Power System Technology
ISSN:1000-3673

Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

Sustainable Energy and Power System Solutions for Architectural Urban Heritage Management: Adrar in the Touat Region Case Study

Abdelmalek Abdelaoui*[1], Mohamed Hocine Ait Saadi [1], Mohamed Benabdelfattah [2]

[1] *Institute of Architecture and Urbanism, ETAP Laboratory, Saad Dahlab University of Blida, Soumaa Road, P.O. Box 270, 09000 Blida, Algeria*
abdelaoui_abdelmalek@univ-blida.dz ; aitsaadi_mohamedhocine@univ-blida.dz
[2] *Department of Civil Engineering, Faculty of Science and Technology, LDDI Laboratory, Ahmed Draia University of Adrar, RN 06, 01000 Adrar, Algeria.*
Benabdelfattah_med@univ-adrar.edu.dz

Abstract: - The Touat region in Adrar, Algeria, contains a worldwide important collection of earthen buildings which includes its ancient Ksour and its Casbahs. The area experiences an immediate governance emergency because urban development outpaces planning efforts which threatens the cultural heritage site. The research applies MACTOR (Matrix of Alliances and Conflicts: Tactics, Objectives, and Recommendations) strategic analysis tool to analyze how various actors and their objectives affect the evolution of urban areas. The research study reveals six essential players who work toward six essential goals which show how local governments and business developers control the area while pushing out the people who originally protected the cultural heritage. The research establishes numerical positions for actors which show a powerful conflict between their present financial targets and their required environmental protection efforts. The research results demonstrate that organizations need to establish an entirely different governance system. The research establishes a strategic development plan which uses the "Golden Equation" to achieve sustainability through three main elements that include multi-stakeholder collaboration and heritage economic value creation and compulsory urban planning regulations for earthen architecture. The proposed model functions as a testing model which can be applied in the Gourrara and Tidikelt region.

Keywords: *Touat region, Heritage safeguarding, Urban development Ksour to City, Key actor, MACTOR tool.*

1. Introduction

1.1. Background and Context

The Touat region in the wilaya of Adrar, Algeria, serves as a vital historical and cultural center, because of its unique earthen buildings which include the Ksour (fortified villages), and the Foggara system of underground water channels [1] [2]. These structures serve as operational models which show desert residents how to maintain their way of life while teaching them about handling resources and building their communities. The Ksour of Touat

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

represents universal value which protects their status as national treasures of Algeria while their preservation efforts attract international recognition.

1.2. The Problem of Uncontrolled Urbanization and Governance Deficit

The ksour, together with their surrounding cultural environment, are experiencing increasing threats due to rapid population growth and unregulated urban development. Modern construction methods have led to the permanent destruction of authentic architectural designs and historical buildings because they use concrete and industrial materials [3]. The process emerges from an advanced strategic game which develops when conservation programs encounter resistance from local people who support urban development in their territory. The main problem stems from a governance deficit because the current institutional and regulatory system lacks proper mechanisms to handle the conflict between protecting heritage sites and meeting contemporary economic needs (Figure 1-4)

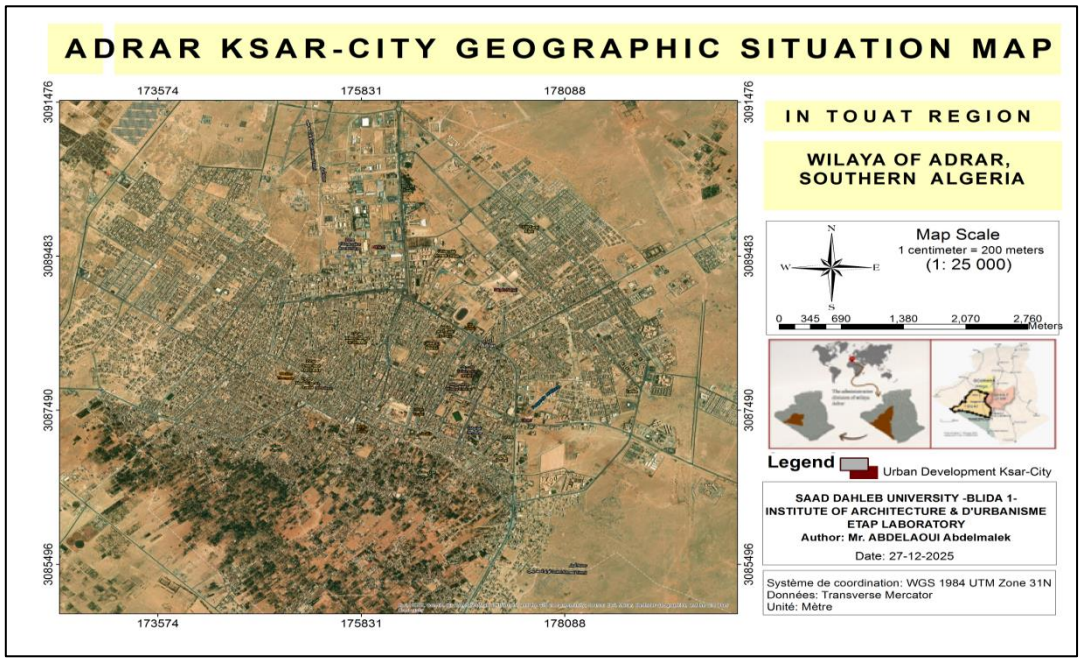

Figure 1. Situation Geographic of Adrar and Urban Development Ksar-City

(source authors)

1.3. Research Objectives and Scope

The research applies an extensive strategic foresight approach to identify all threats which endanger the Touat heritage. The main goals include:

1. To identify and analyze the key actors and strategic objectives in the urban development and heritage management landscape.

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

2. The MACTOR methodology allows us to assess the existing power dynamics and influence patterns which exist between these actors.

3. The analysis needs to identify strategic conflicts and convergences which will reveal the extent of governance deficit.

4. A strategic plan which includes an innovative governance system needs to be created for sustainable heritage protection of Touat urban heritage.

The study focuses on the Adrar wilaya, but the proposed strategic model is designed as a regional prototype applicable to other Saharan regions with similar heritage challenges, such as Timimoun capitale of Gourara region and Ain Salah capitale of Tidikelt region.

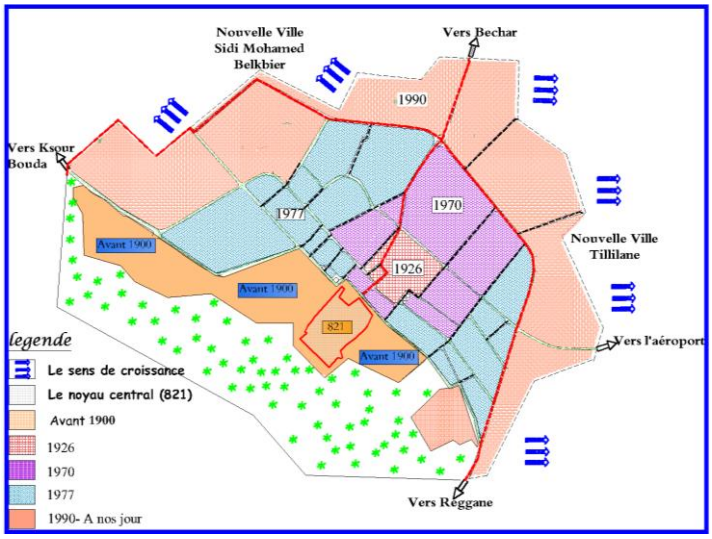

Figure 2. Schematic of Adrar urban evolution from the initial core ksar (source authors)

Figure 3. Casbah of ksar Admer in Adrar, Touat region (source authors)

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

Figure 4. 3D model of Ksar Tamaskhet in Adrar, Touat region (source authors)

2. Literature Review and Theoretical Framework

2.1. Sustainable Urban Heritage Management

Sustainable heritage management involves implementing change management systems which protect cultural values while promoting social progress and economic growth and environmental sustainability [4]. The sustainability of traditional building materials and water systems in arid zones depends on this concept. The Ksour along with other earthen structures base their sustainability on their use of locally sourced renewable materials [5]. The process of becoming modern creates problems which affect the equilibrium between these elements. Organizations need to start viewing cultural assets as development resources to achieve complete conservation management from their current heritage protection status [6]. The main obstacle arises from the need to merge indigenous wisdom with community involvement during official planning operations which most current governance systems fail to recognize [11].

2.2. The MACTOR Strategic Analysis Tool

The research uses MACTOR (Matrix of Alliances and Conflicts: Tactics, Objectives, and Recommendations) to study the intricate heritage governance system which involves multiple stakeholders. The strategic foresight tool MACTOR enables users to study system actor interactions through its "strategic game" analysis method [7].

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

The MACTOR process requires three fundamental stages which begin with System Identification to identify actors and their goals before moving to Strategic Analysis for A-A and A-O matrix quantification and finish with Strategic Recommendations to develop a strategic plan [8]. The research benefits from MACTOR because this tool enables developers to create specific governance solutions through its measurable visual framework which shows strategic positions and their associated power conflicts [14].

3. Methodology

3.1. Study Area and Data Collection

The study focuses on the interface between the historic Ksour and the rapidly expanding modern city of Adrar. The MACTOR analysis was initiated by identifying the key actors whose decisions or actions significantly impact the urban heritage of Touat. The analysis identified six key actors (A1 to A6) and six strategic objectives (O1 to O6) that define the strategic game, as presented in Table 1.

Table 1. System Variables: Actors and Strategic Objectives

Code	Actors (Stakeholders)	Code	Strategic Objectives
A1	Local Authorities (Wilaya/Municipalities)	O1	Preservation of Earthen Architecture (*Ksour*)
A2	Directorate of Culture and Heritage (DCP)	O2	Controlled Urban Expansion
A3	Local Community/Ksour Residents	O3	Development of Sustainable Tourism
A4	Private Developers/Construction Sector	O4	Modernization of Infrastructure
A5	Tourism Operators	O5	Local Community Involvement in Planning
A6	Academic and Research Institutions	O6	Economic Diversification

3.2. Application of the MACTOR Process

The core of the methodology involves the construction and analysis of the A-A and A-O matrices. The relationships in both matrices are quantified using a scale from -2 to +2, reflecting the degree of influence (A-A) or support/opposition (A-O). The power of an actor

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

is calculated as the sum of their direct influence scores over all other actors. The Net Power (Influence minus Dependence) provides a nuanced understanding of strategic weight.

4. Results and Strategic Analysis

4.1. Power Dynamics: The Actor-Actor (A-A) Matrix

The analysis of the A-A matrix reveals a clear power hierarchy, with significant implications for governance. The full synthesized A-A matrix, including the calculation of influence, dependence, and net power, is presented in Table 2.

Table 2. Synthesized Actor-Actor (A-A) Influence and Dependence Matrix

Influence (X on Y)	A1	A2	A3	A4	A5	A6	Total Influence (Power)	Total Dependence	Net Power	Classification
A1 (Local Authorities)	-	+2	+2	+2	+2	+2	10	4	+6	Dominant
A2 (Culture/Heritage)	+1	-	+1	+1	+1	+1	5	6	-1	Relay
A3 (Local Community)	-1	0	-	0	0	+1	0	7	-7	Dominated
A4 (Private Developers)	+2	+1	+1	-	+1	+1	6	5	+1	Relay
A5 (Tourism Operators)	0	0	+1	0	-	+1	2	6	-4	Dominated
A6 (Academics)	0	+1	+1	0	0	-	2	5	-3	Dominated

The results confirm that A1 (Local Authorities) is the Dominant Actor (Net Power +6), controlling permits and regulatory enforcement. A4 (Private Developers) is a powerful Relay Actor (Net Power +1), wielding influence through economic capital. Critically, A3 (Local Community) is the most Dominated Actor (Net Power -7), reflecting their severe marginalization in the decision-making process despite being the custodians of the heritage (Figure 2).

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

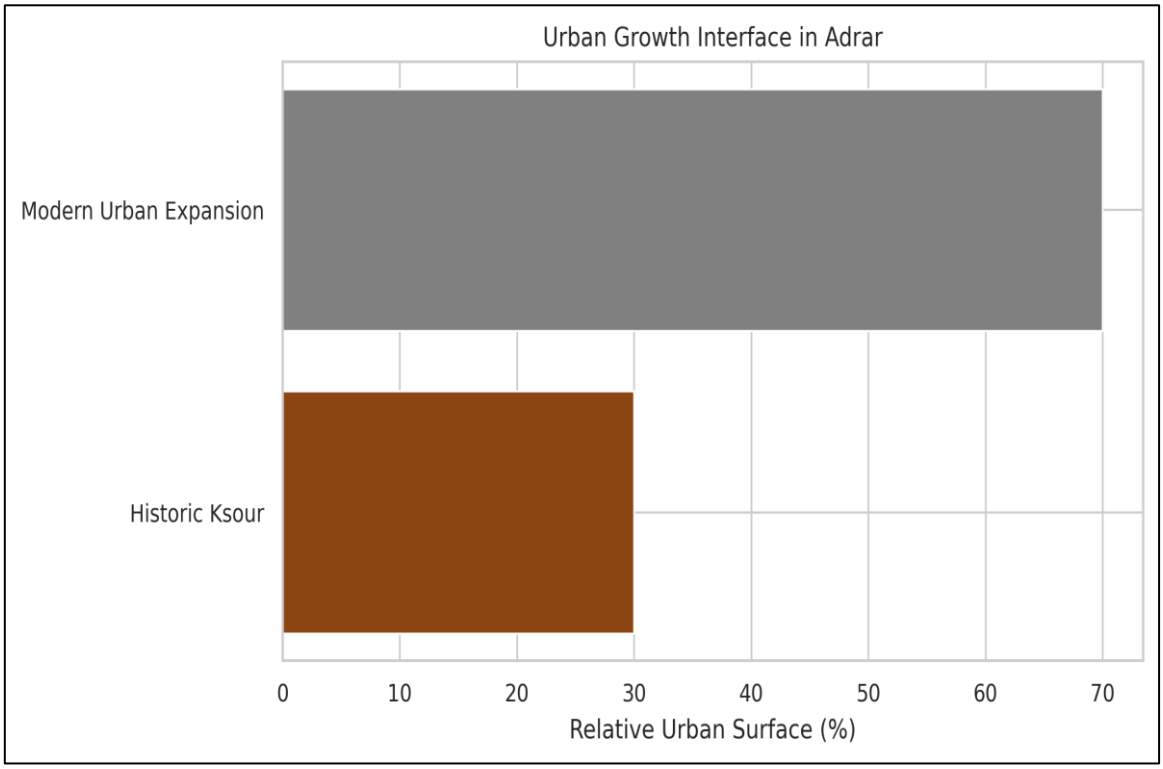

Figure 5. Influence and dependencies between actors

The use of **MACTOR** software.

4.2. Strategic Positions: The Actor-Objective (A-O) Matrix

The A-O matrix (Table 3) shows how each actor stands in relation to the six objectives which reveal their main disagreements and possible teamwork opportunities.

Table 3. Strategic Positions: The Actor-Objective (A-O) Matrix

Actor	O1 (Preservation)	O2 (Controlled Expansion)	O3 (Sustainable Tourism)	O4 (Modernization)	O5 (Community Involvement)	O6 (Economic Diversification)	Net Position	Strategic Orientation
A1 (Local Authorities)	+1	+1	+1	+2	+1	+1	+7	Pro-Development (Pragmatic)

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

Actor	O1 (Preservation)	O2 (Controlled Expansion)	O3 (Sustainable Tourism)	O4 (Modernization)	O5 (Community Involvement)	O6 (Economic Diversification)	Net Position	Strategic Orientation
A2 (Culture/Heritage)	+2	+2	+2	0	+2	+1	+9	Pro-Conservation (Idealistic)
A3 (Local Community)	+2	+1	+2	-1	+2	+1	+7	Pro-Conservation (Social)
A4 (Private Developers)	-2	-2	-1	+2	-1	+1	-3	Pro-Profit (Oppositional)
A5 (Tourism Operators)	+1	+1	+2	0	+1	+2	+7	Pro-Economic (Sustainable)
A6 (Academics)	+2	+1	+1	-1	+1	+1	+5	Pro-Conservation (Technical)

4.3. Analysis of Conflits and Convergences

The research indicates that organizations must deal with a severe market competition struggle. The main disagreement between Private Developers (A4) and Preservation (O1) and Controlled Expansion (O2) exists because these groups lack sufficient financial potential (O1 & O2). This directly opposes the strong support from the Local Community (A3) and the Directorate of Culture (A2).

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

The local authorities support preservation in theory but they choose to focus on modernization development (O4: +2) instead of preservation (A1: +1). The strategic conflict between these two systems produces regulatory gaps which A4 uses to its advantage.

Potential Alliance: The most promising alliance is between the conservationists (A2, A3, A6) and the sustainable economic actors (A5). The A3 and A5 frameworks demonstrate full support for Sustainable Tourism (O3: +2) because they indicate that economic benefits should be used to achieve heritage conservation for system rebalancing.

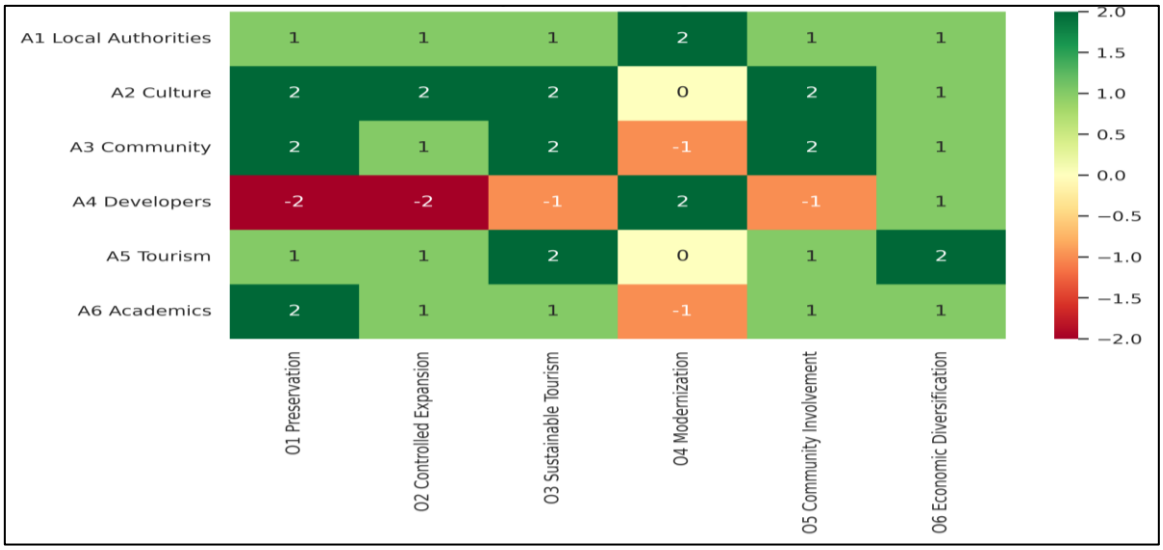

Figure 6. Actor-Objective positioning Matrix (A-O)

5. Discussion: The Governance Deficit and the Golden Equation

5.1. The Systemic Consequences of Power Imbalance

The organizational structure which A1 and A4 maintain control over A3 creates various effects throughout the organization. A3 faces marginalization because the local community holds a Net Power score of +7 which eliminate their conservation support thus causing their social connections to fade and their historical upkeep methods to become obsolete [15].

The research shows that A4 holds significant power over A1 because the construction industry runs urban planning operations which lead to heritage destruction [16]. +3 The transition to concrete construction results in two major losses which include destruction of physical heritage and the disappearance of A3's traditional expertise needed to preserve Ksour and Foggara systems [17].

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

The Golden Equation for Sustainable Development

To formalize the required strategic rebalancing, this research proposes a "Golden Equation" for sustainable development, a conceptual model for a new governance paradigm based on Integrated Conservation and Social Legitimacy. The Sustainable Development formula enables contemporary development practices to work with cultural heritage preservation through direct participation of local communities.

This equation signifies:

The process of modernization requires heritage preservation to function as a multiplier which limits the advancement of O4 (Modernization) through O1 (Preservation). All development activities need to protect heritage sites which will make A1 and A4 organizations understand the expenses required for preservation.

+5 The product needs to be divided by Community Involvement: The essential non-negotiable denominator becomes O5 (Community Involvement) at this point. The Sustainable Development quotient loses all value when Community Involvement reaches zero because this indicates a complete breakdown of social legitimacy. The system enables A3 to exercise veto authority which makes them the most powerful actor because they can stop any project which society finds unacceptable. The model enables urban intervention sustainability assessment through particular measurable criteria which advance assessment from following rules to achieve strategic equilibrium.

5.2. Strategic Roadmap and Recommendations

Based on the MACTOR analysis and the principles of the Golden Equation, this research proposes a three-pronged strategic roadmap to transform the governance of urban heritage in Touat (Figure 4).

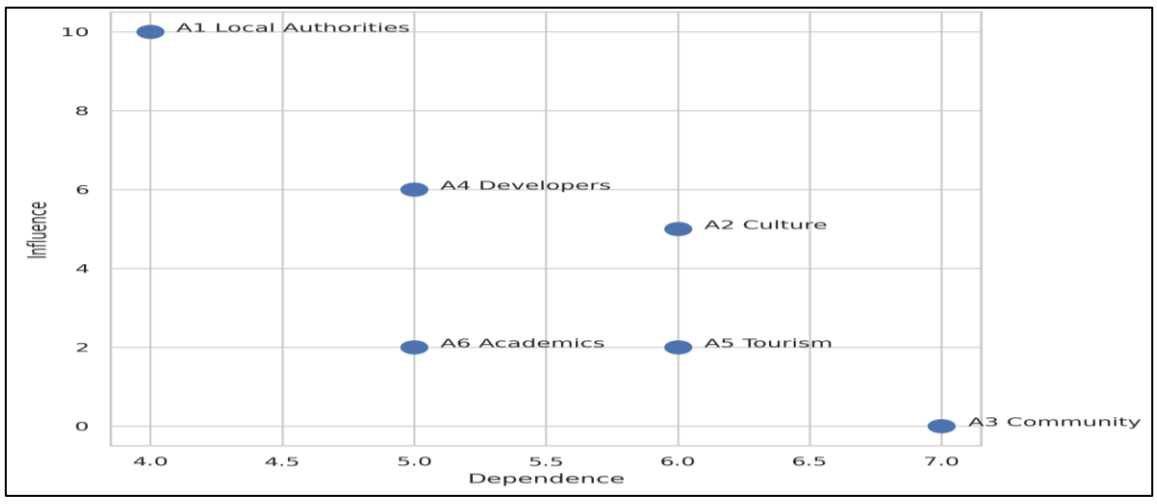

Figure 7. Actor power-dependence Map (MACTOR)

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

5.3. Institutional Reform: The Touat Heritage Council (THC)

The MACTOR analysis with Golden Equation principles serve as guidelines for this research to create a three-part strategic plan which will transform Touat's urban heritage governance system.

5.4. The Touat Heritage Council (THC) serves as an institutional reform initiative.

The existing power inequality requires institutions to develop new structures which will give dominated groups their rightful authority. The proposed Touat Heritage Council (THC) must be legally mandated.

Recommendation 1: The THC needs a legal framework which will function as governance system to support all stakeholders.

The committee serves as a representative body which includes members from all six actors (A1-A6).

• Veto Power: The THC needs to receive veto authority to review all urban development initiatives which damage the heritage landscape (O1) or do not fulfill the requirements for controlled growth (O2). This directly addresses the overreach of A4 and the duplicity of A1.

• Power Rebalancing: The THC structure needs A3 (Local Community) and A6 (Academics) to gain voting rights with weighted voting authority which will fight against A1's control and will use the Golden Equation for all development projects.

5.5. Economic Reorientation: The Heritage-Tourism Nexus

The short-term economic benefits of concrete construction require heritage to become an economic resource through sustainable tourism development (O3).

Recommendation 2: Link Ksour Restoration to Sustainable Tourism Development.

• Revolving Fund: The Revolving Fund will operate as a financial resource which uses tourism earnings together with international funding to offer affordable funding for Ksour restoration work through traditional methods. The system creates rewards which drive A3 and A4 to dedicate resources to O1.

• Certification System: The quality label for "Earthen Accommodation" should enable A5 (Tourism Operators) to increase their pricing because their revenue (O6) will support the protection of the constructed environment (O1).

The tourism circuit needs Foggara management and Ksour interpretation through local community members (A3) who will lead the area to establish sustainable financial growth which safeguards its historical heritage.

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

5.6. The Mandatory Earthen Code functions as a system which unites regulatory elements.

The current regulatory framework requires transformation to create conservation as a mandatory legal requirement which organizations need to follow instead of making it an optional choice. The third recommendation demands land use planning (POS) to establish an Earthen Code system which must be included in all earthen architecture projects (Figure 5).

The process of creating an enforceable Earthen Architecture Building Code needs to establish itself as a mandatory requirement which applies to particular heritage protection areas. The system requires two sets of specifications which include material requirements that demand local materials and technical standards that help construct earthquake-resistant earthen buildings.

The area needs zoning regulations which will establish rules for how the area should expand (O2). The zoning plan should establish two separate zones which include a Core Zone for absolute protection and a Buffer Zone that requires Earthen Code compliance and maintains strict density limits. The new regulations establish a legally binding system which merges O1 and O2 into development work to fulfill A4 opposition requirements and A1 operational needs (Figure 6).

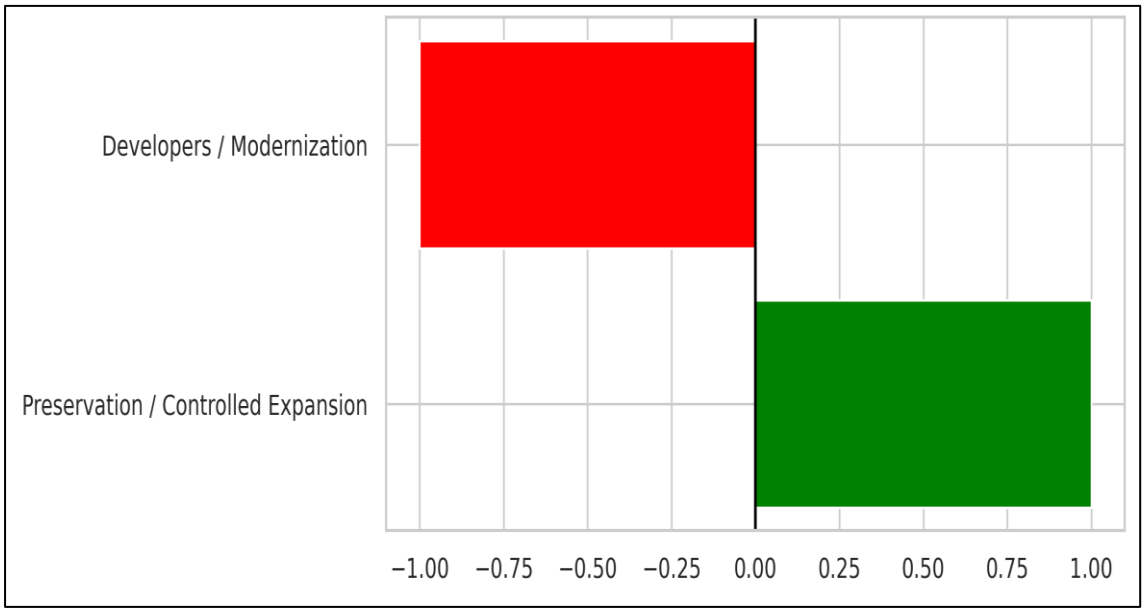

Figure 8. Core Strategic Conflict

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

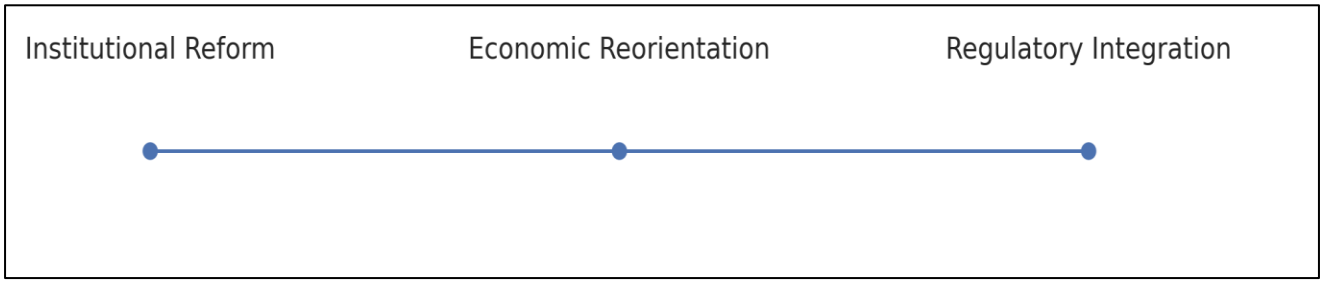

Figure 9. Strategic Governance Roadmap for Touat

6. Conclusion and Regional Prototype

The MACTOR strategic analysis tool enabled this research to analyze the multiple governance problems which affect Touat region urban heritage. The research showed that governance fails to work properly because local authorities and private developers hold too much power which leads to a fierce struggle between environmental conservation and short-term financial gains. The main contribution presents the Golden Equation for Sustainable Development as a prescriptive tool which functions as a conceptual framework. The equation establishes a system which requires development projects to achieve excellent results in Heritage Preservation and Community Involvement before they can be considered for implementation.

The proposed strategic roadmap includes three implementation components which are the Touat Heritage Council (THC) and the Heritage-Tourism Nexus and the mandatory Earthen Code. The proposed solutions work to enhance the strength of subordinate groups while they redirect the dominant party's attention and establish beneficial rewards for the oppositional party to use environmentally friendly methods.

The model developed for Touat serves as a Regional Prototype for the integrated management of similar fragile environments across the Algerian Sahara, including Timimoun and Ain Salah. The Touat region will achieve sustainable development through its strategic method which protects all cultural elements of the area. The Touat region will establish a global model for arid zone heritage protection through its successful transformation of threatened cultural assets into sustainable development drivers.

References

[1] UNESCO. (2002). Les oasis à foggaras et les ksour du Grand Erg Occidental (Touat Oases group), Algeria. World Heritage Tentative List. UNESCO World Heritage Centre. https://whc.unesco.org/en/tentativelists/1772

[2] Mahcar, F. I., Durak, S., Benabbou, R., et al. (2024). The impact of the colonial architecture on the urban sustainability of Laghouat city in Algeria: Ksar of Laghouat as a case. Heritage Science, 12, Article 191. https://doi.org/10.1186/s40494-024-01272-8

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

[3] Correia, M., & Duarte Carlos, G. (2021). Introduction: Earthen architecture, an endangered vernacular heritage. Built Heritage, 5, Article 22. https://doi.org/10.1186/s43238-021-00046

[4] Oxley Green, A., & Hunton-Clarke, L. (2003). A typology of stakeholder participation for company environmental decision-making. Business Strategy and the Environment, 12(5), 292–299. https://doi.org/10.1002/bse.371

[5] Vafadari Komarolya, D. (2025). Analysis of stakeholder power and convergence for climate-resilient urban parks: A MACTOR study in Tabriz. Environmental and Sustainability Indicators, 28, 101019. https://doi.org/10.1016/j.indic.2025.101019

[6] Godet, M. (2006a). Creating futures: Scenario planning as a strategic management tool. Economica.

[7] Godet, M. (2006b). The MACTOR method: A tool for strategic analysis. Futures Research Quarterly, 22(2), 5–25.

[8] Kadaifci, I. (2024). A new approach to MACTOR considering interaction effects: An example from the telecommunications industry in Turkey. Technological Forecasting and Social Change, 209, 123793. https://doi.org/10.1016/j.techfore.2024.123793

[9] Zaghez, I., Attoui, R., & Saou-Dufrêne, B. N. (2023, April). Restoration and sustainability of earthen architecture: Ksar Khanguet Sidi Nadji in the Algerian Sahara as a case study. Research Square (Preprint). https://doi.org/10.21203/rs.3.rs-2855953/v1

[10] Minke, G. (2006). Building with earth: Design and technology of a sustainable architecture. Birkhäuser

[11] North, D. C. (1990). Institutions, institutional change and economic performance. Cambridge University Press.

[12] Stigler, G. J. (1971). The theory of economic regulation. The Bell Journal of Economics and Management Science, 2(1), 3–21. https://doi.org/10.2307/3003160

[13] Stovel, H. (1998). Risk preparedness: A management manual for world cultural heritage. ICCROM.

[14] Nguyen, T. N., & Nguyen, N. T. (2023). The role of local communities in the conservation of cultural heritage sites: A case study of Vietnam. International Journal of Social Sciences Perspectives, 14(2), 45–60. https://doi.org/10.55493/5003.v14i2.5057

[15] Ben Hassen, T., El Bilali, H., Allahyari, M. S., & Chatti, C. B. (2025). Traditional irrigation knowledge for sustainable water resource management in arid environments: Insights from the MENA region. Journal of Arid Environments, 231, 105466. https://doi.org/10.1016/j.jaridenv.2025.105466

Power System Technology
ISSN:1000-3673
Received: 06-11-2025 Revised: 15-12-2025 Accepted: 18-01-2026

[16] Wilkinson, D. (2018). Strategic foresight in urban planning: A review of tools and applications. Journal of Planning Literature, 33(4), 418–434.

[17] World Bank. (1992). Governance and development. World Bank Publications.

[18] Bandarin, F., & van Oers, R. (2012). The historic urban landscape: Managing heritage in an urban century. Wiley-Blackwell.

[19] Al-Hathloul, S. (2002). The role of local communities in the conservation of traditional settlements. Habitat International, 26(2), 245–256.