stakeholder engagement, especially participatory stakeholder engagement. According to the SER Standards, “Stakeholders can make or break a project. Recognizing the expectations and interests of stakeholders and directly involving them is key to ensuring that both nature and society mutually benefit” (Gann et al., 2019).

Given the high level of uncertainty associated with restoration, it’s imperative for RCU to assess uncertainty and risk and to mitigate to the highest level possible. The first step in an ecological restoration risk management framework developed for the US Department of Energy, for example, is to “identify the levels of uncertainty that are acceptable at the start of the planning process” (Thom and Hofseth 2004). This chapter, therefore, reviews some of the main risks projected for the Strategy for Ecosystem Restoration and provides key mitigation recommendations for those risks.

11.1. MAIN RISKS CONSIDERATIONS AND PROPOSED MITIGATION MEASURES

The implementation of the Strategy for Ecosystem Restoration faces a wide variety of risks. Table 11.1 below provides a risk assessment matrix, beginning with general/overarching risks, and then moving into a sampling of more specific risks that might be associated with each initiative. The Table includes a column articulating the type of risk, followed by an assessment of the level of risk and the impact of the risk, each on a 1-5 scale with 5 being highest. Multiplying the probability by the impact then results in an overall risk assessment for each identified risk. The Table then includes opportunities to mitigate the risks, especially as outlined in the prior chapters of the Strategy. A final modified risk rating is then provided in the final column based on assumptions of reduced risk as a result of the recommended mitigation being applied.

Probability/severity	Overall and residual risk (Cumulative score: Probability/severity)
Very Low=1	Very low: 1-3
Low=2	Low: 4-8
Medium=3	Medium: 9-15
High=4	High: 16-20
Very High=5	Very high: 21-25

Key for Table 11.1

Table 11.1- Risk assessment matrix for the Strategy.

Risk	Type of Risk	Risk Probability	Risk Impact	Overall Risk	Proposed mitigation	Residual Risk
Overarching Risks						
Reliance on satellite data in the development of the proposed *Ecosystem Restoration Action Plan*	Operational/ Strategic	5	5	Very high	Follow *Ecosystem Restoration Action Plan* direction on ground-truthing to confirm spatial analysis; Fully implement Initiative 2.1A on detailed implementation planning which includes validating mapping, restoration interventions, and localities before commencement.	Medium
Limited local stakeholder consultation specifically regarding ecosystem restoration in the development of programme thematic/geographic scopes	Operational/ Strategic/ Communication	4	5	High	Follow proposed stakeholder engagement guidance and prioritise participatory stakeholder engagement throughout the entirety of the strategic restoration plan; Ensure stakeholder engagement across the entirety of AlUla County.	Medium
Legal and policy constraints and impediments related to the nature of some proposed programmes (e.g., CCAs and CMAs in the al Hima/Traditional Knowledge Programme)	Operational/ Legal/Strategic	5	5	Very high	Review proposed programme, including RCU legal department review of legal/legislative components before official approval; Ensure final design facilitates implementation with or without new designations.	Medium
Adequacy of programme technical scopes in relationship to RCU priorities and preferences	Strategic	1	5	Low	RCU to determine alignment with current and future strategies.	Very low
Inability to implement proposed programmes within planned timeframes	Operational/ Strategic	3	4	Medium	Conduct in-depth programme scheduling with key implementation partners; Ensure sufficient buffers between sequentially timed projects.	Medium
Financial limitations related to availability of funds for programme implementation and resources for ensuring program sustainability	Economic	3	4	Medium	Align timing and programme selection with available budget; Develop and implement recommended sustainable finance plan; Conduct full costings/budgeting process for prioritised programmes prior to determining which programs to implement; Conduct formal Cost-Benefit Analyses as needed, including external ecological and social costs/benefits.	Low
Stakeholder buy-in especially in regard to local communities and other right-holders or resources users.	Governance	5	5	Very high	Undertake pre-programme consultation with core stakeholders before project begin and actively incorporate input into all aspects of the Strategy; Implement the many stakeholder and economic development programmes proposed in order to build social license to operate.	Medium
Overlap with other existing or planned programmes and initiatives by RCU, its partners, or other interest groups from the private or civic sectors	Communication	2	3	Low	Internally, ensure adequate intradepartmental knowledge sharing and project implementation (e.g., produce monthly or quarterly RCU-wide posts with timelines and opportunities for interdepartmental collaboration; Externally, undertake an RCU partners' dialogue and communication upon project start up.	Very low
Limitations related to technical and administrative capacities for programme implementation, including staff turnover	Operational	3	4	Medium	Utilise governance guidance and internal RCU capacity building, along with sequential timing as capacity increases, to ensure adequate capabilities in terms of internal and external knowledge and skills upon programme approval; Ensure high quality record keeping and organizational standard operating procedures so new staff can effectively continue previously developed work.	Low

Table 11.2 Risk assessment matrix for the Strategy. 2

Risk	Type of Risk	Risk Probability	Risk Impact	Overall Risk	Proposed mitigation	Residual Risk
Sample Initiative-specific Risks						
Initiative 1.1 and 1.2 (Phases 1&2 of restoration plan implementation)						
Extreme weather: restoration interventions	Ecological	5	5	Very high	Modify plans and timelines to avoid extreme heat or flood events; Align outplanting and seeding projects with projected water availability; Be prepared to modify timing for certain plantings; Use shade coverings to mitigate heat.	High
Extreme weather: labor	Social-cultural	5	5	Very high	Modify plans and timelines (including modifying work hours or postponing work) to avoid extreme heat (including unsafe heat index) and sun exposure; Conduct a safety session at start of each work day to inform labor force and agree on work conduct for the day; Implement an annual Heat Stress Policy for all outdoor workers and ensure all staff/labor are informed; Train crew leaders in first aid; Provide basic heat- and sun-related personal protective equipment (PPE) for workforce.	Medium
Inappropriate timing of restoration interventions	Ecological	2	5	Medium	Follow proposed restoration plan guidance and timing.	Low
Inappropriate species and stocktypes	Ecological	2	5	Medium	Follow proposed restoration plan guidance, including carefully timed advance planning to ensure seedlings of appropriate species and stocktypes are available and ready for planting on schedule (follow SER native seed standards).	Low
Outplanting survival	Ecological	5	5	Very high	Align with projected water availability and during the recommended outplanting window only; Effective hardening off of plants to increase likelihood of survival; Plant quality seedlings; Choose suitable species for area and project; Follow recommended monitoring and apply immediate adaptive management to support outplanting survival.	High
Direct seeding survival (seed predation, germination, competition)	Ecological	5	5	Very high	Align seeding with projected water availability; Sow seeds into the ground rather than scattering on top of the ground and in appropriate structures to improve water holding capacity; Apply proven, species-relevant seed treatments; Choose suitable species for area and project.	Medium
Herbivory by native wildlife	Ecological	2	3	Low	Native wildlife populations remain low, but as they grow, this will be an increasing risk. Exclude all large herbivores until vegetation is well established and can support grazing by native wildlife without depletion (including tree guards).	Low
Herbivory by legal domestic livestock	Ecological	3	4	Medium	Exclude domestic livestock until vegetation is well established (conduct extensive stakeholder engagement to secure support for closures); Use tree guards/exclosures as needed; Adopt traditional knowledge or al Hima grazing approaches after vegetation has recovered; Patrol to ensure compliance with permits/legal approaches; Follow recommended monitoring and apply immediate adaptive management to support vegetation survival.	Low
Herbivory by illegal grazing (external herds entering protected areas)	Ecological/ Legal	5	5	Very high	Exclude domestic livestock until vegetation is well established; Patrol reserves for compliance with exclusions; Increase consequences for illegal grazing; increase local, controlled (e.g., al Hima or traditional knowledge) grazing approaches so that local communities also act as security against illegal grazing; Increase law enforcement and consequences for violations; Follow recommended monitoring and apply immediate adaptive management to support vegetation survival.	Medium
Limited water availability	Ecological	5	5	Very high	Plant drought tolerant native species; Align planting with projected water availability; Use temporary shade structures for outplantings.	High
Limited irrigation availability	Ecological	3	4	Medium	Plan irrigation based on water availability and assurances against groundwater loss; Plant drought tolerant native species; Align planting with projected water availability.	Low
Groundwater depletion due to irrigation	Ecological	4	5	High	Limit irrigation needs, carefully align irrigation and irrigation amounts with available groundwater supply in a manner that prevents collateral damage; Plant drought tolerant native species; Align planting with projected water availability.	Low
Vegetation targets achieved only by unpalatable species, limiting wildlife recovery and reoccupation of the area	Ecological	3	5	Medium	Monitor for diversity of vegetation recovery and adaptively manage to ensure palatable species are present at the necessary levels to support target wildlife	Low
Domestic grazing is excluded as a restoration intervention	Ecological/ Strategic/ Social-Cultural	5	4	High	After effective vegetation recovery, controlled grazing has the potential to be an important tool for continued ecosystem management and community engagement but may not be legally allowed depending on the nature reserve. RCU should use the al Hima and Traditional Knowledge programmes to test carefully controlled grazing as a restoration intervention. If and as positive lessons are learned, RCU should consider increasing the acreage available for controlled community-led livestock grazing as a restoration tool.	Low
Additional local community use (recreational (e.g., off-road vehicle use) and extractive, e.g., plant collection, wood cutting)	Social-cultural/ Strategic/ Operational	5	5	Very high	Extensive stakeholder engagement to understand community needs and mitigate to accommodate communities in a sustainable and restoration/local traditional use manner, to the highest extent possible; Enforcement as needed.	Medium
Initiative 2.1: Planning and design for implementation						
Limited (to date) field investigation in the development of the proposed *Ecosystem Restoration Action Plan*.	Operational	5	5	Very high	A specific initiative is included to mitigate this risk by validating mapping,restoration interventions, and localities before endorsement/ commencement.	Low
Knowledge-base of contractor regarding standards-based restoration and applying it to detailed implementation plan.	Operational/ Ecological	4	5	High	RCU should hire CERP or CERP-equivalent contractors with a demonstrated understanding and expertise at developing and applying standards-based restoration; Conduct education with hired contractors about rationale for and importance of following the standards; Incorporate additional checks/confirmations of compliance with expected standards into the contract.	Low
Initiative 2.2: Research and development	*Initiatives are all pre-existing RCU initiatives, thus no new risk assessment included here*					
Initiative 2.3: Data management and monitoring						
Database that doesn't meet privacy/data security standards	Operational/ Governance	1	5	Low	Ensure database developer follows KSA and global data security guidance with adequate external backups.	Very low
Database isn't aligned with regional and global restoration reporting guidance	Operational	3	3	Medium	Work with RCU IT department to design database to be consistent and aligned with the FAO Framework for Ecosystem Restoration Monitoring (FERM) database (the FERM is the Global Biodiversity Framework and UN Decade on Ecosystem Restoration reporting mechanism) and with the Restoration Project Information Sharing Framework; Consider creating an interoperational database with the FAO FERM.	Low
Lack of baseline data collection	Operational	3	5	Medium	Failure to collect baseline data makes monitoring and demonstration of effectiveness extremely difficult. Prioritise appropriate baseline data collection as outlined in the *Ecosystems Strategic Guidelines and Principles* chapter; Use the ecological recovery and social benefits wheels from the SER International Principles and Standards to document ecological and social-cultural conditions prior to implementing restoration interventions.	Very low
Proper planning for monitoring frequency, seasonality, and post-intervention follow up	Operational/ Strategic	3	5	Medium	Develop monitoring plans as outlined in the *Ecosystems Strategic Guidelines and Principles* chapter of the Strategy, including starting monitoring planning at the start of the restoration process to assess effectiveness and apply adaptive management as needed. Design monitoring to answer specific questions related to implementation, effectiveness, and impact as outlined in the *Ecosystems Strategic Guidelines and Principles* chapter. Use the ecological recovery and social benefits wheels from the SER International Principles and Standards as well as the UN Decade Standards as a starting point for identifying monitoring priorities.	Very low

Risk	Type of Risk	Risk Probability	Risk Impact	Overall Risk	Proposed mitigation	Residual Risk
Funding for monitoring	Operational/ Strategic/ Economic	3	5	Medium	RCU should ensure that all budgets include dedicated funding for ecological and social-cultural monitoring at all stages of the project, including post-intervention follow up monitoring. Budgets should also include funding to address/design adaptive management interventions when monitoring determines the need for modifications to the restoration plan.	Very low
Initiative 3.1: Local capacity building for restoration						
Training opportunities trail behind local community engagement needs	Operational/ Strategic/ Social-Cultural	3	4	Medium	RCU should prioritise development of and communication about the Restoration Training Academy (RTA) as early as possible to ensure timely capacity building.	Medium
Participation by local community members in RTA courses does not meet expectations (therefore too few trained/qualified local community members)	Operational/ Strategic/ Social-Cultural	4	5	High	RCU should prioritise communication with local stakeholders about opportunities at the Restoration Training Academy (RTA); Courses should be provided for free for local community members and courses should be physically brought to local communities to reduce financial burdens from travel; Successful completion of courses should result in participants earning certificates from the RTA; Some course development and offerings should be sequential and based on successful completion of prior courses; RCU should highlight hiring opportunities (and people hired) as a result of successful completion of courses.	Medium
Too few students successfully complete courses (therefore too few trained local community members)	Operational/ Strategic/ Social-Cultural	4	4	High	Ensure courses are designed to meet students "where they are" and to provide introductory and foundational knowledge needed for them to succeed; Design courses to be short enough or spread out enough to not interfere with other work obligations that students may have.	Low
Participation by women in the RTA does not meet expectations	Operational/ Strategic/ Social-Cultural/ Economic	4	4	High	See mitigation immediately above. In addition, provide childcare for females who are caring for their children; Offer women-only classes as needed; Additional incentives, including monetary incentives, should be provided to reach the target number of women trainees.	Medium
Men may oppose women's participation in courses and in restoration and associated activities other than traditionally recognised women's activities (e.g., handicrafts)	Operational/ Strategic/ Social-Cultural/ Economic	4	4	High	Create opportunities for women's participation to support family financial stability; Consider financial compensation for women who participate in courses; Engage local community and religious leaders to emphasise the value of women being educated and working to restore AlUla County.	Medium
Initiative 3.2: Elevate community-based ecosystem restoration and sustainable land management						
Limited political support for designating Community Conserved or Co-Managed Protected Areas, both from government and from the local community; challenges with legal designations	Strategic/Social/Cultural	4	4	High	Ensure co-design with selected communities and choose pilots with high community interest and capacity to implement traditional approaches; Inform and engage internal RCU stakeholders about the opportunities to test new approaches through this initiative; Work with RCU legal to secure land designations as needed; If land designations are not viable, provide other secure tenure to local community members to facilitate their engagement.	Medium
Limited local expertise within specific communities to apply traditional knowledge or Al Hima practices	Operational	4	4	High	Ensure selected community representatives are trained through the RTA; Engage local elders who may have more knowledge experience from past practices as role models/leaders; Offer training courses through the RTA; Assess effectiveness and community engagement and adapt as needed.	
Initiative 4.1: RCU Capacity Building						
RCU fails to invest in intradepartmental capacity building regarding restoration and the broad suite of beneficial outcomes from restoration interventions across all of RCU objectives	Operational/ Strategic/ Governance	3	4	Medium	Coordinate topically dedicated intradepartmental meetings (e.g., eco-tourism benefits from restoration, and opportunities for RTA ecotourism training courses) to increase knowledge and awareness about the intersectionality of restoration with other departmental priorities. Ensure adequate intradepartmental knowledge sharing and project implementation (e.g., partner with Agriculture department about potential for carefully controlled grazing as a restoration tool (post-vegetation recovery; partner with Economic and Social Development Department regarding implementation of the RTA and the Native plant materials for restoration programmes).	Medium
Misaligned timing between *Ecosystem Restoration Action Plan* implementation and priorities of other RCU departments	Operational/ Strategic/ Governance	4	5	High	Coordinate between RCU departments to identify synergies and potential challenges and to address the timing challenges as best as possible; Produce monthly or quarterly RCU-wide or social media posts with information about upcoming interventions in certain areas across the Protected Areas.	Medium
Initiative 4.2: Partner with local, national, and international stakeholders						
Challenges associated with creating common agreement among varied partners related to objectives, outputs, etc.	Strategic	4	4	High	Engage a facilitator with strong expertise in creating consensus among varied stakeholders and varied interests (e.g., private v public sector, community v private sector); Create a clear "decision context" tied to the Strategy, as the foundation underlying partnerships and collaborations; Design partnerships and outcomes to benefit all partners and to create as level a playing field as possible between prospective partners.	Low
Limited capacity (financial, time, knowledge) of prospective partners to engage in partnerships with RCU.	Operational	3	4	High	Provide capacity support for prospective partners (e.g., financial incentives, training for local community members/NGOs; clearly outline beneficial outcomes of participation); Plan partnership activities to be as low impact from a time commitment perspective as viable, unless participation is financially compensated.	Low
Lack of interest in participating in partnerships with prospective partners (especially local community members)	Strategic	2	4	Medium	Engage community leaders to act as spokespeople to build community support; Engage with local schools and community centers to create interest and buy in with teachers and students, and through those connections to build support from local families; Host community hikes/field learning sessions to build interest and support in the work.	Very low
Initiative 4.3: Promote the results of the strategy						
Incoherent end messages promoting results of the strategy	Strategic	3	3	Medium	Develop a dissemination strategy targeting local, national and regional groups.	Low
Lack of interest from stakeholders in different fields	Strategic	3	3	Medium	Identify linkages between different targeted sectors and ecosystem restoration; Highlight the ecological, social and economic impacts when promoting results; Identify target audiences and utilise the communication tools that those priority audience use (especially regarding social media); Feature real successes with real local participants as spokespeople.	Very low
Length of time (e.g., long time periods) to achieve intended results limits communication opportunities	Operational/ Strategic	4	4	High	Plan interventions in a manner that will secure preliminary results that are illustrative and can be well-promoted; Utilise previous examples from other projects where they are analogous, especially for video/photo oriented communications; Collect before, during, and after photos to create strong documentation of beneficial impact of successful restoration, including aerial photography (create permanent photo points for long-term data collection, with permanent comparable markers).	Low
Limited ability of priority partners to participate in promotional events (e.g., funding to attend conferences)	Operational	3	3	Medium	Incorporate funding for partner travel to conferences and events into overall budget, or into specific contract budgets with partners (e.g., if university students are participating as researchers on a project, include funding for them to participate in national and global conferences).	Very low

11.2. LIMITATIONS OF THE MODELLING OUTPUTS AND FUTURE RECOMMENDATIONS

This study developed a model for a large-scale prioritization of sites for ecological restoration interventions based on data products generated by previous projects commissioned by RCU. Primary data collection and the verification of data quality of the products provided were not included in the terms of reference of this consultancy. Thus, this model used data products that have different resolutions, levels of accuracy, and objectives. While this work endeavored to address these limitations when reviewing and analysing these data, the data input used in this modelling exercise inevitably creates limitations to the accuracy of the resulting priority recommendations. Further preprocessing and treatment of high-resolution satellite images would contribute to refining the selection of suitable sites for restoration. Additionally, further data on aspects such as vegetation abundance, diversity and degradation would significantly enhance modelling outputs.

The high priority ecological conditions model provides a tool to prioritise ecological restoration zones in the six Protected Areas. The output from this tool can be enhanced in future work based on the following recommendations:

- Use of high-resolution satellite imagery that includes a near infrared band and that has a temporal resolution within peak of vegetation months (imagery currently available at RCU) to generate high spatial resolution data related to vegetation, e.g., data reflecting vegetation health and vegetation cover. The replacement of the relevant current layers with higher resolution layers will increase the accuracy of the results and will enhance conformity between the initial resolutions of the different layers (e.g., conformity with the soil erosion susceptibility initially provided through the baseline assessment at a 50-cm. resolution)
- Provision of data related to vegetation sampling throughout the reserves (e.g., vegetation data stratification, degradation, density, diversity) that will enhance the identification of the thresholds of the classes adopted for the data layers included in this model. Enhancing the accuracy of the chosen thresholds based on the local conditions extracted from sampling data will better support the identification of targeted 2024 Priority Areas using this model's parameters
- Development of data products related to soil available water capacity, soil compaction and soil rockiness through detailed modeling (e.g., use of covariates to model the distribution of these parameters throughout each reserve)
- Development of water deficit and surplus parameters through a water balance model that uses high resolution data such as for geology, climate, topography, vegetation, and water aquifers profiles. This can improve the localization of sites that have enhanced physical conditions for the survival and resilience of the native plant species to be planted, both now and under future climatic conditions

The analysis of such data would help further reduce risks associated with ecosystem restoration in arid environments, improve chances of success and enhance the efficiency with which RCU can plan and manage restoration initiatives.

In addition to these recommendations for enhancing the model, it's important to note that ground-truthing will help verify and confirm the results of the model. Where those results are not well aligned, ground-truthing data can also be used to improve the model in the future.

11.3. CONCLUSION

All restoration includes inherent risks, from failure to achieve intended results, to collateral damage, to harm to ecological or social communities. It's imperative that RCU mitigate for both ecological and social risks. The tables above outline some key risks, uncertainties, and mitigation approaches. Following standards-based restoration and implementing all recommended components of the Strategy for Ecosystem Restoration are some of the most important tools that RCU can take to reduce risk and uncertainty and increase the likelihood of successful outcomes.

12. CONCLUSION

The Strategy for Ecosystem Restoration was developed to 1) halt and reverse land degradation and natural resources deterioration in AlUla, 2) preserve the natural beauty of AlUla's landscapes and re-establish the rich diversity of plant-life and wildlife and 3) improve through sustainable ecosystems the overall human wellbeing of local communities. The Strategy for Ecosystem Restoration will accelerate and promote progress towards ecosystem restoration in AlUla within a timeframe of two phases: 2025-2030 and 2030-2035.

12.1. KEY OUTCOMES OF THE STRATEGY FOR ECOSYSTEM RESTORATION

12.1.1.STAKEHOLDER ENGAGEMENT

Local communities in AlUla coexisted with nature for thousands of years, during which time they influenced ecological conditions, both positively and negatively; regardless, current ecosystems evolved with human influence. It is important not just to maintain but also nurture a beneficial relationship between nature and local stakeholder communities. The Strategy for Ecosystem Restoration integrates active engagement with stakeholders that is imperative to long-term restoration success. Strategic guidance for broad stakeholder engagement involved:

1- Stakeholder mapping that classified stakeholders into categories based on their influence and interest in the process of ecosystem restoration.
2- Development of a capacity building program acknowledging potential stakeholder roles in restoration projects and creating an enabling environment that embraces and structures various stakeholders' participation in ecological restoration activities that will improve restoration outcomes.

Key challenge: Stakeholder groups in AlUla are numerous and very diverse, and the results of the Strategy for Ecosystem Restoration integrated stakeholder assessment and analysis of a sub-group of internal and external stakeholders. Crucially, a model has been identified that can be scaled up to represent the entirety of stakeholders in AlUla.

12.1.2.IDENTIFICATION OF KEY AREAS FOR RESTORATION FOR 2025-2035

The Strategy for Ecosystem Restoration describes the process of a three-part, sequential spatial analysis, providing maps and results achieved during each sequential phase for each AlUla Protected Area. The model (based on generated data from a thorough baseline assessment) and the priorities identified are intended to serve as the primary framework for restoration in AlUla. The recommended restoration priorities are intentionally aligned with the

SER International Principles and Standards for the Practice of Ecological Restoration (Gann et al. 2019) and the Standards of practice to guide ecosystem restoration: A contribution to the United Nations Decade on Ecosystem Restoration 2021-2030 (Nelson et al. 2024) as well as other relevant national, regional, and global guidance. This guidance has all been built directly into the Ecosystems Strategic Guidelines and Principles that will guide restoration across AlUla. The information in the Strategy for Ecosystem Restoration provides not only a thorough explanation of the methodology behind each stage of the modeling but also presents different combinations of criteria to allow the opportunity to plan the best path forward.

Key challenge: Reference sites are used to inform the development of reference models used to define potential targets for restoration. Reference sites will have to be identified prior to the final selection and implementation of restoration interventions.

12.1.3.SUSTAINABLE DEVELOPMENT AND LOCAL GOVERNANCE

The proposed governance model in incorporates the socio-economic context and takes into consideration the social structure of AlUla and main drivers for society and its diverse groups. The Strategy for Ecosystem Restoration outlines responsibilities and allocations of roles for both internal and external stakeholders across each of the four pillars.

Key challenge: While ecosystem restoration can provide both ecological and human well-being benefits, it is important to quantify the cost of land degradation and its impact on ecosystem services, thus on livelihoods and human well-being. The cost of land degradation will have to be incorporated into the governance model to provide a more sustainable model for economic development.

12.2. IMPLEMENTATION OF THE STRATEGY FOR ECOSYSTEM RESTORATION

The Strategy for Ecosystem Restoration provides a step-by step plan for the implementation of ecosystem restoration in the 2025-2035 timeframe. Considering the key challenges identified, a few key considerations will have to be taken into account and explored to ensure the smooth transition between the planning phase and implementation. Based on the KPIs, the 2035 restoration target will cover 65,000 ha, divided into two phases.

12.2.1.KEY CONSIDERATIONS FOR IMPLEMENTATION OF PHASE 1 (2025-2030)

Phase one will deliver at least 23,500 ha of restoration. To ensure that the first projects implemented are well received by all stakeholders and especially local communities, the areas will be included within preliminary community suggested sites whether inside or outside

the 2024 Priority Areas for GNR, HUBR, HZNR, and KWVG that intersect with Categories 1, 2, and 3, 65% of SNP areas and all 2024 Priority Areas in WNNR that intersect with Categories 1, 2, and 3.

12.2.2.KEY CONSIDERATIONS FOR IMPLEMENTATION OF PHASE 2 (2030-2035)

Phase two will deliver the remaining 41,500 hectares, including all areas outside the preliminary community suggested sites whether inside or outside the 2024 Priority areas for GNR, HUBR, HZNR, and KWVG that intersect with Categories 1, 2, and 3, 35% of SNP areas and all 2024 Priority areas in WNNR that intersect with Categories 1, 2, and 3.

12.2.3.KEY RECOMMENDATIONS FOR THE IMPLEMENTATION OF THE STRATEGY FOR ECOSYSTEM RESTORATION PHASE 1 AND PHASE 2

Ground truthing

Table 7.3 in Chapter 7 provides a far greater number of hectares than the 2035 Target of 65,000 ha to be restored. The determination for where actual restoration will take place will be done through thorough ground truthing and implementing partners will be able to identify the final areas for Phase 1 and Phase 2 from the suggested areas in table 7.3 and maps in figure 7.5. The following ground truthing steps are recommended prior to the selection of project areas:

- Confirm spatial analysis results to on-site conditions.
- Based on existing baseline assessment, finalize a baseline inventory of the project area.
- Identify Target Habitat (Table 7.5).
- Based on the categorization mapping and target habitat, identify specific restoration interventions and planting densities (Tables 7.4, 7.5 and 7.6).
- Develop Terms of Reference for the specific project to be implemented.

The above steps are essential for all projects identified under Pillar 1 and projects 2.1a and 2.1b under Pillar 2 (table 9.1).

Improvement of plant material quality

The quality of the plant material used for restoration projects dictates the survival of plants in the long term, use of natural resources (primarily underground water) and the cost of maintenance post-planting. While water is very scarce in AlUla, it is considered as a limiting factor, and native plant material such as seedlings have to be adapted to harsh conditions such as drought during their production phase at the native nurseries. Native nursery practices will dictate seedling quality and thus its survival post-planting. Nursery practices range from seed management, planning of the growing season (from sowing to planting on site) to fertilization and irrigation management and other crucial daily and periodic practices.

The seedling stages will be taken into account when adjusting each practice throughout the growing season: 1) establishment phase, 2) rapid growth phase and 3) hardening phase.

Scaling-up of community engagement efforts

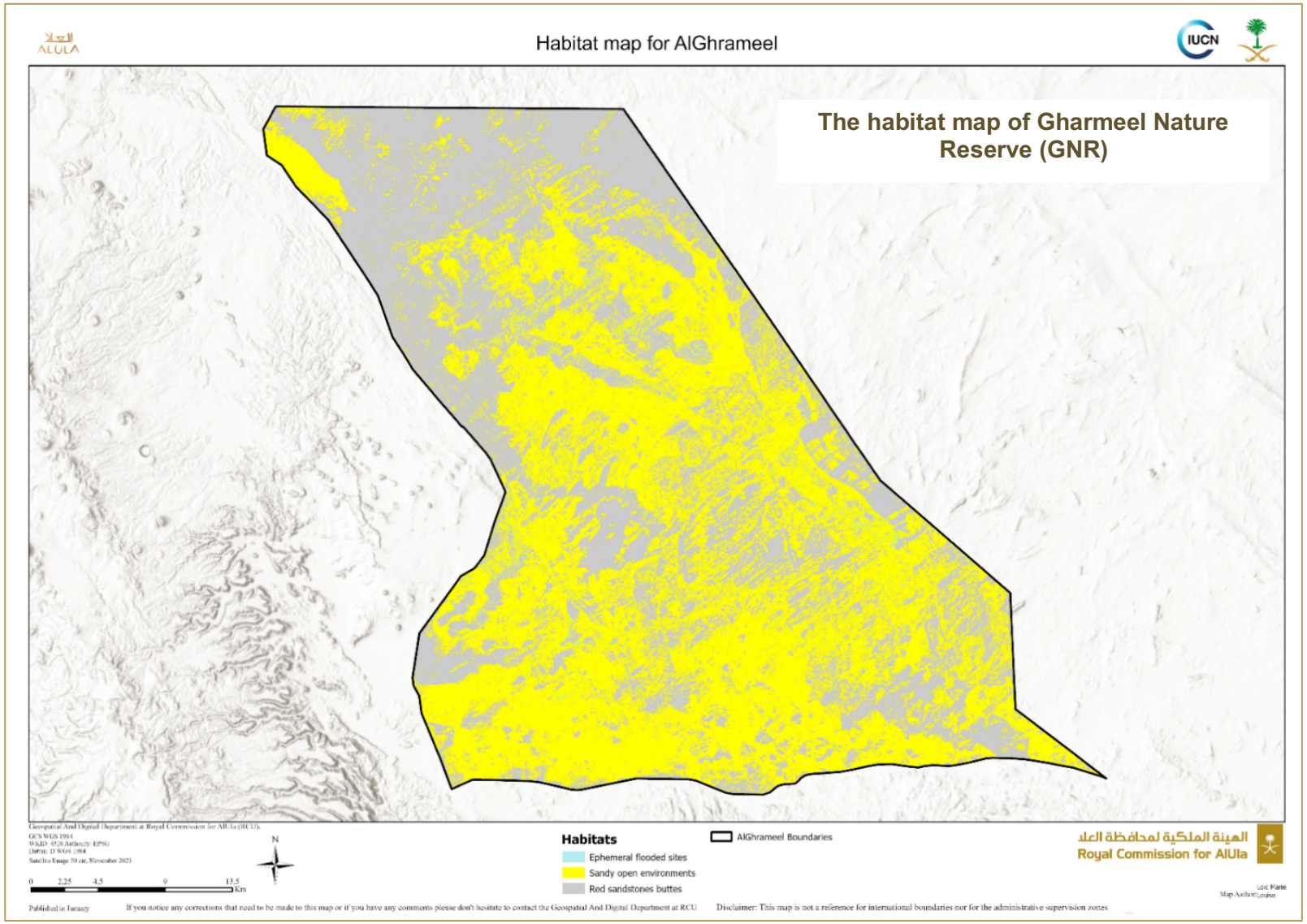
The stakeholder engagement activities and field visits conducted from August 17 to 23, 2024 provided valuable insights into the current ecological, social, and economic conditions across AlUla's nature reserves. They also highlighted the perspectives and needs of local communities concerning proposed ecosystem restoration efforts. Conducted workshops using tools such as interactive maps led to the identification if preliminary community suggested sites for restoration. It is recommended that further stakeholder consultations and workshops be implemented on a wider scale and engaging more stakeholders, especially local communities from the six Protected Areas to identify more community suggested sites. This is important for the sustainability of implemented projects and ensures a functioning local governance model and sustainable economic development in AlUla County.

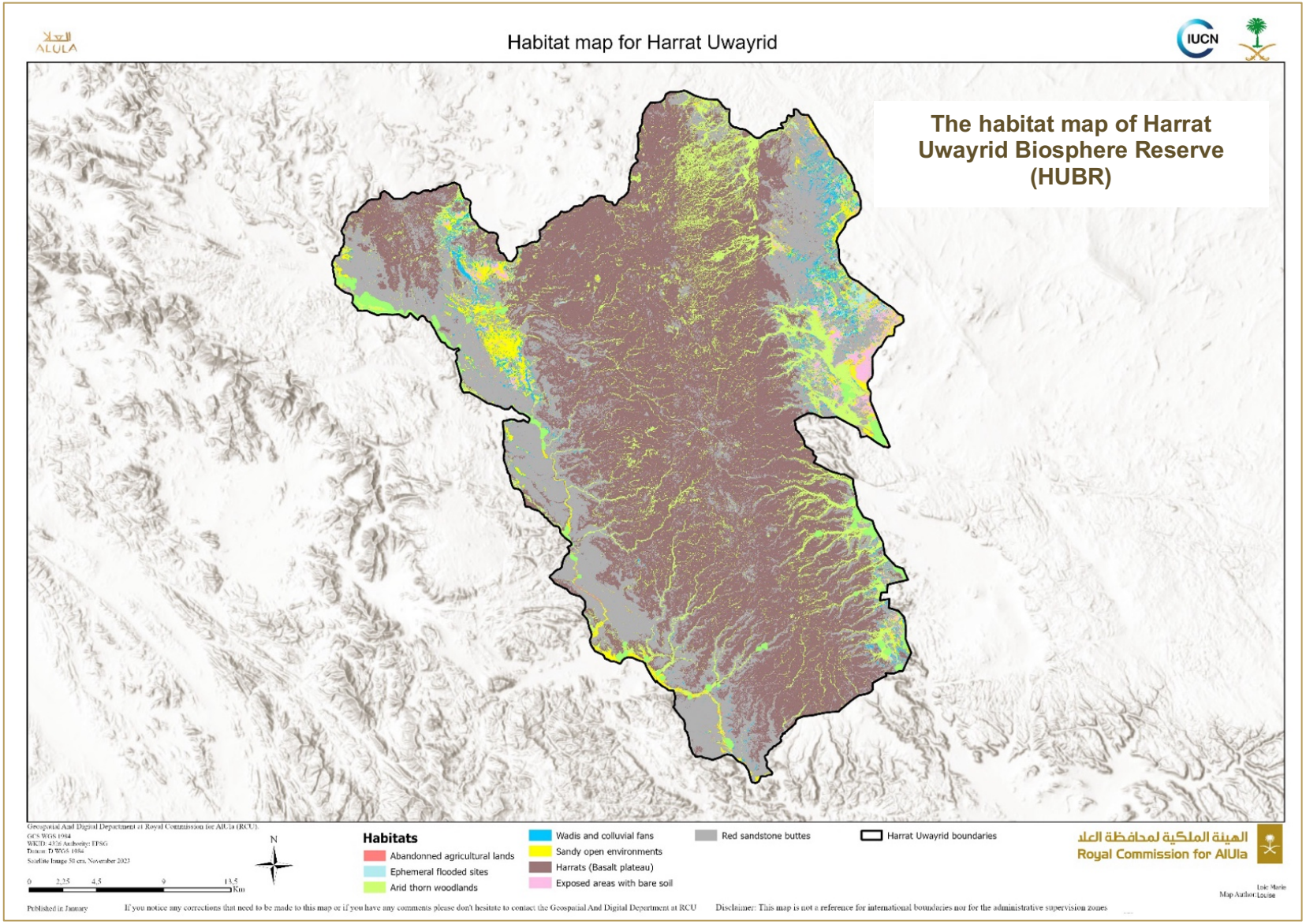
LIST OF REFERENCES

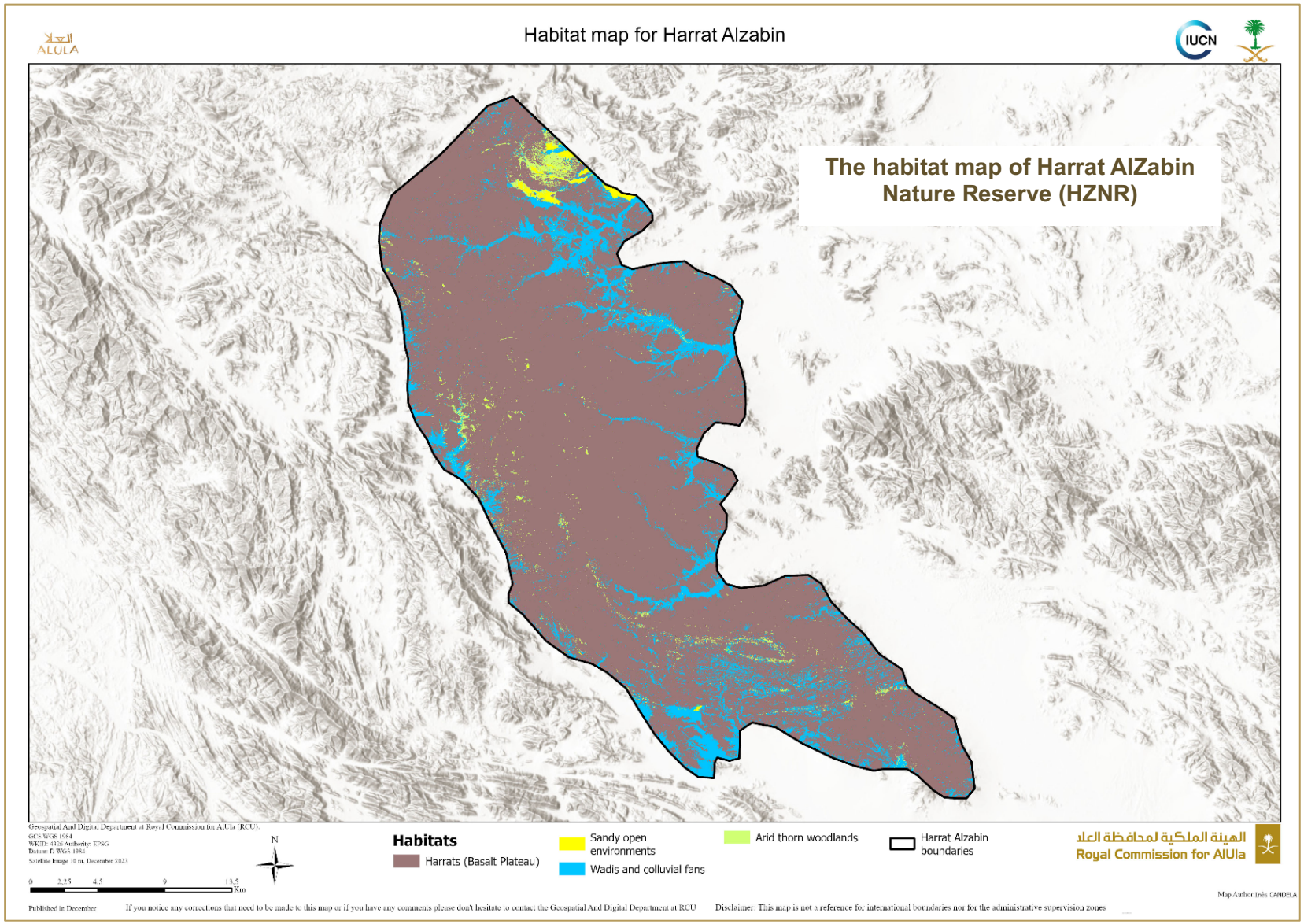
- Coppus, R. 2023. The global distribution of human-induced land degradation and areas at risk. SOLAW21 Technical background report. Rome, FAO. https://doi.org/10.4060/cc2843en
- International Union for Conservation of Nature (IUCN). 2017. Issues Briefs: Drylands and Land Degradation. https://iucn.org/resources/issues-briefs
- United Nations News, 2024. https://news.un.org/en/story/2024/12/1157651#:~:text=Globally%20up%20to%2040%20per,climate%2C%20biodiversity%20and%20people's%20livelihoods
- United Nations. Transforming our world: The 2030 Agenda for Sustainable Development. https://sdgs.un.org/sites/default/files/publications/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf
- Sewell, Annelies, Stefan van der Esch, and Hannah Löwenhardt. 2020. Goals and Commitments for the Restoration Decade: A Global Overview of Countries' Restoration Commitments under the Rio Conventions and Other Pledges. The Hague, Netherlands: PBL Netherlands Environmental Assessment Agency.
- https://www.pbl.nl/en/publications/goals-and-commitments-for-the-restoration-decade (July 8, 2024)
- FAO, (2022), Framework for Ecosystem Restoration Monitoring (FERM): Trinational Atlantic Forest Pact.
- FAO, (2015), Global Guidelines for the Restoration of Degraded Forests and Landscapes in Drylands: Building Resilience and Benefiting Livelihoods.
- FAO, (2023), Guidance on using the Framework Ecosystem Restoration Monitoring (FERM) platform and registry.
- FAO, (2017), Voluntary Guidelines for Sustainable Soil Management.
- IUCN, (2018), Biodiversity guidelines for forest landscape restoration opportunities assessments.
- IUCN Global Protected & Conserved Areas Team & IUCN Regional Office for West Asia. (2022). Report of rapid field assessment of the current status and performance of the newly established network of Protected Areas in AlUla, Saudi Arabia, Results of IUCN Green List Standard IBEX assessment.
- IUCN, (2023), The Restoration Initiative.
- IUCN and WRI, (2014), A Guide to the Restoration Opportunities Assessment Methodology (ROAM): Assessing forest landscape restoration opportunities at the national or sub-national level.
- IUCN WCPA Ecological Restoration Taskforce, (2012), Ecological Restoration for Protected Areas: Principles, Guidelines and Best Practices.
- Maes, J., Egoh, B., Willemen, L., Liquete, C., Vihervaara, P., Schägner, J. P. & Bidoglio, G. (2012). Mapping ecosystem services for policy support and decision making in the European Union. Ecosystem services, 1(1), 31-39Middle East Green Initiative, (2022), Ministers Communiqué.
- SER, (2019), International Principles and Standards for the Practice of Ecological Restoration. Second Edition.
- SER, (2021), Principles and Standards for the ecological restoration of mine sites.
- Zhao, W., and Cheng, G. (2002). Review of several problems on the study of eco-hydrological processes in arid zones. Chinese Science Bulletin, 45, 353-360.
- Sharp et al. (2016). *InVEST 3.0 User's Guide*. Available at: http://ncp542dev.stanford.edu/~dataportal/invest-releases/documentation/current_release/

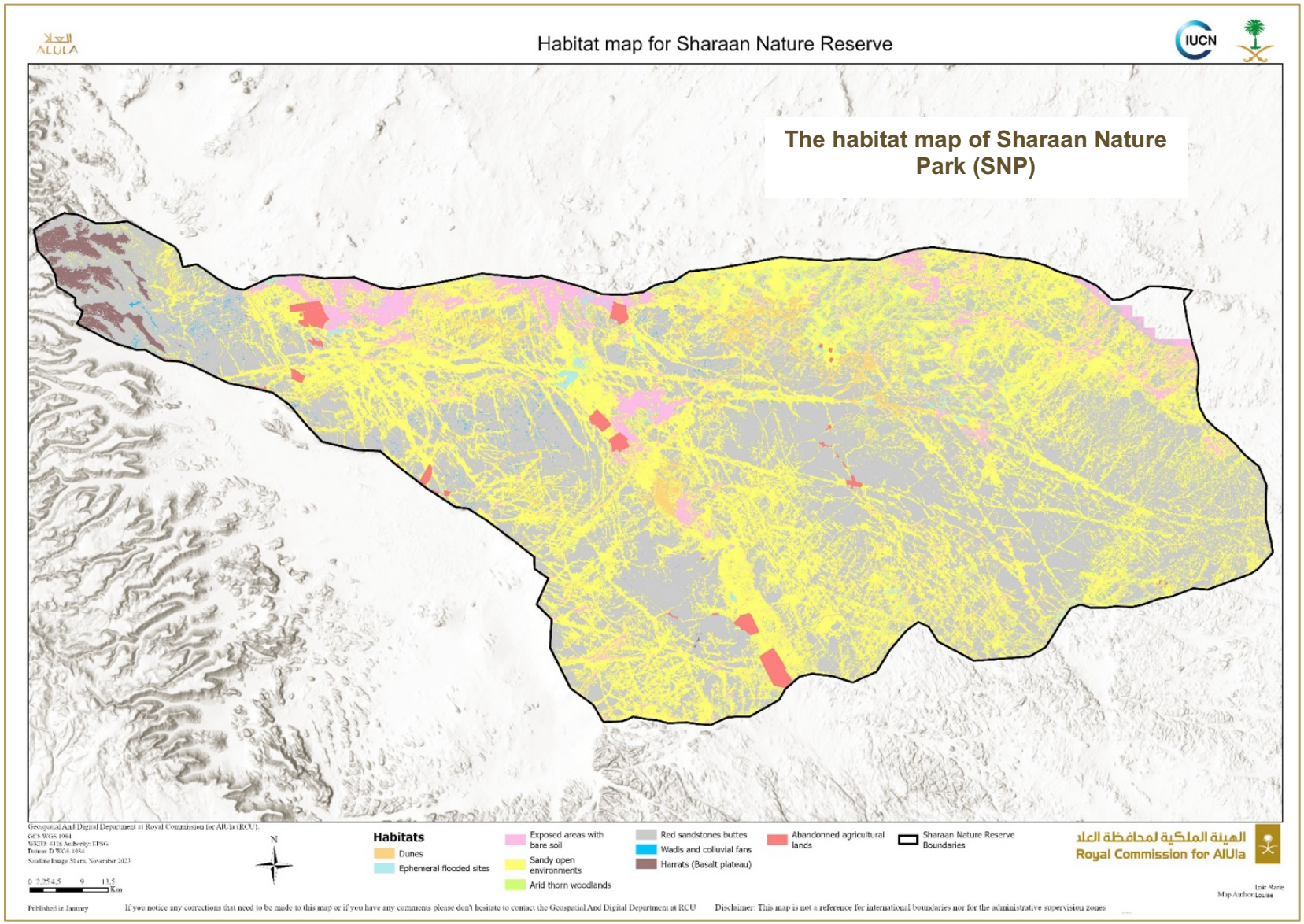
- ELD Initiative. (2015). Report for policy and decision makers: Reaping economic and environmental benefits from sustainable land management. Available from www.eld-initiative.org.
- Panuju, Dyah & Paull, David & Griffin, Amy. (2020). Change Detection Techniques Based on Multispectral Images for Investigating Land Cover Dynamics. Remote Sensing. 12. 1781. 10.3390/rs12111781.
- Rong, Caixia, and Wenxue Fu. 2023. "A Comprehensive Review of Land Use and Land Cover Change Based on Knowledge Graph and Bibliometric Analyses" *Land* 12, no. 8: 1573. https://doi.org/10.3390/land12081573
- Bartholomew and Mosyaftiani et al. (2024). The Global Biodiversity Standard: Manual for assessment and best practices. BGCI, Richmond, UK & SER, Washington, D.C. US
- Centre for Middle Eastern Plants (2023) Inventory and Vegetation of AlUla Flora Project, Final report.
- Davis, Anthony S.; Pinto, Jeremiah R. 2021. The scientific basis of the Target Plant Concept: An overview. Forests. 12: 1293.
- Dumroese RK, Landis TD, Pinto JR, Haase DL, Wilkinson KW, Davis AS (2016) Meeting forest restoration challenges: Using the target plant concept. Reforesta 1: 37-52.
- FAO, SCBD, SER (2024) Delivering restoration outcomes for biodiversity and human well-being – Resource guide to Target 2 of the Kunming-Montreal Global Biodiversity Framework. Rome, Italy. https://openknowledge.fao.org/server/api/core/bitstreams/1f069749-1b94-42b1-bad6-dcbe54cbc962/content
- Gann GD, McDonald T, Walder B, Aronson J, Nelson CR, Jonson J, Hallett JG, Eisenberg C, Guariguata MR, Liu J, Hua F, Echeverría C, Gonzales E, Shaw N, Decleer K, Dixon KW (2019) International principles and standards for the practice of ecological restoration. Second edition Restoration Ecology 27(S1): S1–S46. https://doi.org/10.1111/rec.13035
- FAO, IUCN CEM, SER (2021) Principles for ecosystem restoration to guide the United Nations Decade 2021–2030. FAO, Rome, Italy. https://openknowledge.fao.org/handle/20.500.14283/cb6591en
- Nelson, C.R., Hallett, J.G., Romero Montoya, A.E., Andrade, A., Besacier, C., Boerger, V., Bouazza, K., Chazdon, R., Cohen-Shacham, E., Danano, D., Diederichsen, A., Fernandez, Y., Gann, G.D., Gonzales, E.K., Gruca, M., Guariguata, M.R., Gutierrez, V., Hancock, B., Innecken, P., Katz, S.M., McCormick, R., Moraes, L.F.D., Murcia, C., Nagabhatla, N., Pouaty Nzembialela, D., Rosado-May, F.J., Shaw, K., Swiderska, K., Vasseur, L., Venkataraman, R., Walder, B., Wang, Z., Weidlich, E.W.A. (2024) Standards of practice to guide ecosystem restoration – A contribution to the United Nations Decade on Ecosystem Restoration 2021-2030. Rome, FAO, Washington, DC, SER and Gland, Switzerland, IUCN CEM. Link: Standards of practice to guide ecosystem restoration (fao.org)
- Deutz A, Heal GM, Niu R, Swanson E, Townshend T, Zhu L, Delmar A, Meghji A, Sethi SA, and Tobin-de la Puente J (2020) Financing Nature: Closing the global biodiversity financing gap. The Paulson Institute, The Nature Conservancy, and the Cornell Atkinson Center for Sustainability.
- UNDP (2008) Capacity assessment methodology - user's guide. New York, New York.
- Thom, R.M., H.L. Diefenderfer, and K.D. Hofseth. 2004. A Framework for Risk Analysis in Ecological Restoration Projects. U.S. Department of Energy. http://ccrm.berkeley.edu/resin/pdfs_and_other_docs/backgroundlit/FrameworkRiskAnalysisEcologicalRestorationProjects.pdf

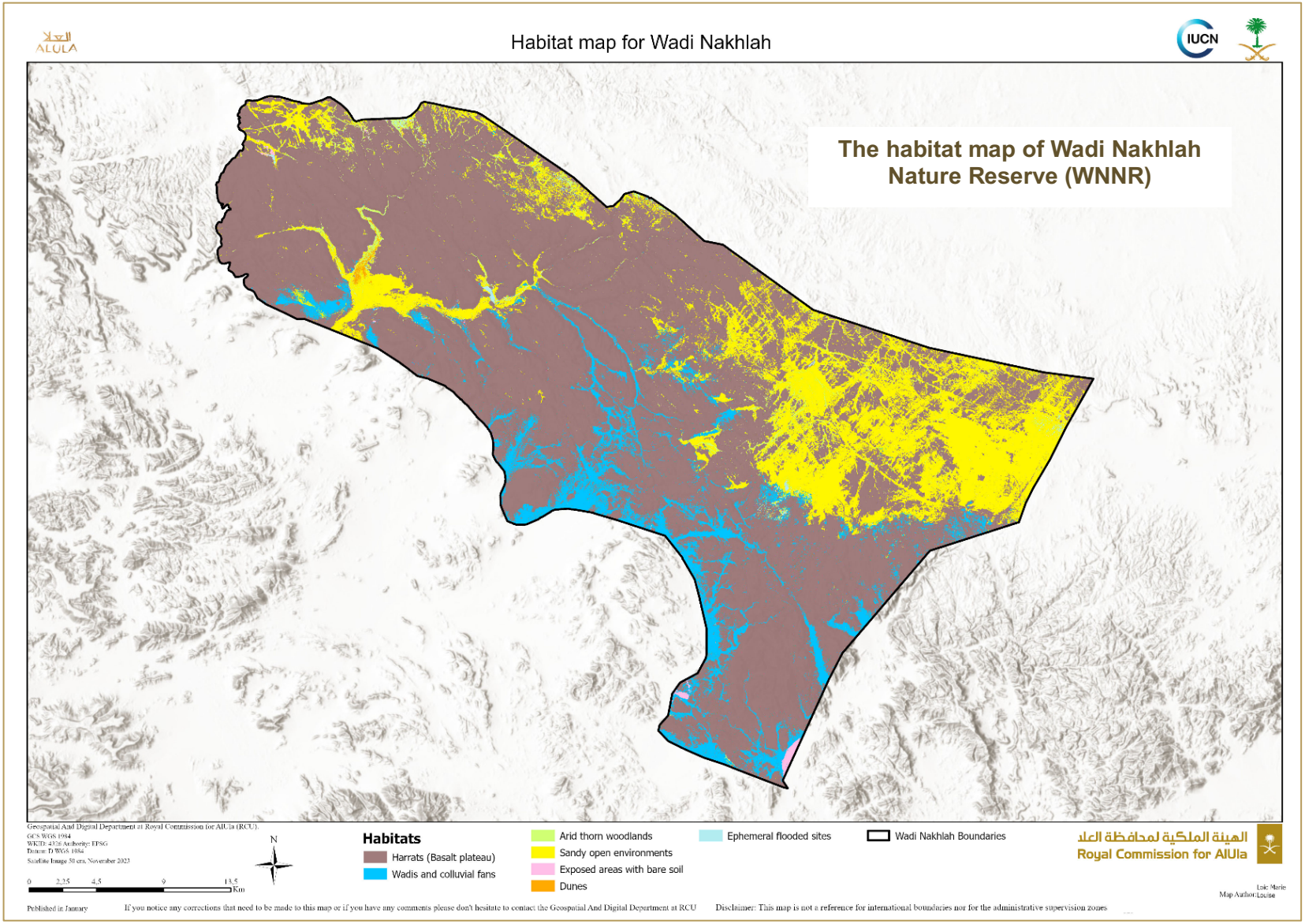
ANNEX (1) - HABITATS' MAPS OF THE SIX PROTECTED AREAS

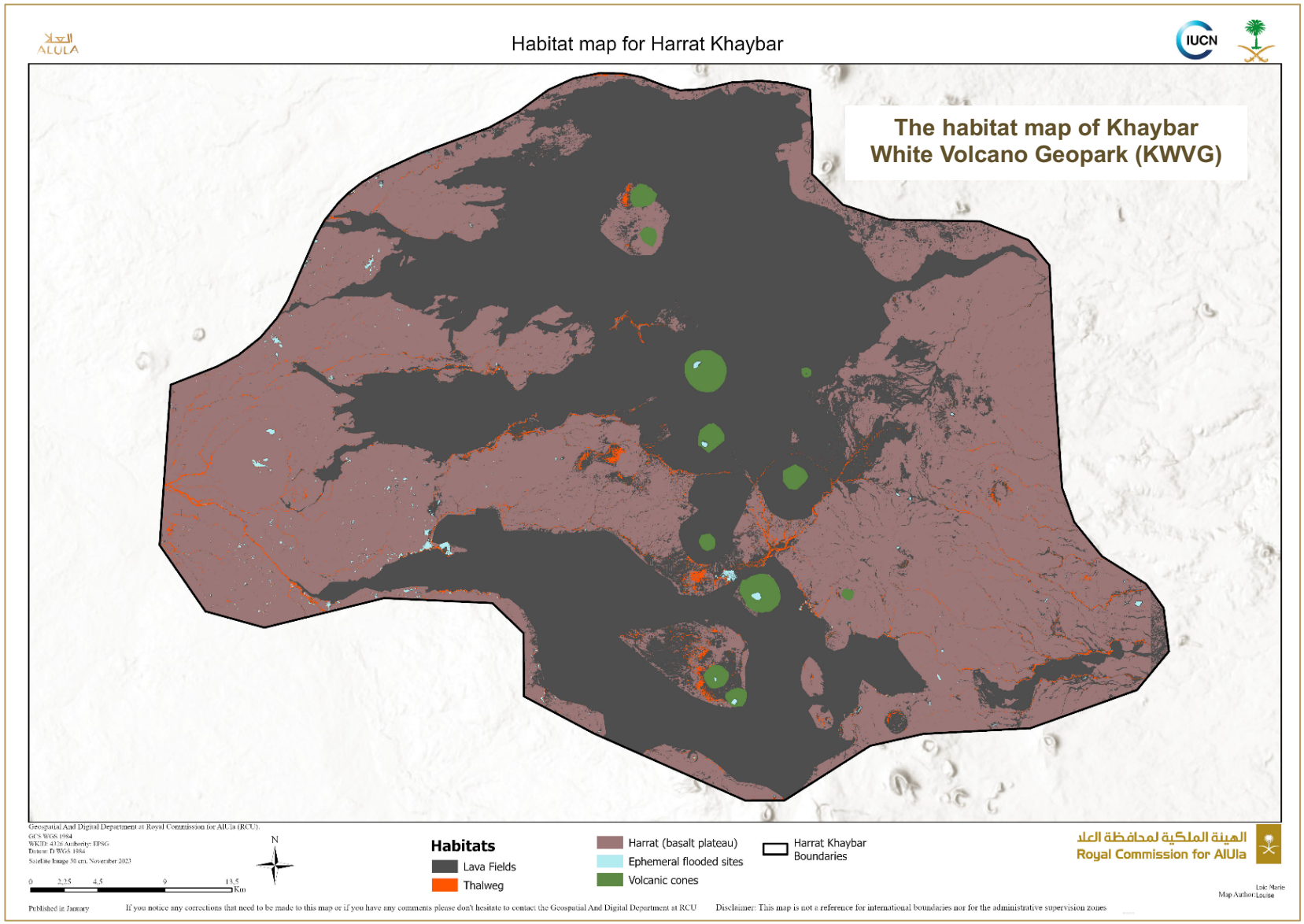



Habitat map for Harrat Uwayrid
The habitat map of Harrat Uwayrid Biosphere Reserve (HUBR)
Habitats
Abandonned agricultural lands
Ephemeral flooded sites
Arid thorn woodlands
Wadis and colluvial fans
Sandy open environments
Harrats (Basalt plateau)
Exposed areas with bare soil
Red sandstone buttes
Harrat Uwayrid boundaries
N
0 2,25 4,5 9 13,5 Km
الهيئة الملكية لمحافظة العلا
Royal Commission for AlUla
Published in January
If you notice any corrections that need to be made to this map or if you have any comments please don't hesitate to contact the Geospatial And Digital Department at RCU
Disclaimer: This map is not a reference for international boundaries nor for the administrative supervision zones


Habitat map for Harrat Alzabin
IUCN
The habitat map of Harrat AlZabin Nature Reserve (HZNR)
Geospatial And Digital Department at Royal Commission for AlUla (RCU).
GCS WGS 1984
WKID: 4326 Authority: EPSG
Datum: D_WGS_1984
Satellite Image 10 m, December 2023
0 2,25 4,5 9 13,5
Km
N
Habitats
Harrats (Basalt Plateau)
Sandy open environments
Wadis and colluvial fans
Arid thorn woodlands
Harrat Alzabin boundaries
الهيئة الملكية لمحافظة العلا
Royal Commission for AlUla
Map Author: Inès CANDELA
Published in December
If you notice any corrections that need to be made to this map or if you have any comments please don't hesitate to contact the Geospatial And Digital Department at RCU
Disclaimer: This map is not a reference for international boundaries nor for the administrative supervision zones


Habitat map for Sharaan Nature Reserve
The habitat map of Sharaan Nature Park (SNP)
Habitats
Dunes
Ephemeral flooded sites
Exposed areas with bare soil
Sandy open environments
Arid thorn woodlands
Red sandstones buttes
Wadis and colluvial fans
Harrats (Basalt plateau)
Abandonned agricultural lands
Sharaan Nature Reserve Boundaries
N
0 2.25 4.5 9 13.5 Km
Geospatial And Digital Department at Royal Commission for AlUla (RCU).
GCS WGS 1984
WKID: 4326 Authority: EPSG
Datum: D_WGS_1984
Satellite Image 50 cm, November 2023
Published in January
If you notice any corrections that need to be made to this map or if you have any comments please don't hesitate to contact the Geospatial And Digital Department at RCU
Disclaimer: This map is not a reference for international boundaries nor for the administrative supervision zones
الهيئة الملكية لمحافظة العلا
Royal Commission for AlUla
Loic Marie
Map Author Louise


Habitat map for Wadi Nakhlah
The habitat map of Wadi Nakhlah Nature Reserve (WNNR)
Habitats
Harrats (Basalt plateau)
Wadis and colluvial fans
Arid thorn woodlands
Sandy open environments
Exposed areas with bare soil
Dunes
Ephemeral flooded sites
Wadi Nakhlah Boundaries
N
0 2,25 4,5 9 13,5 Km
الهيئة الملكية لمحافظة العلا
Royal Commission for AlUla
Loic Marie
Map Author/Louise
Published in January
If you notice any corrections that need to be made to this map or if you have any comments please don't hesitate to contact the Geospatial And Digital Department at RCU
Disclaimer: This map is not a reference for international boundaries nor for the administrative supervision zones


Habitat map for Harrat Khaybar
The habitat map of Khaybar White Volcano Geopark (KWVG)
Habitats
Lava Fields
Thalweg
Harrat (basalt plateau)
Ephemeral flooded sites
Volcanic cones
Harrat Khaybar Boundaries
N
0 2,25 4,5 9 13,5 Km
الهيئة الملكية لمحافظة العلا
Royal Commission for AlUla
Published in January
If you notice any corrections that need to be made to this map or if you have any comments please don't hesitate to contact the Geospatial And Digital Department at RCU
Disclaimer: This map is not a reference for international boundaries nor for the administrative supervision zones

ANNEX (2) - LIST OF PLANT SPECIES OF INTEREST FOR ECOLOGICAL RESTORATION

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
1	*Achillea fragrantissima*	قيصوم	*Achillea fragrantissima (Forssk.) Sch.Bip.*	Asteraceae	No	No	No	No	No	Yes	Yes	No	Nurse	Shrub	Priority
2	*Abutilon fruticosum*	الرين	*Abutilon fruticosum* Guill. & Perr.	Malvaceae	No	Yes	Yes	No	No	No	No	No	Specialist	Shrub	Priority
3	*Abutilon hirtum*	اكرن	*Abutilon hirtum* (Lam.) Sweet	Malvaceae	No	Yes	Yes	No	No	No	No	Yes	Specialist	Shrub	Priority
4	*Aerva javanica*	طِرف / ريل / الراء	*Aerva javanica (Burm.f.) Juss. ex Schult.*	Amaranthaceae	No	No	No	Yes	No	Yes	No	Yes	Specialist	Shrub	Priority
5	*Anabasis setifera*	غسل / الشعران	*Anabasis setifera Moq.*	Amaranthaceae	No	Yes	No	No	Yes	Yes	No	No	Specialist	Shrub	Priority
6	*Anastatica hierochuntica*	كف مريم	*Anastatica hierochuntica* L.	Brassicaceae	No	No	No	Yes	Yes	No	Yes	No	Specialist	Herbaceous	Priority
7	*Anthemis melampodina*	الأقحوان	*Anthemis melampodina* Delile	Asteraceae	Yes	Yes	No	No	No	No	No	No	Specialist	Herbaceous	Priority
8	*Anvillea garcinii*	نِقَد	*Anvillea garcinii (Burm.f.) DC.*	Asteraceae	No	Yes	No	No	No	No	No	Yes	Nurse	Shrub	High priority
9	*Artemisia judaica*	شيح / بعيثران	*Artemisia judaica L.*	Asteraceae	No	No	No	No	No	Yes	Yes	No	Nurse	Shrub	Priority
10	*Artemisia monosperma*	عاذر	*Artemisia monosperma Delile*	Asteraceae	Yes	Yes	No	Yes	No	No	No	No	Nurse	Shrub	High priority
11	*Artemisia sieberi*	شيح	*Artemisia sieberi Besser*	Asteraceae	No	No	No	No	No	Yes	Yes	No	Nurse	Shrub	Priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
12	*Asparagus horridus*	-	*Asparagus horridus L.*	Asparagaceae	No	No	No	No	No	No	Yes	Yes	Specialist	Shrub	Priority
13	*Asteriscus graveolens*	النُقُد	*Asteriscus graveolens (Forssk.) Less.*	Asteraceae	No	No	Yes	Yes	Yes	Yes	No	No	Nurse	Shrub	High priority
14	*Astragalus sieberi*	قتاد	*Astragalus sieberi DC.*	Fabaceae	Yes	Yes	No	Yes	No	No	No	No	Nurse	Shrub	High priority
15	*Astragalus spinosus*	قتاد	*Astragalus spinosus (Forssk.) Muschl.*	Fabaceae	No	Yes	No	No	No	Yes	Yes	Yes	Nurse	Shrub	High priority
16	*Astragalus tribuloides*	القفعاء	*Astragalus tribuloides* Delile	Fabaceae	No	No	No	Yes	Yes	No	No	No	Nurse	Herbaceous	Priority
17	*Atriplex leucoclada*	الرغل	*Atriplex turcomanica (Moq.) Boiss.*	Amaranthaceae	No	No	No	Yes	Yes	No	No	No	Specialist	Shrub	Priority
18	*Ballota undulata*	الزقوم	*Pseudodictamnus undulatus (Benth.) Salmaki & Siadati*	Lamiaceae	No	No	No	No	No	No	No	Yes	Specialist	Shrub	Priority
19	*Blepharis ciliaris*	نقيع السّحاء/شوك الضب /	*Blepharis ciliaris* (L.) B.L.Burtt	Acanthaceae	No	No	No	No	No	Yes	Yes	Yes	Specialist	Herbaceous	Priority
20	*Calligonum comosum*	أرطى	*Calligonum comosum L'Hér.*	Polygonaceae	Yes	Yes	No	Yes	No	No	No	No	Nurse	Shrub	High priority
21	*Capparis cartilaginea*	لصف	*Capparis cartilaginea Decne.*	Capparaceae	No	No	No	No	No	Yes	No	Yes	Nurse	Shrub	High priority
22	*Capparis decidua*	التنضُب	*Capparis decidua (Forssk.) Edgew.*	Capparaceae	No	Yes	Yes	Yes	No	No	No	No	Nurse	Tree	High priority
23	*Capparis spinosa*	قبار / الشَّفَلَح	*Capparis spinosa L.*	Capparaceae	No	No	No	No	No	No	No	Yes	Nurse	Shrub	Priority
24	*Caroxylon imbricatum*	الثرمد	*Caroxylon imbricatum (Forssk.) Moq.*	Amaranthaceae	No	No	No	Yes	Yes	No	No	No	Specialist	Shrub	Priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
25	*Centropodia forsskalii*	قصبا	*Centropodia forskaolii (Vahl) Cope*	Poaceae	Yes	Yes	No	No	No	No	No	No	Specialist	Herbaceous	Priority
26	*Cenchrus ciliaris*	الأبيد	*Cenchrus ciliaris* L.	Poaceae	No	Yes	No	No	No	No	No	Yes	Specialist	Herbaceous	Priority
27	*Centaurea eryngioides*	لحية البدن	*Centaurea eryngioides* Lam.	Asteraceae	No	No	No	No	No	No	No	Yes	Specialist	Herbaceous	Priority
28	*Centaurea scoparia*	-	*Centaurea scoparia* Sieber ex Spreng.	Asteraceae	No	Yes	No	Yes	No	No	No	Yes	Nurse	Shrub	Priority
29	*Cenchrus divisus*	ثيموم / الصبغاء	*Cenchrus divisus (J.F.Gmel.) Verloove*	Poaceae	No	No	No	Yes	No	No	No	No	Nurse	Herbaceous	High priority
30	*Citrullus colocynthis*	حنظل/شرى	*Citrullus colocynthis* (L.) Schrad.	Cucurbitaceae	No	Yes	Yes	Yes	Yes	Yes	No	No	Nurse	Herbaceous	Priority
31	*Cleome chrysantha*	صفيرة	*Cleome chrysantha Decne.*	Cleomaceae	No	No	No	No	No	Yes	No	Yes	Nurse	Shrub	Priority
32	*Cocculus pendulus*	فضحة / الغاشية	*Cebatha pendula (J.R.Forst. & G.Forst.) Kuntze*	Menispermaceae	No	No	No	No	No	Yes	No	Yes	Nurse	Tree	Priority
33	*Convolvulus pilosellifolius*	الرخامى	*Convolvulus pilosellifolius* Desr.	Convolvulaceae	No	Yes	No	No	No	No	No	No	Specialist	Herbaceous	Priority
34	*Convolvulus spicatus*	الرخامى	*Convolvulus spicatus Peter ex Hallier f.*	Convolvulaceae	Yes	Yes	No	Yes	No	No	No	No	Nurse	Herbaceous	High priority
35	*Convolvulus cephalopodus subsp. bushiricus*	رخام . رخيمي . ياره	*Convolvulus cephalopodus* subsp. *bushiricus* (Bornm.) J.R.I.Wood & Scotland	Convolvulaceae	No	Yes	No	Yes	No	No	No	No	Nurse	Herbaceous	Priority
36	*Crotalaria aegyptiaca*	-	*Crotalaria aegyptiaca Benth.*	Fabaceae	No	Yes	No	Yes	No	Yes	Yes	No	Nurse	Shrub	High priority
37	*Cucumis prophetarum*	مشط الذئب/شرى الذئب	*Cucumis prophetarum* L.	Cucurbitaceae	No	Yes	Yes	Yes	Yes	Yes	No	No	Nurse	Herbaceous	Priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
38	*Cymbopogon commutatus*	-	*Cymbopogon commutatus (Steud.) Stapf*	Poaceae	No	No	No	No	No	Yes	Yes	Yes	Nurse	Herbaceous	High priority
39	*Cymbopogon schoenanthus*	صخرا / ادخر/حمره	*Cymbopogon schoenanthus (L.) Spreng.*	Poaceae	No	No	No	No	No	Yes	Yes	Yes	Nurse	Herbaceous	High priority
40	*Deverra triradiata*	حزا / القروح	*Deverra triradiata Hochst. ex Boiss.*	Apiaceae	Yes	Yes	No	No	No	No	No	No	Specialist	Shrub	Priority
41	*Ducrosia flabellifolia*	الحزاء	*Ducrosia flabellifolia Boiss.*	Apiaceae	No	No	No	No	No	Yes	Yes	No	Specialist	Herbaceous	High priority
42	*Echium rauwolfii*	الكحلاء	*Echium rauwolfii* Delile	Boraginaceae	No	No	No	No	No	Yes	Yes	Yes	Nurse	Herbaceous	Priority
43	*Ephedra alata*	علند	*Ephedra alata Decne.*	Ephedraceae	Yes	Yes	No	No	No	No	No	No	Nurse	Shrub	High priority
44	*Ephedra aphylla*	-	*Ephedra aphylla Forssk.*	Ephedraceae	No	Yes	No	No	No	No	No	No	Specialist	Shrub	Priority
45	*Ephedra cf. foliata*	عطف / العلجان	*Ephedra ciliata Fisch. & C.A.Mey.*	Ephedraceae	No	Yes	Yes	Yes	No	Yes	No	Yes	Nurse	Shrub	Priority
46	*Farsetia aegyptia*	الحمأة	*Farsetia aegyptia Turra*	Brassicaceae	No	Yes	No	Yes	No	Yes	No	Yes	Nurse	Shrub	Priority
47	*Farsetia burtoniae*	جربية / الحفرى	*Farsetia burtoniae Oliv.*	Brassicaceae	No	No	No	Yes	No	Yes	No	Yes	Nurse	Shrub	Priority
48	*Farsetia longisiliqua*	الحمأة	*Farsetia longisiliqua* Decne.	Brassicaceae	No	Yes	No	Yes	No	Yes	No	No	Nurse	Shrub	Priority
49	*Ferula sinaica*	كلخ/محروث	*Ferula sinaica* Boiss.	Apiaceae	No	No	No	No	No	No	Yes	No	Specialist	Herbaceous	Priority
50	*Ficus palmata*	حماط	*Ficus palmata Forssk.*	Moraceae	No	No	No	No	No	No	No	Yes	Specialist	Tree	Priority
51	*Ficus salicifolia*	ألثاب	*Ficus salicifolia Vahl*	Moraceae	No	No	No	No	No	No	No	Yes	Specialist	Tree	Priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
52	*Gymnocarpos decander*	الجرد / العضرّس/ام لبن	*Gymnocarpos decander Forssk.*	Caryophyllaceae	No	No	No	No	No	Yes	Yes	Yes	Specialist	Shrub	Priority
53	*Gypsophila capillaris*	رقيقة / السُمنة / عشب الضبي	*Gypsophila capillaris* (Forssk.) C.Chr.	Caryophyllaceae	No	Yes	No	No	No	Yes	Yes	Yes	Nurse	Shrub	Priority
54	*Haloxylon persicum*	غضا	*Haloxylon persicum Bunge*	Amaranthaceae	Yes	Yes	No	No	No	No	No	No	Pillar	Tree	High priority
55	*Haloxylon salicornicum*	رمث	*Haloxylon salicornicum (Moq.) Bunge ex Boiss.*	Amaranthaceae	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Generalist	Shrub	High priority
56	*Helianthemum lippii*	رقروق	*Helianthemum lippii (L.) Dum.Cours.*	Cistaceae	No	No	Yes	No	No	Yes	Yes	Yes	Specialist	Shrub	Priority
57	*Heliotropium arbainense*	رمرام	*Heliotropium arbainense* Fresen.	Boraginaceae	No	No	No	No	No	Yes	Yes	Yes	Nurse	Shrub	Priority
58	*Heliotropium bacciferum*	رمرام	*Heliotropium bacciferum Forssk.*	Boraginaceae	No	Yes	No	Yes	Yes	No	No	No	Nurse	Shrub	Priority
59	*Heliotropium digynum*	رمرام	*Heliotropium digynum (Forssk.) Asch. ex C.Chr.*	Boraginaceae	Yes	Yes	No	Yes	No	No	No	No	Nurse	Shrub	Priority
60	*Heliotropium ramosissimum*	رمرام	*Heliotropium ramosissimum* (Lehm.) Sieber ex DC.	Boraginaceae	No	Yes	No	Yes	Yes	No	No	No	Nurse	Shrub	Priority
61	*Hibiscus micranthus*	كرش الغراب	*Hibiscus micranthus* L.f.	Malvaceae	No	No	No	No	No	Yes	Yes	Yes	Nurse	Shrub	Priority
62	*Hyparrhenia hirta*	الإسنوم/ح مرور أشعر	*Hyparrhenia hirta* (L.) Stapf	Poaceae	No	Yes	No	No	No	Yes	Yes	Yes	Nurse	Herbaceous	Priority
63	*Kickxia aegyptiaca*	الصفيرا	*Kickxia aegyptiaca* (L.) Nábělek	Scrophulariaceae	No	Yes	No	Yes	Yes	Yes	No	Yes	Nurse	Herbaceous	Priority
64	*Kickxia pseudoscoparia*	حرشاء	*Kickxia pseudoscoparia*	Scrophulariaceae	No	No	No	No	No	Yes	No	Yes	Nurse	Shrub	Priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
			V.A.W.Sm. & D.A.Sutton												
65	*Iphiona scabra*	لُعقب	*Iphiona scabra DC. ex Decne.*	Asteraceae	No	No	No	No	No	Yes	No	Yes	Specialist	Shrub	Priority
66	*Lasiospermum brachyglossum*	-	*Lasiospermum brachyglossum* DC.	Asteraceae	No	Yes	No	No	No	No	No	Yes	Specialist	Herbaceous	High priority
67	*Lasiurus scindicus*	-	*Lasiurus scindicus* Henrard	Poaceae	No	Yes	Yes	Yes	No	No	No	No	Nurse	Herbaceous	High priority
68	*Lavandula coronopifolia*	زيتة / لافند / الشَّيْعة	*Lavandula coronopifolia Poir.*	Lamiaceae	No	No	No	No	No	Yes	No	Yes	Specialist	Shrub	Priority
69	*Lavandula pubescens*	زيتة / لافند / الشَّيْعة	*Lavandula pubescens Decne.*	Lamiaceae	No	No	No	No	No	Yes	No	Yes	Specialist	Shrub	Priority
70	*Launaea spinosa*	أم كلب / الحواء الشوكية	*Launaea spinosa (Forsk.) Sch.Bip. ex O.Kuntze*	Asteraceae	No	No	No	No	No	Yes	No	Yes	Specialist	Shrub	Priority
71	*Lepidium aucheri*	الرشاد البري	*Lepidium aucheri* Boiss.	Brassicaceae	No	No	No	Yes	Yes	No	No	No	Specialist	Herbaceous	High priority
72	*Leptaleum filifolium*	-	*Leptaleum filifolium* (Willd.) DC.	Brassicaceae	No	No	No	Yes	Yes	No	No	No	Specialist	Herbaceous	High priority
73	*Leptadenia pyrotechnica*	مرخ	*Leptadenia pyrotechnica (Forssk.) Decne.*	Apocynaceae	No	Yes	Yes	No	No	Yes	No	No	Specialist	Tree	High priority
74	*Lindenbergia indica*	الحويمضة	*Lindenbergia indica* (L.) Vatke	Scrophulariaceae	No	No	No	No	No	No	No	Yes	Specialist	Shrub	High priority
75	*Lycium shawii*	عوسج	*Lycium shawii Roem. & Schult.*	Solanaceae	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Pillar	Shrub	High priority
76	*Matricaria aurea*	البابونج / الحندقوق	*Matricaria aurea* (Loefl.) Sch.Bip.	Asteraceae	No	No	No	Yes	Yes	No	No	No	Specialist	Herbaceous	High priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
77	*Matthiola arabica*	منثور / شقارة / غمغم	*Matthiola arabica* Boiss.	Brassicaceae	No	Yes	No	Yes	No	No	No	No	Nurse	Herbaceous	High priority
78	*Moltkiopsis ciliata*	حَلَم	*Moltkiopsis ciliata (Forssk.) I.M.Johnst.*	Boraginaceae	Yes	Yes	No	Yes	No	No	No	No	Nurse	Shrub	High priority
79	*Maerua crassifolia*	سرح	*Maerua crassifolia Forssk.*	Capparaceae	No	Yes	No	No	No	Yes	No	Yes	Pillar	Tree	High priority
80	*Monsonia nivea*	القرنوة/خزام/ دهمة	*Monsonia nivea* (Decne.) Webb	Geraniaceae	Yes	Yes	No	No	No	No	No	No	Nurse	Herbaceous	Priority
81	*Moraea sisyrinchium*	السوسن / العنصل	*Moraea sisyrinchium (L.) Ker Gawl.*	Iridaceae	No	No	No	Yes	Yes	No	Yes	No	Specialist	Herbaceous	Priority
82	*Morettia parviflora*	ريل / الثغر	*Morettia parviflora Boiss.*	Brassicaceae	No	No	No	Yes	Yes	Yes	Yes	Yes	Generalist	Shrub	Priority
83	*Moringa peregrina*	بان	*Moringa peregrina (Forssk.) Fiori*	Moringaceae	No	No	No	No	No	Yes	No	Yes	Specialist	Tree	High priority
84	*Ochradenus baccatus*	قرضي	*Ochradenus baccatus Delile*	Resedaceae	No	Yes	Yes	Yes	No	Yes	No	Yes	Generalist	Shrub	High priority
85	*Otostegia fruticosa*	الشَّرَم	*Otostegia fruticosa (Forssk.) Schweinf. ex Penzig*	Lamiaceae	No	No	No	No	No	Yes	No	Yes	Specialist	Shrub	High priority
86	*Panicum turgidum*	ثمام	*Panicum turgidum Forssk.*	Poaceae	No	Yes	Yes	Yes	No	Yes	No	No	Nurse	Herbaceous	High priority
87	*Peganum harmala*	الحرمل	*Peganum harmala L.*	Nitrariaceae	No	No	Yes	Yes	No	Yes	Yes	No	Nurse	Herbaceous	Priority
88	*Pergularia tomentosa*	غلقة / عطنة	*Pergularia tomentosa L.*	Apocynaceae	No	Yes	Yes	Yes	No	Yes	No	Yes	Specialist	Shrub	Priority
89	*Periploca aphylla*	السَّواس	*Periploca aphylla Decne.*	Apocynaceae	No	Yes	Yes	Yes	No	No	No	Yes	Nurse	Tree	High priority
90	*Phagnalon sinaicum*	خنينة النعجة	*Phagnalon sinaicum* Bornm. & Kneuck.	Asteraceae	No	No	No	No	No	No	No	Yes	Specialist	Shrub	Priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
91	*Pistacia cf. khinjuk*	ضرو	*Pistacia khinjuk Stocks*	Anacardiaceae	No	No	No	No	No	No	No	Yes	Specialist	Tree	High priority
92	*Polycarpaea repens*	المكر/رقيقة	*Polycarpaea repens* (Forssk.) Asch. & Schweinf.	Caryophyllaceae	No	Yes	Yes	Yes	Yes	No	No	No	Nurse	Herbaceous	Priority
93	*Polycarpaea robbairea*	رقيّقة	*Polycarpaea robbairea* (Kuntze) Greuter & Burdet	Caryophyllaceae	No	No	No	Yes	Yes	No	No	No	Specialist	Herbaceous	Priority
94	*Polygala negevensis*	سواسي / سمار	*Polygala sinaica* var. *glabrescens* (Zohary) Boulos	Polygonaceae	No	No	No	No	No	No	No	Yes	Specialist	Shrub	Priority
95	*Pulicaria incisa*	خاع / العرار	*Pulicaria incisa (Lam.) DC.*	Asteraceae	No	No	No	Yes	No	Yes	Yes	Yes	Generalist	Shrub	Priority
96	*Pulicaria undulata*	الجثجاث	*Pulicaria undulata (L.) C.A.Mey.*	Asteraceae	No	Yes	Yes	Yes	No	Yes	Yes	No	Generalist	Shrub	Priority
97	*Pycnocycla saxatilis*	-	*Pycnocycla saxatilis Danin, Hedge & Lamond*	Apiaceae	No	No	No	No	No	No	No	Yes	Specialist	Herbaceous	High priority
98	*Retama raetam*	رتم	*Retama raetam (Forssk.) Webb & Berthel.*	Fabaceae	No	Yes	Yes	Yes	No	Yes	Yes	No	Nurse	Shrub	High priority
99	*Reaumuria hirtella*	نديانة	*Reaumuria hirtella* Jaub. & Spach	Tamaricaceae	No	Yes	No	No	No	No	No	Yes	Specialist	Shrub	Priority
100	*Rhamnus disperma*	حنة	*Rhamnus disperma Ehrenb. ex Boiss.*	Rhamnaceae	No	No	No	No	No	No	Yes	Yes	Specialist	Shrub	Priority
101	*Rhanterium epapposum*	العَرْفَج	*Rhanterium epapposum Oliv.*	Asteraceae	No	Yes	No	No	No	No	No	Yes	Nurse	Shrub	High priority
102	*Rhazya stricta*	حرمل	*Rhazya stricta* Decne.	Apocynaceae	No	Yes	Yes	Yes	No	Yes	Yes	No	Nurse	Shrub	Priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
103	*Sageretia thea*	نمت	*Sageretia thea (Osbeck) M.C.Johnst.*	Rhamnaceae	No	No	Yes	No	No	Yes	No	Yes	Specialist	Tree	High priority
104	*Salvadora persica*	مسواك - آراك الاراك	*Salvadora persica L.*	Salvadoraceae	No	No	No	No	No	Yes	No	Yes	Specialist	Tree	High priority
105	*Salvia aegyptiaca*	شجيرة الغزال	*Salvia aegyptiaca L.*	Lamiaceae	No	No	No	No	No	Yes	Yes	Yes	Specialist	Shrub	Priority
106	*Salvia deserti*	جنع	*Salvia deserti Decne.*	Lamiaceae	No	No	No	No	No	Yes	Yes	Yes	Specialist	Shrub	Priority
107	*Salvia spinosa*	لسان الثور/حرشا / شجرة الجمل / طعلبة	*Salvia spinosa L.*	Lamiaceae	No	No	No	No	No	Yes	Yes	Yes	Specialist	Shrub	Priority
108	*Scrophularia deserti*	ذعلوق / ذعلوق البعير	*Scrophularia deserti* Delile	Scrophulariaceae	No	No	No	No	No	No	Yes	Yes	Nurse	Shrub	Priority
109	*Scrophularia hypericifolia*	العلقى	*Scrophularia hypericifolia Wydler*	Scrophulariaceae	Yes	Yes	No	No	No	No	No	No	Specialist	Shrub	High priority
110	*Searsia tripartita*	العَرن	*Searsia tripartita (Ucria) Moffett*	Anacardiaceae	No	No	No	No	No	No	No	Yes	Specialist	Tree	Priority
111	*Seidlitzia rosmarinus*	العنظوان / الشنان	*Seidlitzia rosmarinus Bunge ex Boiss.*	Amaranthaceae	No	No	No	Yes	Yes	Yes	No	No	Specialist	Shrub	Priority
112	*Senna italica*	سَنا / العِشرق	*Senna italica Mill.*	Fabaceae	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Generalist	Shrub	Priority
113	*Solenostemma arghel*	حرجل	*Solenostemma arghel* (Delile) Hayne	Asclepiadaceae	No	Yes	No	Yes	No	Yes	No	Yes	Specialist	Shrub	Priority

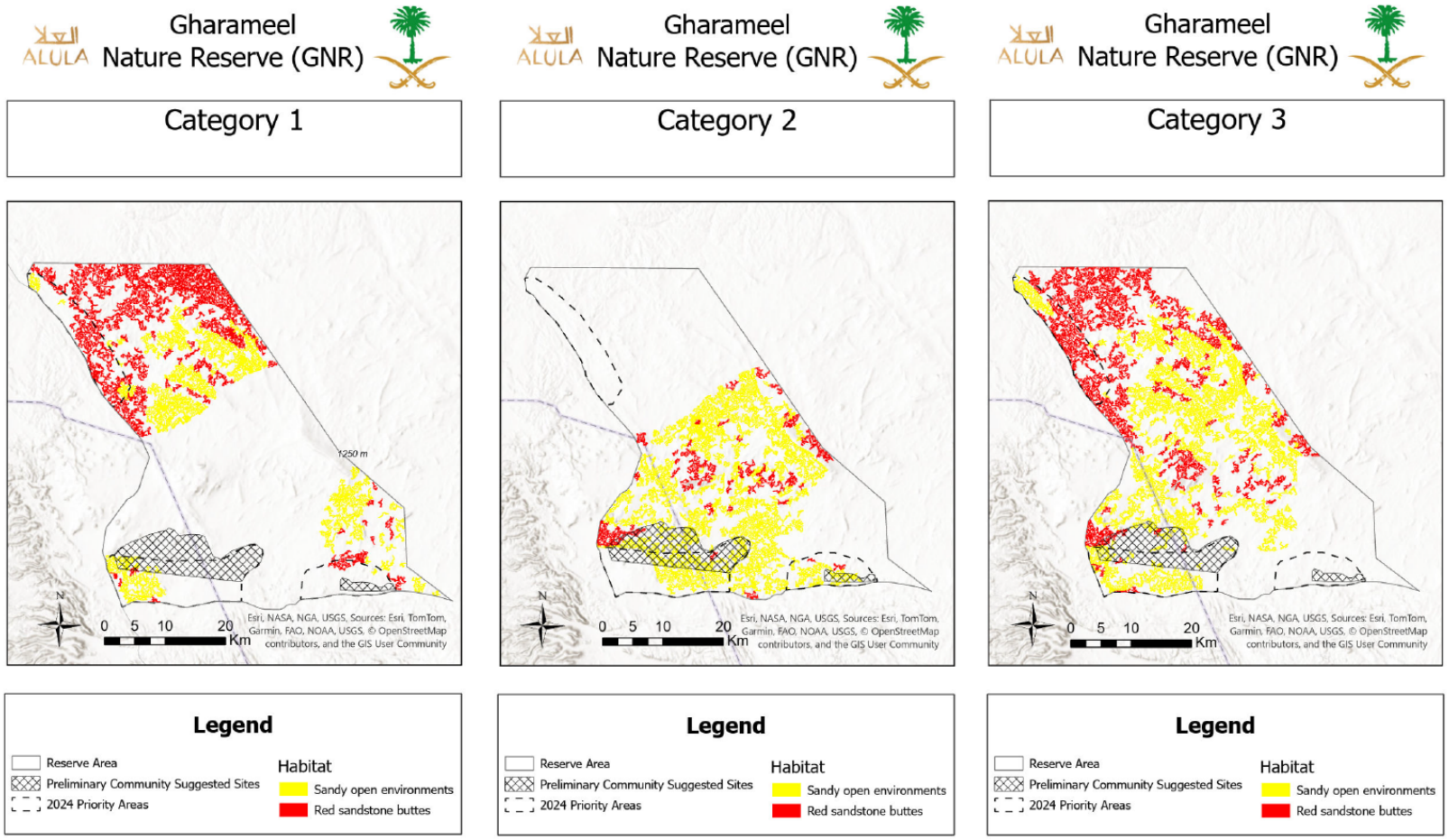
N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
114	*Stipagrostis ciliata*	صليان	*Stipagrostis ciliata (Desf.) De Winter*	Poaceae	Yes	Yes	Yes	Yes	No	No	No	No	Nurse	Herbaceous	High priority
115	*Stipagrostis obtusa*	-	*Stipagrostis obtusa (Delile) Nees*	Poaceae	No	Yes	Yes	Yes	No	No	No	No	Nurse	Herbaceous	High priority
116	*Stipagrostis plumosa*	نصي	*Stipagrostis plumosa Munro ex T.Anderson*	Poaceae	Yes	Yes	Yes	Yes	No	Yes	No	No	Pioneer	Herbaceous	High priority
117	*Suaeda vermiculata*	سويدة	*Suaeda vermiculata* Forssk. ex J.F.Gmel.	Amaranthaceae	No	No	No	Yes	Yes	No	No	No	Pioneer	Shrub	Priority
118	*Tephrosia purpurea subsp. Apollinea*	حويرة	*Tephrosia purpurea* subsp. *apollinea*	Fabaceae	No	Yes	No	Yes	Yes	Yes	Yes	No	Nurse	Shrub	Priority
119	*Teucrium polium*	جعد/ جعدة	*Teucrium polium* L.	Lamiaceae	No	No	No	No	No	Yes	Yes	Yes	Nurse	Shrub	High priority
120	*Thymbra nabateorum*	الزعتر	*Thymbra nabateorum (Danin & Hedge) Bräuchler*	Lamiaceae	No	No	No	No	No	No	No	Yes	Specialist	Shrub	High priority
121	*Traganum nudatum*	الضمران	*Traganum nudatum Delile*	Amaranthaceae	No	Yes	No	Yes	Yes	No	No	No	Nurse	Shrub	Priority
122	*Vachellia gerrardii*	طلح	*Vachellia gerrardi var. najdensis (Chaudhary) Ragup., Seigler, Ebinger & Maslin*	Fabaceae	No	Yes	Yes	Yes	No	No	No	No	Pillar	Tree	High priority
123	*Vachellia seyal*	السّيَال	*Vachellia seyal (Delile) P.J.H.Hurter*	Fabaceae	No	No	Yes	Yes	No	Yes	No	No	Pillar	Tree	High priority
124	*Vachellia tortilis*	سمر	*Vachellia tortilis (Forssk.) Galasso & Banfi*	Fabaceae	No	No	Yes	Yes	No	Yes	No	No	Pillar	Tree	High priority
125	*Vachellia tortilis subsp. raddiana*	سمر	*Vachellia tortilis subsp. raddiana (Savi) Kyal. & Boatwr.*	Fabaceae	No	No	Yes	Yes	No	Yes	No	No	Pillar	Tree	High priority

N°	Species Field Name	Botanical information			Habitat occurency								Ecological information		
		Arabic Name	Scientific name	Family	Dunes	Sandy open environment	Species rich open shrubland formations	Abandoned agricultural lands	Ephemeral flooded depression	Wadis and colluvial fans	Harrats	Vegetated rock outcrops and mountains	Pillar/Nurse	Vegetation strata	Priority for restoration
126	*Withania somnifera*	سم الفار / العُبَب/عبعبة	*Withania somnifera (L.) Dunal*	Solanaceae	No	No	No	No	No	No	No	Yes	Specialist	Shrub	Priority
127	*Zilla spinosa*	زلة / السُّبرُم	*Zilla spinosa (L.) Prantl*	Brassicaceae	No	No	No	No	No	Yes	Yes	No	Nurse	Shrub	Priority
128	*Ziziphus nummularia*	سِدر بري	*Ziziphus nummularia (Burm.f.) Wight & Arn.*	Rhamnaceae	No	Yes	Yes	Yes	No	No	No	No	Pillar	Tree	High priority
129	*Zygophyllum bruguieri*	جنبة / شكاعة / الدرماء	*Zygophyllum bruguieri (DC.) Christenh. & Byng*	Zygophyllaceae	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Generalist	Shrub	High priority
130	*Zygophyllum glutinosum*	جنب الضب	*Zygophyllum glutinosum (Delile) Christenh. & Byng*	Zygophyllaceae	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Generalist	Shrub	Priority
131	*Zygophyllum molle*	دريمة الجبل	*Zygophyllum molle (Delile) Christenh. & Byng*	Zygophyllaceae	No	No	No	No	No	No	No	Yes	Specialist	Shrub	Priority

** This list of species of interest for the 6 Nature reserves of AlUla County is also provided in database format via supplementary documents*

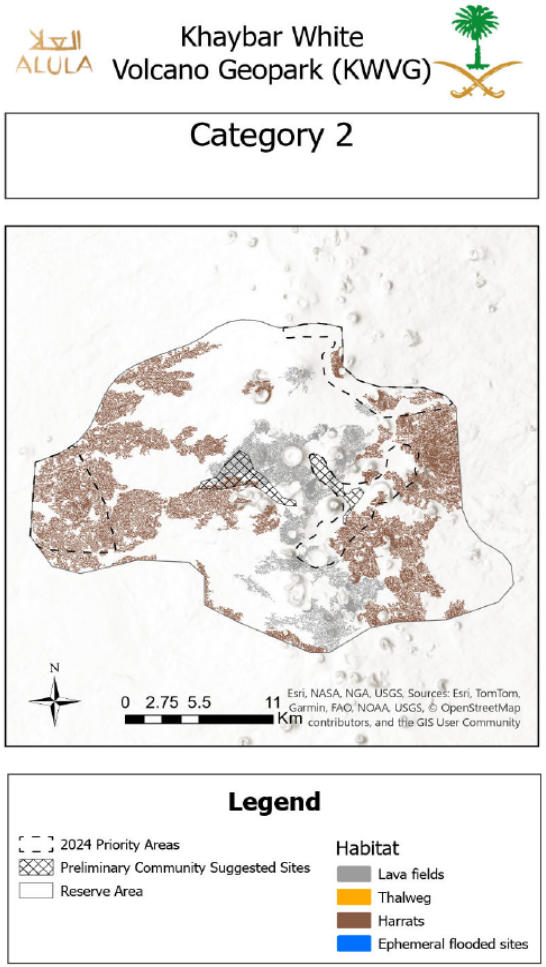
ANNEX (3) - AREAS PER PROTECTED AREA AND HABITAT UNDER CATEGORY 1, 2 AND 3.

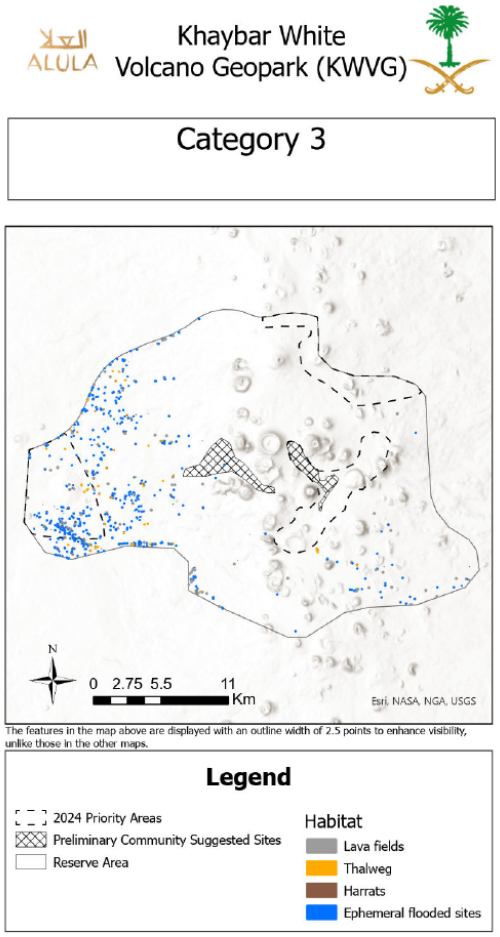
Gharameel Nature Reserve areas per habitat under Category 1, 2 and 3.



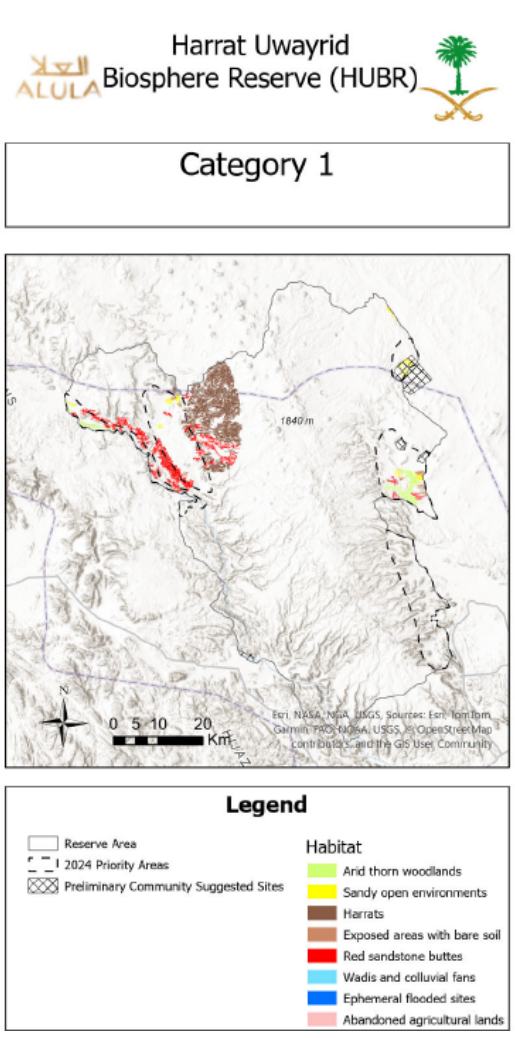
Khaybar White Volcano Geopark areas per habitat under Category 1, 2 and 3.

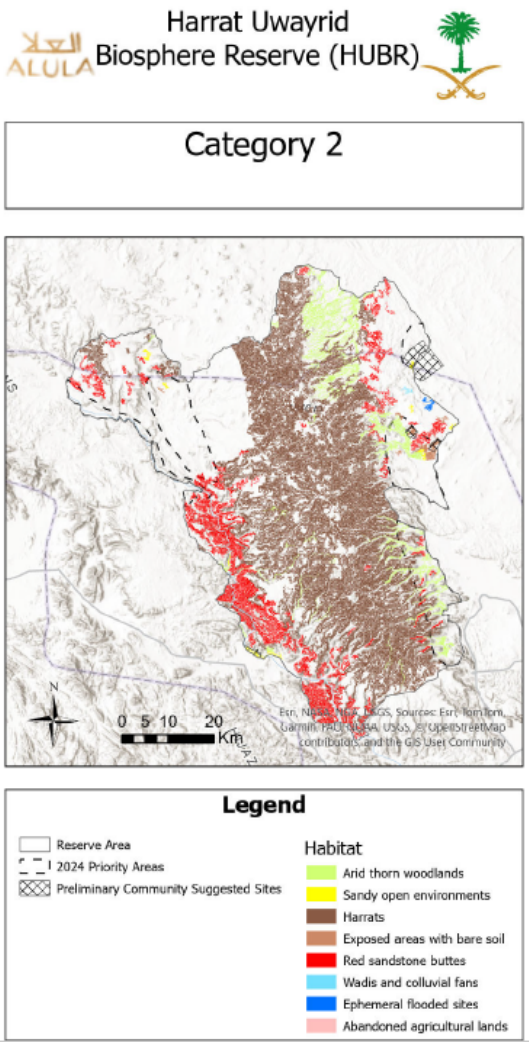


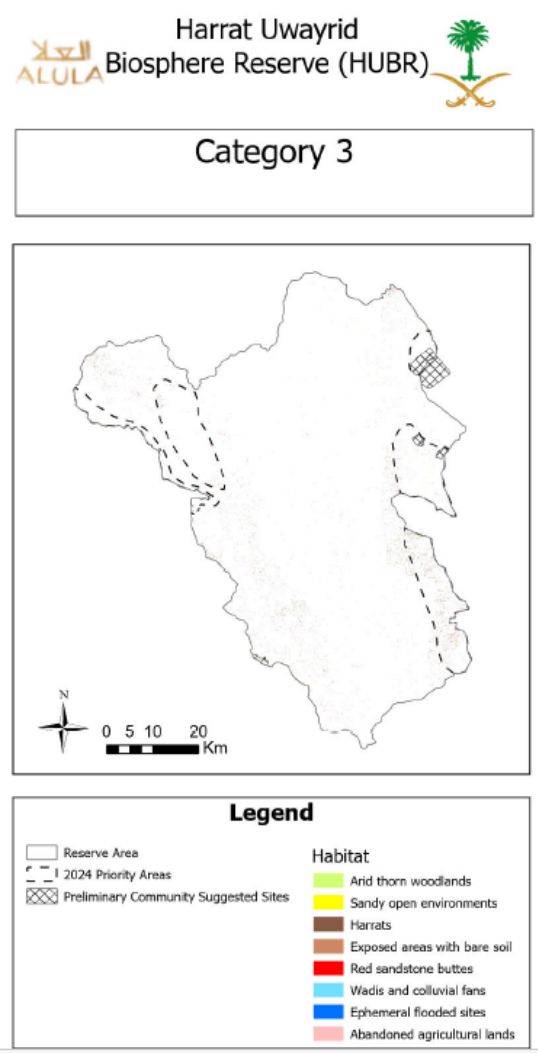




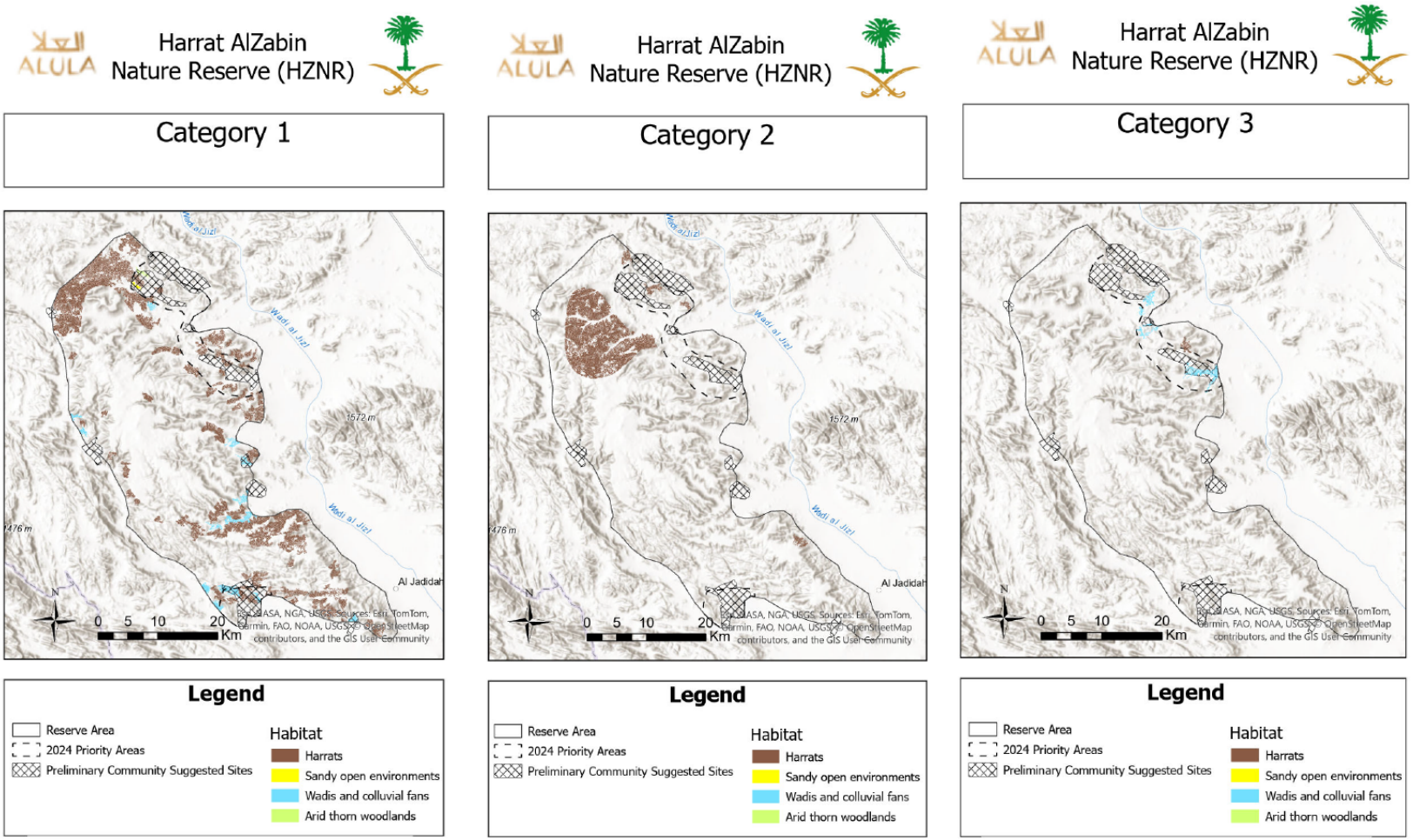
Harrat Uwayrid Biosphere Reserve areas per habitat under Category 1, 2 and 3.



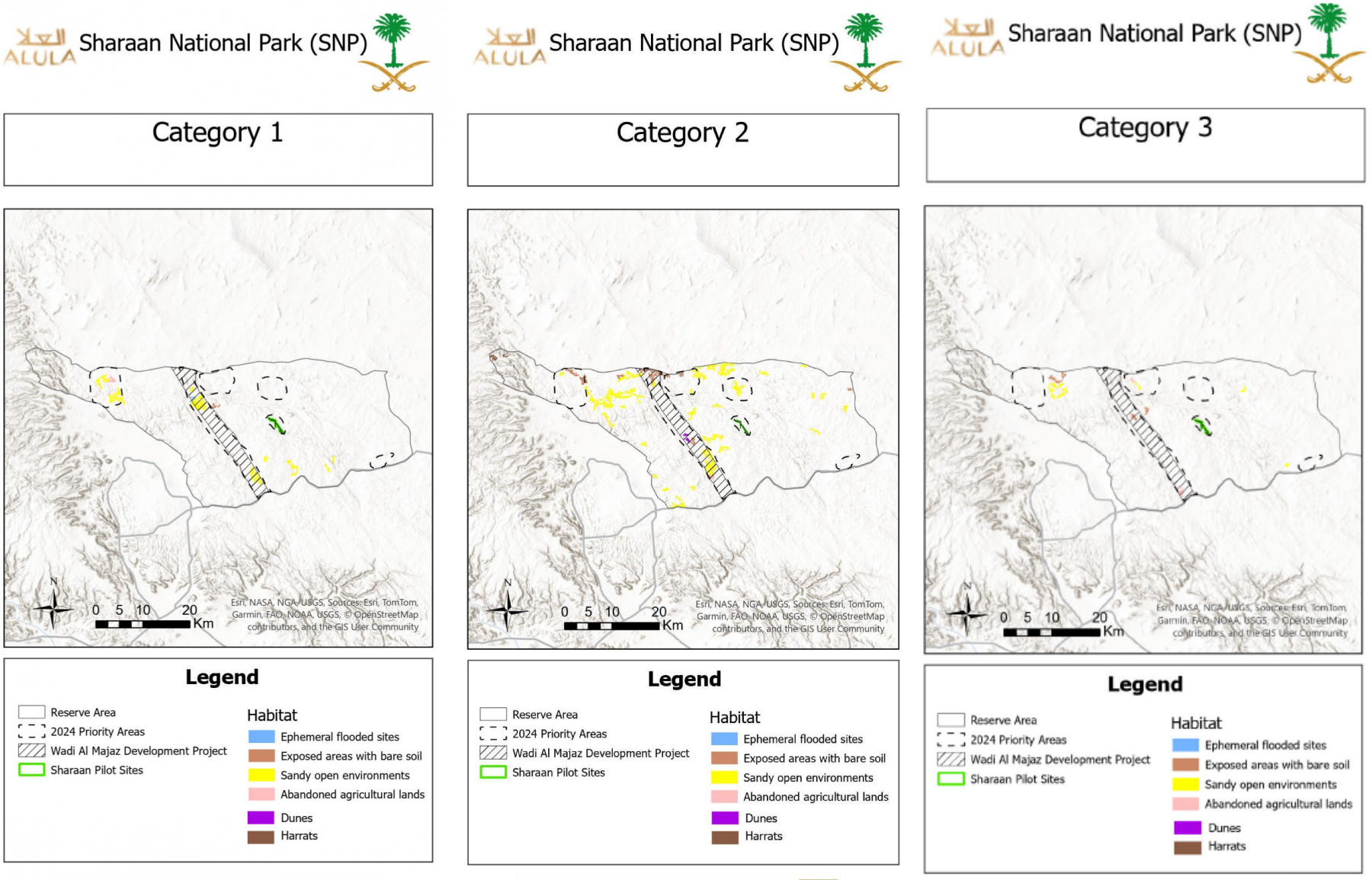




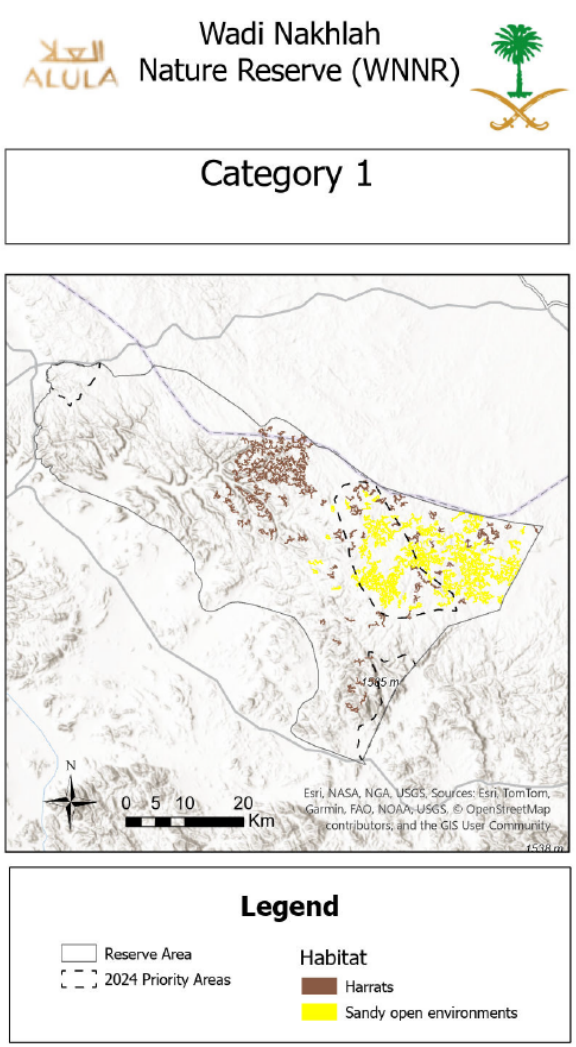
Harrat AlZabin Nature Reserve areas per habitat under Category 1, 2 and 3.

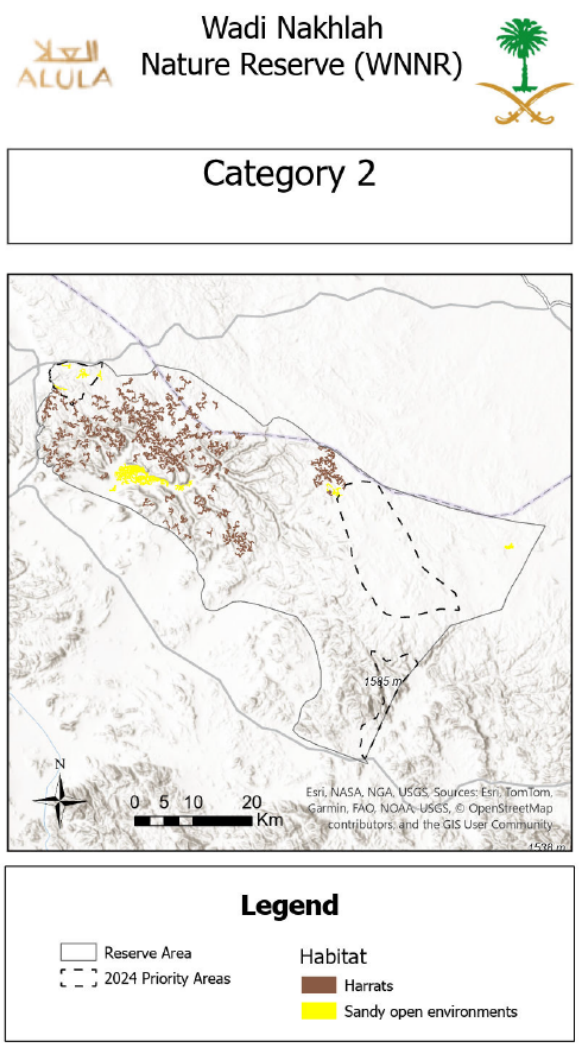


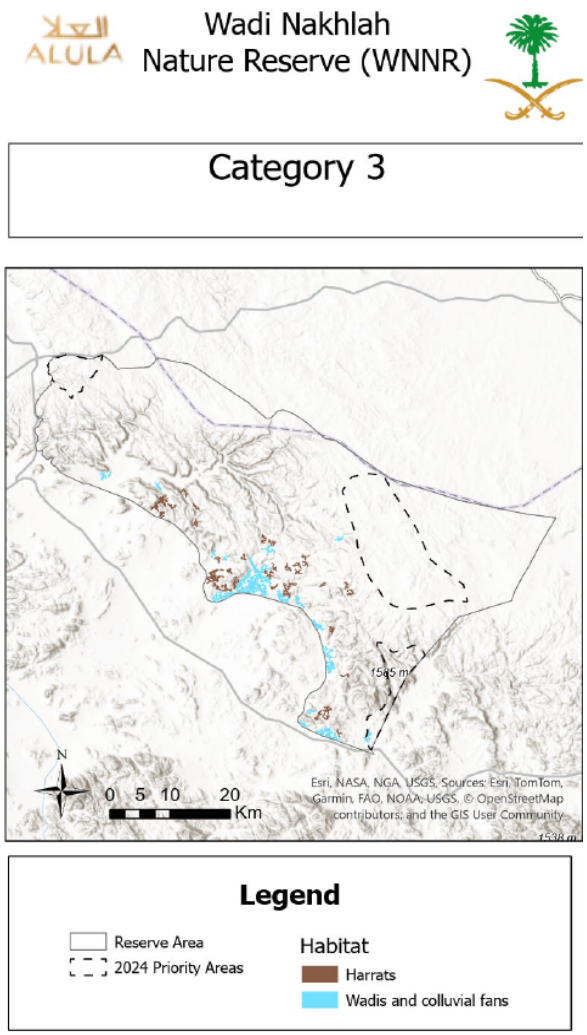
Sharaan National Park areas per habitat under Category 1, 2 and 3.



Wadi Nakhlah Nature Reserve areas per habitat under Category 1, 2 and 3.







الهيئة الملكية لمحافظة العلا

ROYAL COMMISSION FOR ALULA