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Co-Design Ecological Masterplanning: Insights From the Moroccan Oases of Abaynou and Targua N'Touchka

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Abstract

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Abaynou and Targua N'Touchka are Moroccan oases landscapes, historically shaped by ancestral water systems, spring-fed irrigation, permaculture traditions, and long-standing agro-cultural practices. Today, both sites face accelerating pressures from climate change, water scarcity, ecological degradation, and shifting socio-economic conditions. Recognising their cultural significance and ecotourism potential, the Moroccan government has initiated masterplans and pilot projects for their revitalisation. This paper examines their shared environmental, socio-cultural characteristics, critically evaluates the planning approaches adopted in both cases. Through field assessments, spatial analysis, and participatory workshops. The masterplans articulated community priorities such as rehabilitating irrigation networks, improving public areas, and regenerating agro-forestry systems. Results indicate that small-scale, context-sensitive interventions, combined with community-led ecotourism, can strengthen local livelihoods while preserving cultural identity. The paper argues that integrating ecological restoration with traditional knowledge offers a robust framework for regenerating oasis environments and demonstrates the value of participatory design in guiding sustainable development in vulnerable environments.

Keywords: Oasis Revitalisation; Cultural Landscape; Ecotourism; Water Systems; Community Participatory.

1. Introduction

Oasis landscapes are intricate socio-ecological environments formed over time through sustained interactions between natural processes and human activities, including ancestral water management, irrigation systems, and agroforestry traditions. In southern Morocco, oases such as Abaynou (Province of Guelmim) and Targua N'Touchka (Province of Agadir) embody these relationships, where ecological balance and cultural practices are closely intertwined. However, these systems are increasingly under pressure from climate change, water scarcity, ecological degradation, and shifting socio-economic conditions. These dynamics are contributing to the decline of traditional agricultural practices, land abandonment, and the weakening of local livelihoods. In response, recent national initiatives have sought to revitalise oasis regions through masterplanning strategies that integrate environmental restoration with economic development, particularly through ecotourism. Within this context, this paper examines how co-designed ecological masterplanning can support the regeneration of oasis environments. Focusing on the cases of Abaynou and Targua N'Touchka, the study analyses how participatory processes inform planning strategies and how similar methodologies produce different spatial and socio-economic outcomes depending on local conditions.

The paper contributes to current debates on sustainable planning in vulnerable landscapes by demonstrating that ecological masterplanning must be context-specific, multidisciplinary, adaptive, and grounded in local knowledge systems. It argues that co-design provides a critical framework for bridging ecological restoration, community needs, and development strategies in oasis environments. The study addresses the following research question: How can co-designed ecological masterplanning contribute to the regeneration of oasis systems while supporting local livelihoods and preserving cultural identity?

2. Literature Review

Oasis landscapes are increasingly understood as complex socio-ecological systems shaped by long-term interactions between environmental processes, cultural practices, and economic activities. Rather than functioning as isolated agricultural units, oases operate as integrated systems structured by water availability, land management, and social

organisation. In arid environments, reliable water sources enable the emergence of highly organised landscapes in which ecological and human systems co-evolve. As such, oases can be defined as adaptive systems developed to manage, distribute, and sustain livelihoods over time. Recent research highlights the importance of water-dependent cultural ecosystem services in maintaining social cohesion and collective identity, particularly in regions such as the Middle Drâa Valley (Choumane et al., 2025). This perspective reinforces the understanding of oases as living cultural landscapes. Their historical depth and adaptive capacity are further evidenced through geoarchaeological and spatial analyses, where soil stratification reflects long-term agricultural adaptation (Hamed et al., 2021), while global assessments point to cycles of expansion, transformation, and increasing degradation (Santoro et al., 2026).

At the core of oasis systems lies the integration of water management and agricultural practices that together generate distinctive productive and microclimatic conditions. Traditional irrigation networks, including *seguias*¹, *foggaras*², and *qanats*³, distribute water through gravity-fed systems that structure both cultivation and settlement patterns (Angelakis et al., 2025). These hydraulic systems are closely associated with multi-layered agricultural configurations, commonly described as three-tier systems composed of ground crops, intermediate fruit trees, and upper-layer palm canopies. This vertical organisation enhances biodiversity, reduces evapotranspiration, and creates shaded microclimates that support cultivation under harsh climatic conditions. At the same time, settlement structures, building techniques, and collective water governance reflect strong social cohesion and locally embedded management systems, further reinforcing the role of oases as integrated socio-ecological landscapes (Choumane et al., 2025; Hamed et al., 2021).

Despite their historical resilience, oasis systems are increasingly under pressure from environmental and socio-economic transformations. Climate change, prolonged drought, and desertification are altering hydrological cycles, reducing recharge rates, and intensifying water scarcity (Hussain et al., 2024). Concurrently, the expansion of modern irrigation technologies, particularly groundwater pumping, has shifted water use from collective surface-based systems to individualised extraction practices. This transition disrupts traditional governance structures and accelerates aquifer depletion. These dynamics are further compounded by fragmented institutional frameworks in Morocco, where overlapping mandates between basin agencies, agricultural institutions, and local administrations limit coordinated groundwater regulation, despite formal permit systems (El Amrani, 2022; Ghiotti et al., 2015; Nsengimana, 2024).

In parallel, agricultural practices within oasis systems have undergone significant transformation. The expansion of market-oriented agriculture has introduced water-intensive crops and monoculture systems that prioritise productivity over ecological balance. These practices compete with traditional smallholder systems for limited water resources and contribute to soil degradation and biodiversity loss (Benfetta et al., 2017). Additional pressures, including overgrazing and land abandonment, further destabilise ecological equilibrium and accelerate processes of degradation (Kuper et al., 2018). Together, these transformations highlight the increasing fragility of oasis systems under combined environmental and socio-economic stressors.

In response, the literature emphasises the need for integrated and adaptive approaches to dryland management. Ecological restoration has emerged as a key framework, focusing on restoring ecosystem functionality rather than implementing isolated interventions. In arid environments, this includes strategies such as assisted regeneration, the use of drought-resistant species, and soil and water conservation techniques (O'Connor et al., 2024). Agroforestry, in particular, has gained prominence as an approach that reintroduces multi-layered vegetation systems, enhancing soil quality, improving water retention, and increasing biomass while aligning closely with traditional oasis practices (Mekuria et al., 2018; Ozel et al., 2021). Complementary approaches such as permaculture emphasise closed-loop systems and resource efficiency, while advances in ecological engineering, including water-saving irrigation technologies and soil enhancement methods, expand the range of tools available for restoring degraded dryland systems (Li et al., 2022). Together, these approaches demonstrate the importance of combining traditional knowledge with contemporary scientific innovation.

Beyond ecological and technical strategies, increasing attention is given to participatory and community-centred approaches in addressing the complexity of vulnerable environments. Co-design methodologies enable the integration of local knowledge, stakeholder perspectives, and context-specific needs into planning processes, particularly in regions where livelihoods are closely tied to environmental conditions (Aziz Amen & Ali, 2025; Amen et al., 2024). Recent studies show that participatory approaches can support adaptive responses to climate change by facilitating collaboration between communities and experts and aligning development strategies with local priorities (Nhamo et al., 2025). Within this framework, community-based ecotourism has emerged as a complementary strategy linking environmental conservation with local economic development. By prioritising local ownership and participatory governance, ecotourism can contribute to income generation while reinforcing environmental stewardship and cultural preservation (Kunjuraman et al., 2022; Zharkimbayeva et al., 2021). However, the literature also highlights risks associated with poorly managed tourism, including environmental degradation and unequal distribution of benefits, underscoring the need for its integration within broader ecological and spatial planning frameworks.

Collectively, the literature demonstrates a growing convergence between ecological restoration, participatory design, and community-based development approaches. However, these domains often remain fragmented in both research and practice. This gap highlights the need for integrative frameworks capable of linking environmental processes, social dynamics, and spatial planning. In this context, co-designed ecological masterplanning emerges as a promising approach for addressing the multidimensional challenges of oasis environments and guiding context-sensitive, sustainable development strategies.

3. Case Study Context

This section presents the two case studies of Abaynou and Tragua N'touchka as constrained yet comparable oasis systems. While both are shaped by long standing relationships between water management, agriculture, and settlement patterns,

they differ significantly in their geomorphology, accessibility, and socio-economic dynamics. These differences provide a critical basis for evaluating how ecological masterplans and participatory approaches respond to diverse territorial conditions. Both oases are situated within the arid to semi-arid climatic zone of southern Morocco, characterised by low and irregular annual precipitation, high evaporation rates, and pronounced seasonal and inter-annual variability. Abaynou, located near the Atlantic coast at the foothills of the Anti-Atlas, experiences a pre-Saharan climate moderated by maritime influence, with mild winters and hot, dry summers. Targua N'Touchka, situated further inland within the mountainous Anti-Atlas, falls within a semi-arid mountain climate marked by greater diurnal temperature variation, cooler winters, and higher exposure to seasonal rainfall events that feed its wadi system. These differing climatic conditions directly shape water availability, agricultural calendars, and the ecological dynamics of each oasis.

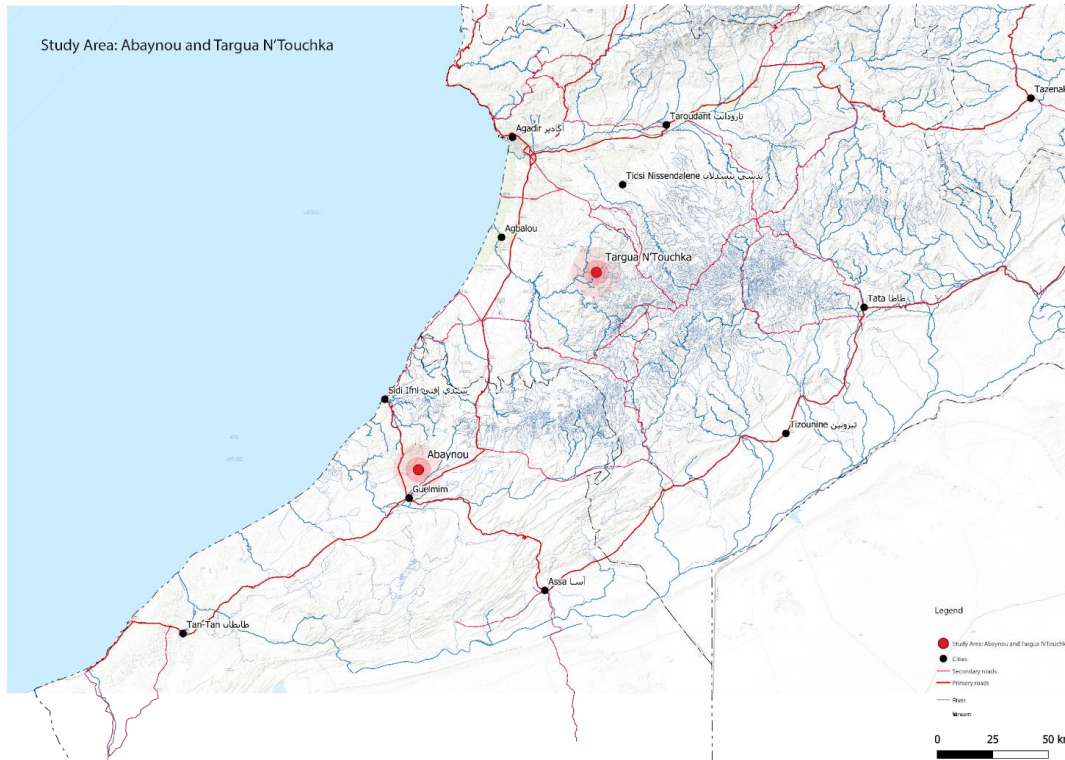


Figure 1. Location and environmental context of Abaynou and Targua N'Touchka in southern Morocco, illustrating their position within the Anti-Atlas region and their relationship to regional hydrological systems and infrastructure.

3.1 Geographic and Environmental Context

Abaynou and Targua N'Touchka are located within the Anti-Atlas region of southern Morocco, yet occupy distinct environmental settings that directly influence their spatial organisation and ecological functioning.

Abaynou is situated approximately 10 km north of Guelmim, at the interface between the Anti-Atlas foothills and a seasonal wadi system. The oasis is formed within a *cone de déjection*, where a confined valley expands into an alluvial plain. This geomorphological condition supports a hybrid hydrological system combining episodic flood-based irrigation with continuous supply from thermal springs. Flood events contribute to soil fertility through sediment deposition, while the springs provide a stable water source for perennial cultivation. Water distribution occurs through a network of channels, partially transformed in recent decades, with approximately 40% of traditional earthen seguias replaced by concrete infrastructure. While this reduces conveyance losses, it also limits groundwater recharge and alters hydrological balance, reflecting broader material transitions observed in Moroccan rural contexts (Bagaganan, 2022; INRA Maroc; Architecture en Terre Crue, 2022).

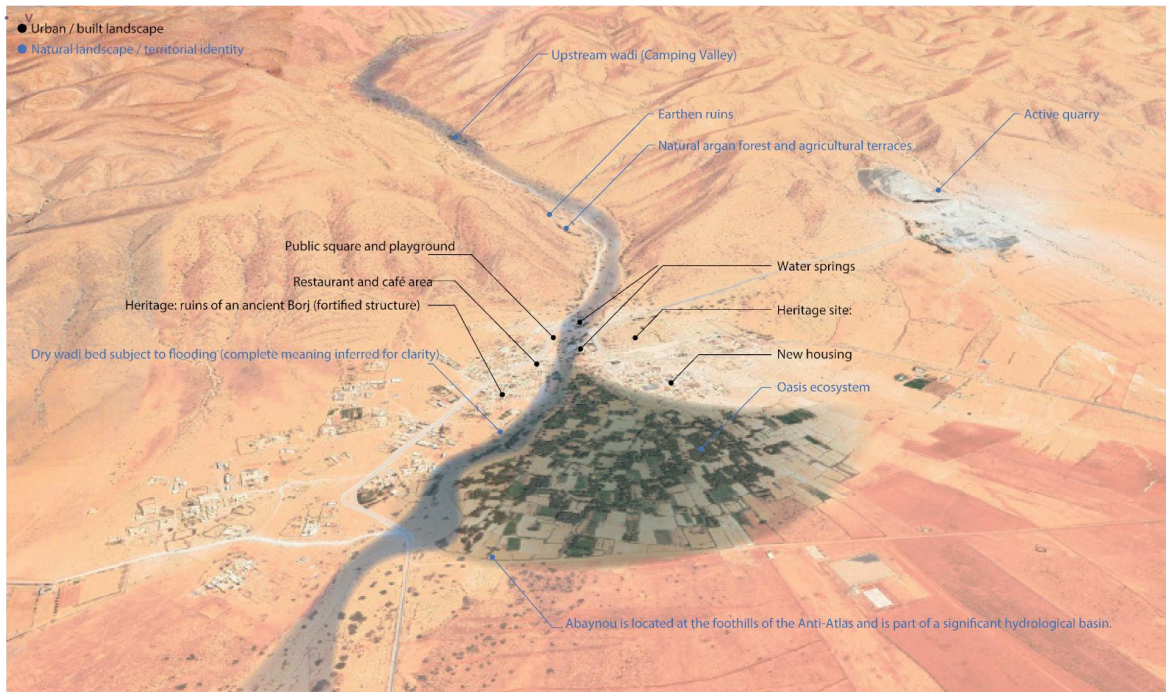


Figure 2. Aerial view of Abaynou oasis and its surrounding landscape, identifying key natural and built features including the wadi system, agricultural terraces, heritage sites, and expanding settlement areas within a broader hydrological basin.

The broader landscape is structured through three interconnected systems: mountainous slopes with sparse vegetation including argan and olive trees; wadi corridors shaped by intermittent flows and drought-resistant species such as acacia; and the oasis itself, organised as a multi-layered agroforestry system. This vertically stratified structure enhances biodiversity, reduces evapotranspiration, and contributes to microclimatic regulation (Mekuria et al., 2018; Hussain et al., 2024). Positioned between enclosed mountainous terrain and an open floodplain, the oasis functions as the ecological and productive core of the settlement. However, reduced maintenance and changing land-use practices have contributed to increasing ecological fragility and declining agricultural productivity (Santoro et al., 2026).

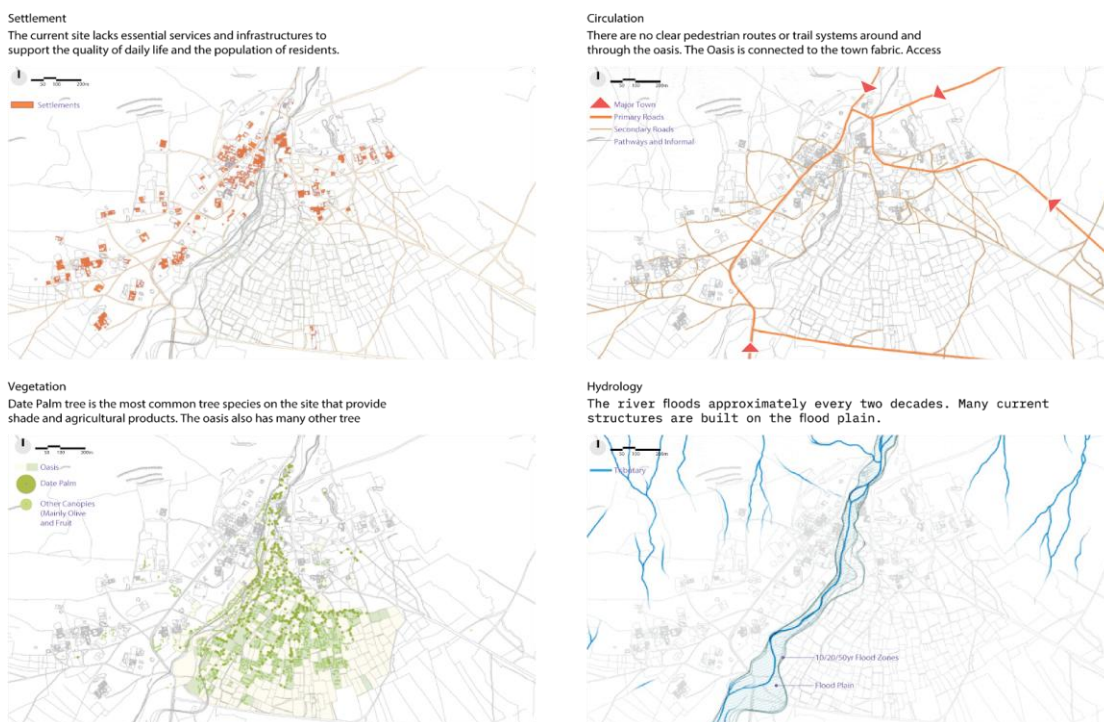
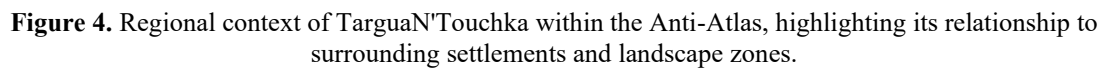


Figure 3. Diagnostic map identifying constraints and opportunities affecting ecotourism development in Abaynou.

In contrast, Targua N'Touchka is a mountainous oasis characterised by steep topography, strong spatial enclosure, and a rainfall-dependent hydrological regime. The system is structured through the convergence of multiple wadis descending from surrounding catchments, forming a cultivated core with a star-shaped spatial configuration. Water distribution relies on gravity-fed channels aligned with topography, yet remains irregular and uneven due to dependence on seasonal rainfall.



The landscape similarly consists of three interdependent systems: mountainous terrain with minimal vegetation; wadi corridors transporting seasonal flows and sediment; and cultivated areas organised along irrigation lines. Agricultural plots are often terraced or elongated, reflecting adaptation to terrain but resulting in a fragmented spatial structure with limited expansion potential. Compared to Abaynou's more continuous agroforestry system, Targua N'Touchka exhibits a more dispersed and environmentally sensitive configuration. Its geographic isolation and limited infrastructure further reinforce its vulnerability to climatic variability, contributing to declining agricultural productivity and system fragility.

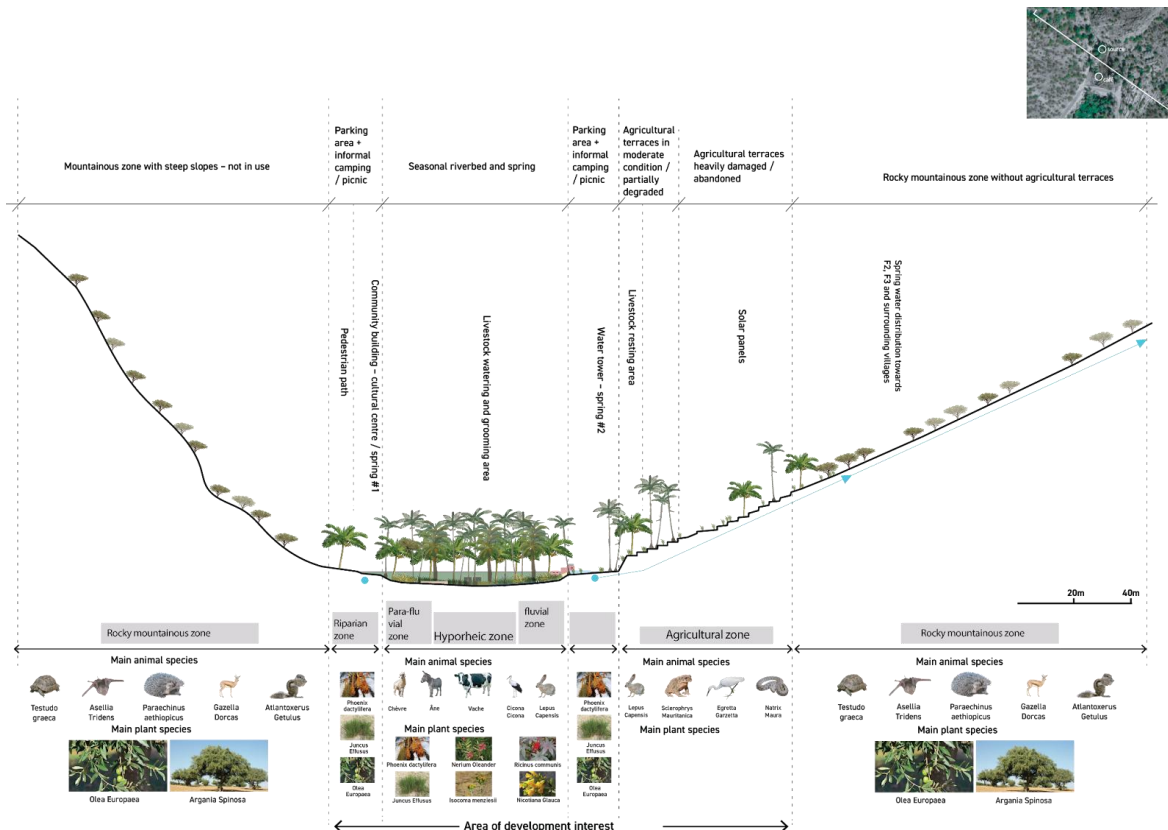


Figure 5. The valley section of Targua N'Touchka's current context illustrates the spatial relationship between wadi, oasis vegetation, agricultural terraces, and surrounding mountainous terrain.

Together, these two cases illustrate how differences in hydrological regimes and topographic conditions directly shape the structure, productivity, and resilience of oasis environments.

3.2 Socio-Cultural Context

Although both oases function as socio-cultural landscapes where livelihoods and spatial organisation are tied to ecological systems, their roles within wider territorial networks differ significantly. Abaynou operates as both a productive landscape and a regional socio-cultural node: its proximity to Guelmim makes it an accessible destination for leisure and wellness uses linked to the thermal springs, which coexist with agricultural production. At the settlement scale, the progressive replacement of earthen construction with concrete and road-driven expansion have produced more dispersed development patterns, weakening historically integrated relationships between habitation, water systems, and agricultural land.

In contrast, Targua N'Touchka is characterised by a more localised and environmentally dependent socio-cultural system. Geographic isolation restricts external interaction and constrains economic diversification, while social practices remain tied to subsistence agriculture and water management. Ongoing population decline and rural exodus have reduced agricultural labour, contributing to the deterioration of irrigation infrastructure and further fragmentation of the oasis system. These contrasting dynamics underscore that socio-cultural processes do not merely respond to environmental conditions but actively shape the resilience and transformation of oasis systems.

3.3 Planning Context and Existing Initiatives

Planning initiatives at both sites aim to revitalise the oasis systems through ecological restoration and sustainable development, but diverge in response to local conditions. In Abaynou, planning builds on the site's accessibility and emerging regional role: thermal springs and the productive agroforestry system support integrated agritourism and wellness-based strategies, with priorities including restoring connectivity between settlement and oasis, addressing ecological imbalances caused by infrastructural transformations, and enhancing public space. In Targua N'Touchka, by contrast, steep topography, fragmented agricultural systems, and variable water availability restrict large-scale interventions, leading to an incremental, adaptive approach focused on stabilising irrigation networks, supporting small-scale agriculture, and addressing land abandonment. Together, the two cases show that ecological masterplanning must operate as a flexible, context-responsive framework: Abaynou leverages accessibility and socio-economic opportunities to support integrated development, whereas Targua prioritises adaptation, maintenance, and resilience within environmental limits.

Table 1: synthesises the key environmental, socio-cultural, and spatial characteristics of Abaynou and Targua N'Touchka. It provides a comparative overview of the systems that structure each oasis, forming the basis for subsequent analysis of their differing development trajectories and planning responses.

Category	Abaynou	Targua N'touchka
Geographic Setting	Located ~10 km north of Guelmim at the interface of the Anti-Atlas foothills and an alluvial floodplain (cone de déjection)	Mountain oasis in the Anti-Atlas, embedded within steep and enclosed terrain with limited expansion capacity
Hydrological System	Hybrid system combining flood-based irrigation and thermal spring water (continuous supply)	Rainfall-dependent system structured by multiple converging wadis with seasonal and irregular flows
Water Infrastructure	Traditional seguias partially transformed; ~40% replaced by concrete channels, affecting groundwater recharge	Predominantly gravity-fed irrigation; uneven water distribution across plots; limited storage and regulation capacity
Ecological Structure	Continuous agroforestry system with three layers (palms, fruit trees, ground crops), supported by stable water availability	Fragmented agricultural system organised along wadis; dispersed plots with strong dependency on topography and rainfall
Landscape Systems	Three interconnected systems: mountains (argan/olive), wadi (acacia), oasis (dense agroforestry)	Three systems: steep mountains (sparse vegetation), wadis (seasonal flow), dispersed cultivated patches
Spatial Configuration	Transition from enclosed mountains to open floodplain; oasis acts as a central productive core	Star-shaped configuration structured by multiple wadis; fragmented and spatially dispersed system
Accessibility	Relatively accessible; strong connection to Guelmim and surrounding regions	Isolated and difficult to access, distant from major urban centres (e.g., Agadir)
Socio-Cultural Role	Functions as a regional leisure and wellness destination; weekly use for recreation and thermal bathing	Primarily subsistence-based, with limited external interaction and no significant tourism activity
Settlement Morphology	Two historical cores; expansion influenced by road infrastructure; increasing disconnection from oasis	Dispersed settlement pattern directly linked to water access and agricultural plots
Material Transformation	Transition from earthen to concrete construction in buildings and irrigation systems	Predominantly vernacular structures, with increasing deterioration due to lack of maintenance
Demographic Trends	Moderate transformation with continued activity and external attraction	Population decline and rural exodus, leading to reduced agricultural labour
Key Pressures	Urban–oasis disconnection, hydrological imbalance due to concrete channels, changing land use	Water scarcity, isolation, land abandonment, infrastructure degradation
Planning Approach	Opportunity-driven: agritourism, wellness, public space enhancement, irrigation rehabilitation	Constraint-driven: system stabilisation, small-scale agriculture support, adaptive management
Participatory Focus	Identifying development opportunities (tourism, public space, accessibility improvements)	Identifying constraints and prioritising feasible, low-resource interventions

4. Methodology

This study utilised qualitative, design-research methodology combining field-based investigation, spatial analysis, and participatory approaches. The methodology is structured to capture both physical characteristics of the oasis landscape

and socio-cultural dynamics that shape their use and transformation. The approach is applied comparatively across the two case studies, Abayou and Targua N'touchka, in order to identify both shared patterns and context-specific conditions.

4.1 Field Assessments

Field assessments constituted the primary empirical basis of the research, enabling direct observation of environmental conditions, spatial configurations, and everyday practices within each oasis system. Site visits included systematic exploration of agricultural areas, irrigation networks, settlement structures, and public spaces, supported by photographic documentation and ecological readings focusing on water flows, vegetation patterns, and land-use conditions.

Fieldwork was conducted through multiple visits across both sites, with three visits in Abaynou and two in Targua N'Touchka, each lasting approximately one week. The process involved engagement with a range of stakeholders, including local authorities, agricultural actors, technical experts, and community representatives. These interactions provided contextual insight into environmental challenges, agricultural practices, and institutional dynamics. Field assessments therefore combined spatial observation with stakeholder engagement, forming a grounded understanding of both physical systems and lived experiences.

4.2 Spatial Analysis

Spatial analysis was employed to translate field observations into structured representations of the oasis landscapes. The analysis focused on identifying key systems organising each site, including topography, hydrology, land use, built form, and circulation networks.

In Abaynou, spatial analysis was developed through thematic mapping based on satellite imagery and field interpretation. This included the identification of hydrological relationships between the thermal spring, wadi system, and irrigation networks, as well as distinctions between natural and constructed water flows. Land-use mapping differentiated between active, degraded, and abandoned agricultural zones, while analysis of the built environment revealed a transition from compact earthen settlements to more dispersed patterns associated with contemporary construction. Circulation mapping highlighted increasing disconnection between residential areas and the oasis, indicating a weakening relationship between habitation and productive landscapes.

In Targua N'Touchka, spatial analysis was conducted primarily at territorial and landscape scales based on available project documentation. The analysis focused on relationships between water sources, agricultural terraces, settlement clusters, and circulation routes within a mountainous context. This revealed a decentralised system structured by multiple wadis, where the oasis operates as a distributed ecological core rather than a centralised entity. Additional mapping of cultural and infrastructural elements provided insight into patterns of use, decline, and potential areas for intervention. Compared to Abaynou, the analysis remained more interpretive, reflecting differences in data availability and project scope.

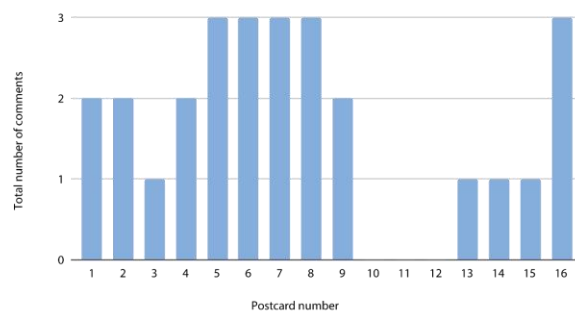
4.3 Participatory Workshops and Co-Design Process

Participatory workshops formed a central component of the methodology, supporting the integration of local knowledge and stakeholder perspectives into the planning process. A co-design approach was adopted to facilitate inclusive engagement and to align proposed strategies with local needs, priorities, and constraints.

In Abaynou, the process was structured through a series of mixed-gender workshops involving diverse stakeholder groups, including farmers, residents, cooperative members, and tourism actors. Two complementary co-design tools were developed for these sessions. First, a bilingual questionnaire in Arabic and French was distributed to participants, organised around thematic sections addressing water systems, agriculture, infrastructure, accommodation, public space, and community priorities. The bilingual format ensured accessibility across literacy levels and language preferences. Second, a programme board game was used in which participants received themed cards, each colour corresponding to a programmatic theme such as infrastructure, water, accommodation, or agriculture, paired with images illustrating concrete project propositions. Participants were asked to place two cards per theme on a base map of the oasis: one indicating their preferred location for a given programme, and one indicating where it was most needed. This approach encouraged dialogue, negotiation, and collective prioritisation among team members. Outputs were documented and synthesised into graphical and thematic representations informing the masterplanning process.

In Targua N'Touchka, given the more conservative cultural context of the community, workshops were conducted with gender-separated groups to ensure full and comfortable participation. Three participatory tools were used in combination. The first was a postcard game, in which participants commented on a curated set of landscape photographs of the oasis, identifying valued elements as well as sources of concern (Figure 6). The second was a circulation game, in which wool threads of different colours were laid over a base map to trace daily movement patterns, livestock routes, and seasonal pathways, revealing how the territory is actually used and navigated. The third was the same programme board game used in Abaynou, adapted to the thematic priorities of Targua N'Touchka. Stakeholder input across these tools focused on identifying constraints, resource limitations, and feasible intervention strategies. The outcomes were synthesised into qualitative insights guiding context-sensitive planning responses.

Number of comments left by participants per postcard



Most commented postcards



Figure 6. Participatory workshop outputs from Targua N'Touchka showing the most frequently commented landscape elements, highlighting key community concerns such as irrigation system degradation, environmental risks, and waste accumulation.

4.4 Synthesis and Comparative Approach

The final stage of the methodology involved the synthesis of data collected through field work, spatial analysis, and participatory engagement. While the initial research process did not include a formal comparative framework, the availability of the two complemented project reports for Abaynou and Targua N'touchka enabled the development of structured comparison to better understand how similar design approaches respond to distinct environmental and social spatial conditions.

To support this analysis, a comparative matrix was constructed using key indicators derived from both reports, including hydrological systems, land use patterns, agricultural practices, settlement structure, and the scale and distribution of proposed interventions. Rather than relying on exhaustive quantitative data sets, which were not consistently available across both cases, the comparison focuses on qualitative and spatially grounded indicators that directly inform planning and design strategies.

Table 2 presents a comparative synthesis of environmental systems, spatial structures, and socio-economic dynamics alongside their corresponding masterplanning strategies. It supports the evaluation of how similar participatory approaches produce differentiated outcomes under varying territorial conditions.

Category	Indicator	Abaynou Oasis	Targua N'Touchka Oasis
Environmental & Hydrological Systems	Water source type	Hybrid system (thermal spring + flood-based irrigation)	Spring-fed system with multiple water sources (Ain Targua, Ain Tizki)

	Hydrological structure	Wadi-based flooding combined with spring channels	Integrated hydrographic network including springs and cascades
Agricultural Structure & Land Use	% cultivated land	—	~33% of oasis actively cultivated
	Agricultural system	Multi-layer agroforestry system (palm–tree–shrub–ground crops)	Mixed system combining cultivation and naturally sustained vegetation
	Land management	Locally managed agricultural plots	~90% cultivated by external farmers from nearby villages
	Irrigation transformation	Approx. 40% of traditional seguias converted to concrete	Traditional system supported by continuous water availability
	Ecological condition	Declining productivity and fragmentation of cultivated areas	Stable vegetation, including in non-cultivated areas due to water availability
Built Environment & Spatial Structure	Settlement pattern	Linear development along the wadi edge	Dispersed settlement across mountainous terrain
	Historical structure	Two original earthen settlement cores	Multiple dispersed douars integrated within the landscape
Socio-Economic & Tourism Dynamics	Tourism role	Regional leisure destination linked to thermal water use	Emerging eco-tourism landscape connected to natural and cultural assets
	Tourism infrastructure	Existing leisure use (thermal baths)	Identified network of cultural, ecological, and hiking destinations
Masterplan Intervention Logic	Intervention scale	Large-scale, multi-programmatic across the oasis	Localised, focused on the spring and immediate surroundings
	Public space strategy	Multiple distributed interventions	Concentrated interventions around the water source
	Accommodation strategy	Proposed eco-tourism development integrated into oasis system	Limited and emerging, linked to regional tourism network
Spatial Dynamics (Comparative Insight)	Agricultural continuity	Fragmented and reduced over time	Stable and continuous, even where not actively cultivated
	Landscape evolution	Progressive degradation linked to water stress and maintenance gaps	Ecological persistence supported by consistent water availability

5. Comparative Analysis of Ecological Masterplanning Approaches

The comparative analysis of Abaynou and Targua N'Touchka shows how a shared ecological and participatory methodology can produce divergent masterplanning outcomes across distinct environmental and institutional contexts. Although both projects are grounded in water-sensitive planning and co-design, their spatial strategies, intervention scales, and implementation frameworks diverge significantly due to differences in water availability, governance, and financial capacity.

Water systems operate as the primary generative framework in both masterplans, structuring spatial organisation, programmatic distribution, and intervention strategies. In Abaynou, hydrological analysis revealed critical risks associated with flood-prone areas, particularly the location of existing thermal facilities within the wadi floodplain. This condition necessitated the relocation of the thermal complex outside the flood zone, a decision that fundamentally restructured the spatial hierarchy of the masterplan. Water variability and seasonal flooding thus acted as drivers of redistribution, leading to a reorganisation of circulation, land use, and programme allocation. Furthermore, the analysis of irrigation systems identified inefficiencies caused by the replacement of traditional earthen *seguias* with concrete channels, prompting strategies aimed at improving water management while preserving agricultural productivity. These interventions included the introduction of controlled access routes and a peripheral activity belt, ensuring the protection of cultivated areas while enabling public engagement. In contrast, Targua N'Touchka benefits from relatively stable water availability, supported by multiple permanent springs and a resilient hydrographic network. Rather than responding to risk, the masterplan focuses on optimising existing resources and reinforcing ecological continuity. The spring functions as the central ecological and social anchor, around which spatial organisation is concentrated. This results in a more compact and incremental planning logic, where interventions are localised and designed to enhance existing systems rather than restructure them. The comparison highlights that water systems not only define environmental conditions but also produce distinct design logics: a redistributive approach in contexts of scarcity and risk, and a consolidating approach in contexts of stability.

Beyond environmental factors, institutional frameworks play a decisive role in shaping planning outcomes. In Abaynou, the project was commissioned by the Région de Guelmim with sufficient financial and organisational capacity to support a multidisciplinary design process and a phased implementation strategy. Although initially conceived as a site-specific intervention focused on the thermal spring, the project evolved into a comprehensive ecological masterplan integrating environmental restoration, agricultural revitalisation, and tourism development. This expansion was facilitated by institutional support, enabling the translation of design concepts into a detailed operational framework.

Conversely, the Targua N'Touchka project, commissioned by the Société de Développement Régional du Tourisme (SDRT), operated under more constrained conditions. While the project similarly expanded from a site-specific intervention to a broader territorial vision, limited financial resources and shorter timelines restricted its development to a strategic and conceptual level. The masterplan functions primarily as a guiding framework for future interventions rather than a fully resolved implementation plan. This distinction underscores the importance of governance and resource availability in determining whether ecological masterplanning can progress from vision to execution.

These institutional differences are reflected in the planning logics of the two projects. Abaynou adopts a comprehensive, phased approach structured around three main stages. The first phase focuses on environmental restructuring and the relocation of key infrastructure, including the thermal complex, alongside the development of circulation systems and public spaces. The second phase addresses the rehabilitation of the village and the introduction of accommodation typologies, linking tourism with local economic development. The third phase extends the intervention to a broader territorial scale, incorporating surrounding landscapes and creating an integrated ecotourism network. This multi-scalar strategy reflects both the ambition and the implementation capacity of the project. In contrast, Targua N'Touchka follows a more flexible and open-ended planning model. The masterplan prioritises the spring as a catalytic node while maintaining a light-touch approach across the wider landscape. Rather than prescribing detailed phases or technical solutions, it establishes a spatial and programmatic framework capable of guiding incremental development. This approach is closely tied to the site's ecological resilience and the limitations of available resources, emphasising preservation and adaptability over transformation.

Landscape and agricultural strategies further illustrate the divergence between the two projects. In Abaynou, the landscape is conceived as an active system of ecological and productive regeneration. The masterplan seeks to expand cultivated areas and enhance agricultural productivity through the integration of permaculture principles. The proposed Centre de permaculture oasienne serves as a key intervention, functioning simultaneously as a training facility, demonstration site, and productive landscape. By linking production, processing, and distribution within a closed-loop system, the project positions agriculture as both an ecological and economic driver. Additionally, controlled access within the oasis and the creation of a surrounding belt of public spaces enable the coexistence of productive and recreational functions. By contrast, the landscape strategy in Targua N'Touchka is characterised by conservation and minimal intervention. Given the relative ecological stability of the oasis, the primary objective is to preserve existing agricultural systems and maintain environmental balance. Rather than introducing new productive frameworks, the project reinforces traditional practices and focuses on enhancing the visitor experience through landscape interpretation. The oasis is framed as a living cultural landscape, where ecological processes and agricultural activities contribute to a sustainable tourism model. This distinction reflects a broader difference in design approach: transformation in Abaynou versus preservation in Targua.

Spatial organisation and circulation strategies further differentiate the two masterplans. In Abaynou, movement is carefully structured through a hierarchy of access, including peripheral parking areas, pedestrian pathways, and controlled routes within the oasis. This system minimises vehicular intrusion and ensures the protection of agricultural areas while

accommodating increased visitor flows. The introduction of a continuous belt of public spaces reinforces the spatial structure, creating transitional zones that mediate between built and cultivated environments. In Targua N'Touchka, spatial organisation is more diffuse and landscape-driven. The complex topography and fragmented morphology of the site limit the feasibility of rigid circulation systems. Instead, the masterplan enhances existing paths and establishes a network of loosely connected nodes centred around the spring. Movement is guided by topography and visual connections rather than formalised infrastructure, reflecting both the project's strategic nature and its lower anticipated visitor pressure. This results in a more adaptive and flexible spatial framework. Participation plays a central role in both projects, shaping not only the design process but also the definition of values and priorities. In both cases, participatory methods were designed to be inclusive and interactive, using co-design tools and game-based approaches to facilitate engagement. These methods encouraged collaboration, negotiation, and collective decision-making, fostering a sense of ownership among stakeholders. Transparency regarding project limitations further strengthened trust and alignment between designers and communities. However, the impact of participation differs in relation to the level of project development. In Abaynou, participatory inputs are translated into concrete design interventions within a structured implementation framework. In Targua, participation primarily informs the overall vision and strategic direction, with fewer direct translations into detailed spatial solutions. This difference highlights the relationship between participation and institutional capacity: while both projects adopt similar methodologies, their outcomes are shaped by the extent to which they can be operationalised.

Overall, the comparison reveals that the translation of ecological principles into spatial form is not determined by environmental considerations alone, but by the interplay between natural systems, institutional frameworks, and implementation capacity. The same design methodology can produce fundamentally different planning models, from detailed, implementation-driven masterplans to open-ended, vision-based frameworks, and this variability is a necessary condition for context-sensitive outcomes in complex socio-ecological systems.

6. Results

The application of the ecological masterplanning framework to Abaynou and Targua N'Touchka produced results that demonstrate both the robustness of the methodology and its capacity to adapt to differing environmental, institutional, and socio-economic conditions. Rather than evaluating the projects through implemented outcomes alone, this section focuses on the spatial, strategic, and systemic transformations articulated through the masterplans.

A primary result is the confirmation that water systems function as the foundational structuring element of ecological masterplanning in oasis environments. In Abaynou, hydrological analysis of the Oued Abaynou, its floodplain dynamics, and the thermal spring system (measured at 8.1 l/s) directly informed the relocation of the thermal complex outside the flood-prone zone, a decision that addressed recurrent flood risk while reorganising the spatial hierarchy of the site around water flows, retention areas, and ecological buffers. In Targua N'Touchka, although the available data is less extensive, water remains equally central: the spring and its surrounding ecological system form the nucleus of the masterplan, and the persistence of vegetation even in abandoned plots produces a planning approach that prioritises preservation over transformation. A second major result concerns the redefinition of the relationship between tourism and agriculture, moving from coexistence to integration.

In Abaynou, the masterplan proposes a hybrid system in which agricultural production becomes a core component of the tourism experience. This is operationalised through the introduction of a centre for oasis permaculture, the diversification of crops (including olives, date palms, and other fruit-bearing species), and the development of value chains for local products. These strategies respond directly to the observed decline in agricultural productivity and the fragility of the oasis ecosystem, transforming agriculture into both an economic driver and a landscape management tool. The result is a productive landscape that supports tourism while maintaining ecological functions, aligning with broader regional objectives for agritourism and sustainable development.



Figure 7. Illustrates the spatial restructuring of Abaynou through the relocation of the thermal complex, the introduction of a peripheral activity belt, and the integration of agricultural and tourism systems.

In contrast, Targua's approach maintains agriculture as a background system that sustains the oasis rather than being restructured by the project. The emphasis is placed on maintaining existing cultivation patterns and ecological conditions, with limited intervention in agricultural practices. Tourism development is therefore more tightly concentrated around the spring and specific nodes, reducing pressure on cultivated land. This divergence highlights a key finding: ecological masterplanning does not prescribe a uniform relationship between tourism and agriculture, but rather calibrates this relationship based on existing conditions and capacities.

The projects also yield significant results in terms of spatial organisation and landscape structuring. In Abaynou, the masterplan introduces a clearly defined spatial framework composed of several interrelated components: a relocated thermal complex, a network of circulation routes, a series of public spaces forming an activity belt around the oasis, and peripheral parking areas designed to limit vehicular intrusion. This spatial configuration transforms the oasis from a relatively inaccessible and fragmented landscape into a structured and legible system, where movement, access, and programme are carefully coordinated. Importantly, access to the interior of the oasis is controlled through designated pathways and guided routes, reflecting the need to balance public use with the protection of agricultural land.

Targua, by comparison, results in a more diffuse and landscape-driven spatial organisation, where interventions are lighter and more dispersed. The absence of extensive infrastructure and the reliance on existing paths produce a system that is less formalised but more directly embedded within the natural landscape. This approach reflects both the ecological sensitivity of the site and the limited resources available for implementation, demonstrating that coherence in masterplanning can be achieved without extensive physical transformation. Another key outcome relates to the role of institutional capacity in shaping the depth and implementability of the masterplans. Abaynou benefits from strong regional support and access to multidisciplinary expertise, enabling the development of a detailed, phased masterplan. The project is structured into three phases, encompassing the thermal complex and public spaces, village regeneration and accommodation, and the expansion of an ecotourism loop connecting surrounding landscapes. This phased approach provides a clear roadmap for implementation, aligning spatial interventions with investment strategies and governance mechanisms.

In Targua, limited institutional resources result in a masterplan that is intentionally more strategic and open-ended. Rather than detailing specific projects and phasing, the plan establishes a vision intended to guide future interventions by local authorities and private stakeholders. While this limits immediate implementability, it ensures flexibility and adaptability over time. The comparison between the two projects demonstrates that the level of detail in ecological masterplanning is not solely a methodological choice, but a function of institutional and financial context. Participation emerges as another critical dimension of the results. In both case studies, participatory workshops and co-design processes contributed to the identification of local needs, priorities, and knowledge systems. These processes utilised interactive and, at times, game-based tools to facilitate engagement across different stakeholder groups. In Abaynou, the outcomes of participation are directly reflected in the spatial and programmatic components of the masterplan, including the emphasis on local agriculture, public spaces, and community-oriented facilities. In Targua, participation plays a more formative role, shaping the overall vision rather than specific design interventions. This distinction reinforces the finding that participation can operate at different levels of influence, depending on the scope and resolution of the planning process. The results also highlight the importance of risk-sensitive planning in oasis environments, particularly in relation to climate change and natural hazards. In Abaynou, the integration of flood risk analysis into the masterplan leads to critical decisions regarding land use, infrastructure placement, and landscape design. The incorporation of measures such as flood protection works, water retention strategies, and the avoidance of construction in high-risk zones demonstrates a proactive approach to resilience. These strategies are essential in a context characterised by low but intense precipitation, high evaporation rates, and increasing climate variability. Finally, the results underscore that ecological masterplanning in oasis contexts operates as a multi-scalar, adaptive process rather than a fixed design solution. Abaynou represents an integrated, implementation-oriented model, while Targua exemplifies a strategic, vision-driven approach, both valid expressions of the same methodological framework, demonstrating its capacity to accommodate variation while maintaining coherence. Table 3 summarises the key differences in design logic and planning outcomes identified through the comparative analysis.

Dimension	Abaynou	Targua N'Touchka
Water system role	Driver of redistribution and spatial restructuring (flood risk + thermal spring)	Stable ecological anchor guiding minimal intervention
Planning approach	Phased, implementation-oriented masterplan with defined stages	Strategic, open-ended framework guiding incremental development

Intervention scale	Large-scale, multi-programmatic across the oasis	Localised and concentrated around key ecological nodes
Spatial organisation	Structured system with defined zones, circulation hierarchy, and activity belts	Diffuse, landscape-driven system integrated with topography and existing paths
Agriculture–tourism relationship	Integrated model where agriculture becomes a productive and experiential component of tourism	Parallel systems with limited integration; tourism concentrated around specific nodes
Landscape strategy	Transformative: regeneration, expansion of cultivation, and permaculture integration	Conservative: preservation of existing systems and ecological balance
Circulation logic	Controlled access with peripheral parking and defined movement networks	Informal and adaptive paths shaped by terrain and existing use patterns
Institutional capacity impact	Enables detailed design, phasing, and implementation strategies	Limits development to strategic vision and flexible guidance

7. Discussion

The results of this study reinforce and extend existing understandings of ecological planning in arid and semi-arid environments by demonstrating that oasis masterplanning must operate as a water-driven, context-responsive system rather than a transferable design model. While prior studies on oasis resilience and landscape-based planning emphasise the importance of hydrological systems and traditional agro-ecological practices, this research advances the discourse by showing how these principles can be operationalised through integrated masterplanning frameworks that bridge environmental systems, tourism economies, and governance structures.

A key contribution of this research lies in reframing water not as a constraint or resource, but as a generative planning device. In both cases, the structuring of space, programme, and movement emerges directly from hydrological conditions, demonstrating that in oasis contexts water systems are not one layer among many but the primary ordering logic from which all other layers derive, challenging conventional approaches that prioritise land use or infrastructure before environmental systems. The comparative dimension of the study also contributes to closing a gap in existing literature, which often treats participatory and ecological planning as universally applicable frameworks. The findings show instead that methodological consistency does not produce uniform outcomes. In Abaynou, strong institutional backing enables a detailed, phased, and implementation-oriented masterplan, whereas in Targua, limited resources result in a strategic and open-ended vision. This divergence highlights an important conceptual shift: ecological masterplanning should be understood as a scalable methodology, capable of operating across different levels of resolution depending on governance capacity and available resources. Furthermore, the integration of tourism and agriculture observed in Abaynou expands current discussions on sustainable rural development. While agritourism is often framed as a supplementary activity, this research demonstrates how it can be positioned as a central structuring mechanism for both economic viability and ecological regeneration. At the same time, the more conservative approach in Targua underscores that such integration is not universally appropriate; in certain contexts, preservation and minimal intervention may offer more sustainable long-term outcomes. This duality contributes to a more nuanced understanding of adaptive planning strategies in fragile landscapes.

The role of participation, particularly through interactive and game-based co-design tools, extends existing participatory planning literature: rather than functioning solely as a consultative process, participation here becomes a mechanism for knowledge production and spatial negotiation, influencing both vision and implementation. However, the varying degrees to which participatory inputs translate into built outcomes reveal an important limitation, participation depends heavily on institutional frameworks to move from dialogue to execution. Several broader limitations of this research must also be acknowledged: it is based on two case studies within a specific geographic and climatic context, which may limit generalisability; it focuses on planning outputs rather than long-term implementation and post-occupancy evaluation; and the long-term social impacts of the participatory engagements remain to be assessed.

Future research could build on this work by examining the implementation phase of ecological masterplans, particularly in relation to governance mechanisms, funding structures, and stakeholder continuity. Comparative studies across a broader range of oasis or arid-region projects would also help refine the adaptability of the framework. Additionally, further exploration of digital and game-based participatory tools could provide insights into how these methods can be standardised or scaled without losing contextual sensitivity.

8. Conclusion

This paper set out to investigate how ecological masterplanning approaches centering on ecotourism can be applied to oasis environments through a comparative analysis of Abaynou and Targua N'Touchka. The study demonstrates that while both projects are grounded in a shared methodological framework, centred on water systems, landscape integration, and participatory processes, their outcomes diverge significantly in response to contextual variables. These findings confirm that ecological masterplanning is not a fixed model, but an adaptive process capable of generating multiple, context-specific solutions.

The primary insight emerging from this research is the centrality of water as the structuring foundation of oasis planning. In both case studies, hydrological systems and the climate change that affects them dictate spatial organisation, programme distribution, and development boundaries. This reinforces the principle that in fragile environments such as oases, sustainable ecotourism development cannot be achieved without first securing and optimising existing water systems and proposing new ones that promote rainwater catchment and recycling. By positioning water at the core of the planning process, the projects move beyond conventional approaches and establish a system-based logic that integrates environmental, social, and economic dimensions. A second key contribution lies in the demonstrated relationship between institutional capacity and planning resolution. Abaynou, supported by strong regional governance and financial resources, results in a comprehensive and phased masterplan with clear implementation pathways. In contrast, Targua operates within a more constrained framework, with the SDRT only financing the masterplanning phase, producing a strategic vision intended to guide incremental development funded by the rural commune of Targua, the Ministry of Agriculture, and the Ministry of Water and Forests. This comparison highlights that the effectiveness of ecological masterplanning is not determined solely by design quality, but by its alignment with governance structures, resource availability, and implementation capacity.

The research also contributes to professional practice by illustrating how tourism and agriculture can be reconfigured as mutually reinforcing systems. In Abaynou, the integration of agritourism, permaculture, and local value chains transforms the oasis into a productive landscape that supports both ecological regeneration and economic development. At the same time, the Targua case demonstrates the importance of restraint, where preservation and minimal intervention ensure the continuity of existing ecological systems. Together, these approaches offer a flexible model for balancing development and conservation in sensitive environments. Participation emerges as another critical component of the ecological masterplanning process. The use of interactive and game-based co-design tools enables the incorporation of local knowledge and fosters a sense of ownership among stakeholders. This research shows that participation can extend beyond consultation to become a driver of design innovation and strategic alignment. However, it also underscores the necessity of institutional support to translate participatory insights into tangible outcomes.

From a theoretical perspective, this study advances the discourse on ecological planning by proposing a framework of adaptive, water-driven masterplanning tailored to oasis environments. It challenges static and universal planning models, advocating instead for approaches that are responsive to environmental conditions and socio-political contexts. This contributes to a broader rethinking of sustainability in landscape architecture and urban planning, particularly in regions facing increasing climatic stress. In terms of policy implications, the findings suggest that successful oasis development requires integrated strategies that combine environmental management, economic diversification, and community engagement. Policymakers should prioritise water-sensitive planning, support local agricultural systems, and establish governance mechanisms that facilitate both public and private investment while maintaining ecological integrity. The importance of phased development and long-term visioning is also evident, particularly in ensuring that short-term interventions align with broader sustainability goals. Several recommendations for practice emerge from this research. First, ecological masterplanning in oasis contexts should begin with a comprehensive understanding of water systems, including both quantitative and qualitative dimensions. Second, planning processes should be calibrated to institutional capacity, ensuring that proposed interventions are both realistic and implementable. Third, participatory methods should be embedded throughout the planning process, with particular attention to tools that facilitate meaningful engagement and knowledge exchange. Finally, the integration of tourism and agriculture should be approached strategically, recognising the potential for both synergy and conflict.

In conclusion, this paper demonstrates that ecological masterplanning, structured around the integration of ecotourism as a driver of sustainable economic development, offers a viable and flexible approach to addressing the complex challenges of oasis environments in Morocco and beyond. In both Abaynou and Targua N'Touchka, ecotourism is positioned not as a peripheral activity but as the integrative framework through which water systems, agriculture, cultural heritage, and community livelihoods are reconnected. By grounding planning processes in water systems, adapting design strategies to local conditions, and integrating social and economic dimensions, it is possible to develop sustainable and resilient landscapes. The comparative analysis of Abaynou and Targua provides valuable insights into how such approaches can be applied in practice, contributing to both academic discourse and professional practice. Most importantly, the analysis highlights that collaborative and phased masterplanning is particularly well suited to the realities of Global South contexts such as Morocco, where budgets and governance structures may not always be stable or predictable. Rather than requiring the simultaneous completion of all components, this approach drafts an overall vision composed of prioritised actions, with water systems and socio-economic improvements for local communities placed at the highest level of priority. This change of paradigm, from singular and disconnected projects usually by the Moroccan authorities namely here SDRT and the region of Guelmim, was the result of discussions and concertation before the onset of the projects. Ultimately, the study highlights the importance of contextual intelligence, methodological flexibility, and ecological sensitivity in shaping the future of planning in water-scarce regions.

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Conflicts of Interest

The authors report no conflicts of interest.

Data Availability Statement

The data supporting the findings of this study are derived from fieldwork observations, project documentation, and participatory workshop outputs related to the Abaynou and Targua N'Touchka masterplans. Due to the nature of project-based and partially proprietary materials, some data are not publicly available but may be made available by the authors upon reasonable request.

Institutional Review Board Statement

This study involved participatory workshops and stakeholder engagement as part of a design research process. No formal institutional review board approval was required. All participation was conducted voluntarily and in accordance with standard ethical practices for participatory research.

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