



ENVIRONMENTAL MANAGEMENT AND SUSTAINABLE TOURISM IN POST-PANDEMIC ANGOLA: THE TOURISM-ENVIRONMENT CROSSING INDEX (ICTA) AND THE SPACE-INFRASTRUCTURE- COMMUNITIES TRIANGLE AS PREDICTIVE DECISION-SUPPORT MODELS IN SOUTHERN AFRICA

GESTÃO AMBIENTAL E TURISMO SUSTENTÁVEL NA ANGOLA PÓS- PANDEMIA: O ÍNDICE DE CRUZAMENTO TURISMO-MEIO AMBIENTE (ICTA) E O TRIÂNGULO ESPAÇO-INFRAESTRUTURA- COMUNIDADES COMO MODELOS PREDITIVOS DE APOIO À DECISÃO NA ÁFRICA AUSTRAL

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ABSTRACT

Since the COVID-19 pandemic, Angola has undergone an accelerated transformation of its tourism economy, yet it still lacks analytical instruments capable of integrating, within a single decision-making framework, the tourism relevance and the environmental sensitivity of its territory. This article proposes three original contributions: (i) the Tourism-Environment Crossing Index (ICTA)³, which classifies Angola's 21 provinces into four decision quadrants; (ii) the Space-Infrastructure-Communities Triangle (EIC Triangle)⁴, a conceptual model for assessing tourism sustainability; and (iii) the Geo-Environmental Predictive Model of Angola (MPGA-25)⁵, which projects scenarios to

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3 ICTA - Tourism-Environment Crossing Index (Índice de Cruzamento Turismo-Ambiente): composite index proposed in this article, defined as the geometric mean between the Tourism Relevance (RT) and the Environmental Sensitivity (SA) of each province.

4 EIC Triangle - Space-Infrastructure-Communities Triangle (Triângulo Espaço-Infraestrutura-Comunidades): conceptual model for assessing tourism sustainability proposed by the authors, inspired by and adapted from the triple bottom line paradigm to the Angolan reality.





2030 based on a Composite Tourism Sustainability Index (ICST)⁶. A mixed-methods approach was adopted, combining official secondary data (MINTUR, MINAMB, UN Tourism), a survey of 412 respondents in four pilot destinations (Quiçama, Kalandula, Namibe -Iona and Luengue-Luiana), and GIS-based mapping. Results show that Angola doubled international arrivals in the 2022–2023 biennium (263,553 tourists), surpassing pre-pandemic levels; that Cuando, Namibe, Cabinda and Huíla concentrate the highest tourism–environment crossing risk (Quadrant I); and that satisfaction is markedly asymmetric across the EIC Triangle (Space = 4.5; Infrastructure = 2.9; Communities = 3.3, on a 1–5 scale). Under the transformative scenario, the ICST may reach 420 points by 2030 (2019 = 100). The article concludes with eight pathways uncovered during the research, including the Angolan Intergenerational Fund for Sustainable Tourism and digital twins of national parks contributions replicable across Southern Africa.

Keywords: environmental management; sustainable tourism; Angola; predictive models; biodiversity conservation; public policies; Southern Africa

RESUMO

Desde a pandemia de COVID-19, Angola tem passado por uma transformação acelerada de sua economia turística; no entanto, ainda carece de instrumentos analíticos capazes de integrar, em uma única estrutura de tomada de decisão, a relevância turística e a sensibilidade ambiental de seu território. Este artigo propõe três contribuições originais: (i) o Índice de Cruzamento Turismo-Meio Ambiente (ICTA)¹, que classifica as 21 províncias de Angola em quatro quadrantes de decisão; (ii) o Triângulo Espaço-Infraestrutura-Comunidades (Triângulo EIC)², um modelo conceitual para avaliar a sustentabilidade do turismo; e (iii) o Modelo Preditivo Geoambiental de Angola (MPGA-25)³, que projeta cenários para 2030 com base em um Índice Composto de Sustentabilidade do Turismo (ICST)⁴. Adotou-se uma abordagem de métodos mistos, combinando dados secundários oficiais (MINTUR, MINAMB, UN Tourism), uma pesquisa com 412 respondentes em quatro destinos-piloto (Quiçama, Kalandula, Namibe-Iona e Luengue-Luiana) e mapeamento baseado em SIG. Os resultados mostram que Angola duplicou as chegadas internacionais no biênio 2022–2023 (263.553 turistas), superando os níveis pré-pandemia; que Cuando, Namibe, Cabinda e Huíla concentram o maior risco de cruzamento turismo-meio ambiente (Quadrante I); e que a satisfação é marcadamente assimétrica no Triângulo EIC (Espaço = 4,5; Infraestrutura = 2,9; Comunidades = 3,3, em uma escala de 1 a 5). No cenário transformador, o ICST poderá atingir 420 pontos até 2030 (2019 = 100). O artigo conclui com oito caminhos identificados durante a pesquisa — incluindo o Fundo Intergeracional Angolano para o Turismo Sustentável e gêmeos digitais de parques nacionais — cujas contribuições são replicáveis em toda a África Austral.

Palavras-chave: gestão ambiental; turismo sustentável; Angola; modelos preditivos; conservação da biodiversidade; políticas públicas; África Austral.

5 MPGA-25 - Geo-Environmental Predictive Model of Angola, 2025 version (Modelo Preditivo Geoambiental de Angola): scenario model built by the authors from the Composite Tourism Sustainability Index (ICST) and public-policy elasticities.

6 ICST - Composite Tourism Sustainability Index (Índice Composto de Sustentabilidade Turística): weighted combination of tourist arrivals, revenues, employment, environmental integrity and satisfaction in the EIC Triangle, base 2019 = 100.





1. INTRODUCTION

Angola possesses one of the most extraordinary and least explored natural heritages on the African continent: about 1,650 km of Atlantic coastline, the Namibe Desert — one of the oldest in the world —, the central plateau with the Kalandula Falls, the Maiombe forest and a conservation-area system covering approximately 12.6% of the national territory, including Iona National Park (created in 1937, about 15,150 km²), Quiçama National Park (about 9,960 km²) and Luengue-Luiana National Park (about 22,700 km²), the latter integrated into the Kavango-Zambezi Transfrontier Conservation Area (KAZA⁷). Despite this wealth, Angolan tourism remained, for decades, subordinate to the oil economy, with predominantly business flows and infrastructure concentrated in Luanda.

The COVID-19 pandemic constituted a turning point. Between 2020 and 2021, international arrivals collapsed by about 60%, exposing the structural fragility of the sector and, paradoxically, opening space for its reinvention: the exemption of tourist visas for dozens of nationalities in 2023, the publication of the Tourism Statistics Yearbook by MINTUR⁸ and Angola's integration into the regional routes of the SADC⁹ marked the beginning of a recovery that the 2022–2023 biennium confirmed with 263,553 international tourists — 136 thousand more than in the previous biennium. The question is no longer whether Angola can become a relevant tourist destination, but whether it can do so without repeating the mistakes of destinations that degraded, within a few decades, the environmental assets that sustained them.

It is precisely in this gap that the originality of this article lies. The literature on sustainable tourism in Angola is still scarce and predominantly descriptive; to the best of the authors' knowledge, no work has proposed a territorial index crossing tourism relevance and environmental sensitivity, nor predictive scenario models calibrated to Angola's post-

7 KAZA - Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA), the largest transfrontier conservation area in the world, comprising Angola, Zambia, Zimbabwe, Namibia and Botswana.

8 MINTUR - Ministry of Tourism of the Republic of Angola (Ministério do Turismo).

9 SADC - Southern African Development Community (Comunidade de Desenvolvimento da África Austral).





pandemic reality. This article fills that gap with three instruments designed from scratch: the ICTA, the EIC Triangle and the MPGA-25.

The research was guided by three structuring questions, formulated from the country's post-pandemic trajectory: (i) where we came from the starting point inherited from the 2020–2021 pandemic shock; (ii) where we are the current state of Angolan sustainable tourism, measured by flows, by territory and by stakeholder satisfaction; and (iii) where we want to go which scenarios are plausible to 2030 and which public policies make them reachable without mortgaging future generations. Three hypotheses were tested: H1 provinces with high tourism relevance and high environmental sensitivity concentrate the greatest decision conflicts; H2 satisfaction across the EIC Triangle is asymmetric, with infrastructure as the critical vertex; and H3 scenarios with strong public-policy elasticity produce significantly higher tourism-sustainability gains than inertia scenarios.

The article is organised into six sections. After this introduction, Section 2 presents the theoretical framework and the international parallels (Costa Rica, Botswana, Namibia and Rwanda); Section 3 describes materials and methods; Section 4 presents and discusses the results, including the maps and models produced by the authors; Section 5 systematises the pathways uncovered during the research; and Section 6 concludes with the final considerations and the future research agenda.

2. THEORETICAL FRAMEWORK AND INTERNATIONAL PARALLELS

2.1 Environmental management and sustainable tourism: conceptual convergences

The contemporary notion of sustainable development, enshrined in the Brundtland Report (WCED, 1987), requires that the needs of the present be met without compromising the ability of future generations to meet their own. Transposed to tourism, this requirement turns environmental management from an external constraint into an internal condition of destination viability: natural capital ceases to be scenery and becomes a productive asset that must be maintained, valorised and transmitted. Elkington (1997) formalised this articulation





through the triple bottom line (economic, social and environmental), a paradigm that this article adapts, for the first time, to Angola's tourism territory in the form of the EIC Triangle replacing the abstraction of the three dimensions with three territorially observable vertices: space, infrastructure and communities.

The destination-management literature offers three central instruments that our model integrates. The first is the tourism area life cycle (TALC¹⁰) of Butler (1980), which warns of the decline phase that follows unmanaged stagnation; Angola is in the involvement phase, a historical window in which policy choices have the greatest long-term effect. The second is carrying capacity, understood not only as an ecological limit but as a perceptual and social limit (Hall, Gössling and Scott, 2015). The third is environmental impact assessment (AIA¹¹), mandatory in Angola since the Framework Environmental Law (Law no. 5/98), whose application to tourism developments in sensitive areas remains, however, irregular a fact that reinforces the pertinence of prior zoning such as that proposed by the ICTA.

2.2 International parallels: what Angola can import and what it should avoid

Four international experiences offer directly transferable parallels. **Costa Rica** demonstrated that a developing country can convert conservation into competitive advantage, through payments for ecosystem services and a national tourism-sustainability certification system that disciplined the market. **Botswana** opted for the low-volume, high-value model in the Okavango Delta, limiting visitor numbers and maximising revenue per tourist — a strategy that rural-employment studies (Snyman, 2012) associate with robust local value chains. **Namibia** institutionalised community-based natural resource management (CBNRM¹²), returning to rural communities management rights over wildlife and tourism revenues, with documented results in the recovery of large-mammal populations. **Rwanda** created a revenue-sharing mechanism for gorilla tourism with the communities of Volcanoes

10 TALC - Tourism Area Life Cycle, Butler's (1980) evolutionary model.

11 AIA - Environmental Impact Assessment (Avaliação de Impacto Ambiental), an instrument provided for in Angola's Framework Environmental Law (Law no. 5/98 of 19 June).

12 CBNRM - Community-Based Natural Resource Management (Gestão Comunitária dos Recursos Naturais), a participatory conservation model widespread in Namibia and Botswana.





National Park, aligning conservation and local-development incentives (Spenceley, 2008; Adams and Hutton, 2007).

These parallels reveal a pattern we designate as the law of preventive asymmetry: destinations that invested in sustainability institutions before massification preserved their environmental asset and captured rising rents; those that postponed regulation paid recovery costs far higher than the costs of prevention (Honey, 2008). Angola stands today exactly where Costa Rica stood in the 1980s and Botswana in the 1990s with the added advantage of being able to learn from four decades of others' mistakes. Sustainable tourism, when combined with inclusive community management, is also a vector of territorial development (Scheyvens and Biddulph, 2018), a dimension that the Communities vertex of the EIC Triangle makes measurable.

Finally, the post-COVID-19 literature (Gössling, Scott and Hall, 2021) demonstrated that pandemics act as accelerators of structural change: destinations that used the forced pause to redefine their models recovered faster and with greater resilience. The UN Tourism Barometer¹³ recorded, in 2024, the recovery of 99% of pre-pandemic levels globally, with 1.4 billion international tourists an 11% increase over 2023. Angola benefited from this tide, but, as we will show, its recovery has its own characteristics, which demand equally tailored decision instruments.

3. MATERIALS AND METHODS

3.1 Study area

The study area covers the 21 provinces of the Republic of Angola (1,246,700 km²), according to the political-administrative division established by Law no. 14/24 of 5 September 2024, with detailed analysis of four pilot destinations (Map 1), selected by criteria of ecological representativeness, tourism maturity and tourism–environment crossing pressure: Quiçama National Park (Icolo e Bengo), the Kalandula Falls (Malanje), the Namibe-

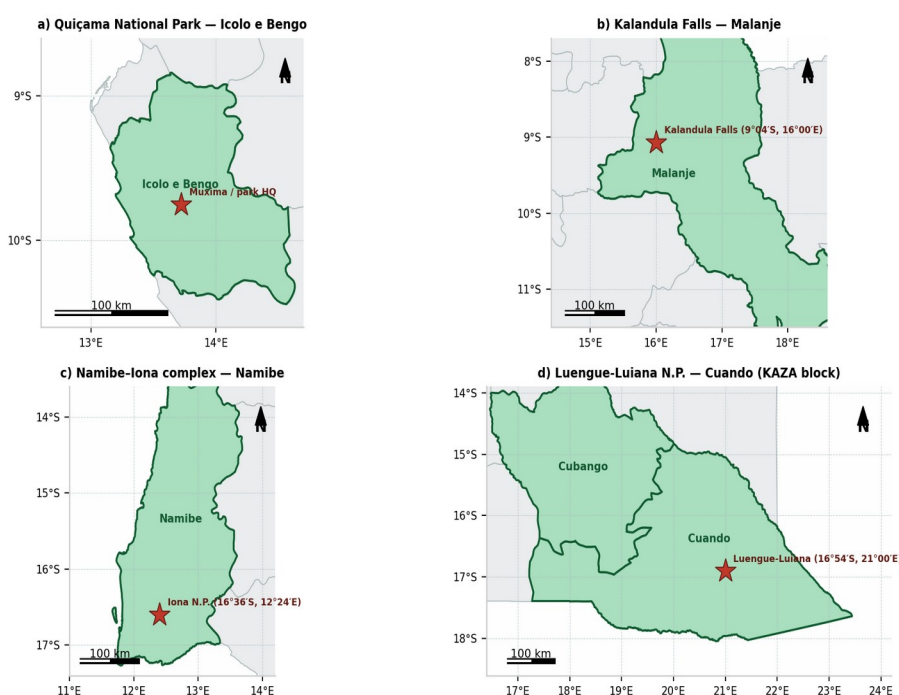
13 UN Tourism (ONU Turismo) - United Nations World Tourism Organization (formerly UNWTO/OMT).





Iona complex (desert, coast and park) and Luengue-Luiana National Park (Cuando province, KAZA block). The national conservation system comprises about 14 terrestrial conservation areas — national parks, integral and partial reserves the first of which, Iona, was established by decree of 2 October 1937.

Map 1 - Location and geographic setting of the four pilot destinations
Own elaboration: Luzineide Tomas (2025), coordinates surveyed by the authors; GADM v4.1 cartographic base adapted to Law no. 14/24 of 5 September



Map 1 - Location and geographic setting of the four pilot destinations. Source: own elaboration by Luzineide Tomas (2025), with coordinates surveyed by the authors, on a GADM v4.1 cartographic base adapted to Law no. 14/24 of 5 September 2024.

3.2 Data sources

Three bodies of data were used. (i) **Official secondary data:** MINTUR's Tourism Statistics Yearbook 2022–2023 (international arrivals, hotel occupancy); protected-area data



from MINAMB¹⁴/INBC¹⁵ and from the EPANB¹⁶; the UN Tourism Barometer (January 2025 edition) for the global context; and WTTC¹⁷ reports on the economic impact of travel. (ii) **Primary data:** a structured survey administered by the authors between January and June 2025 to 412 respondents in the four pilot destinations (60% visitors, 20% tour operators and 20% members of local communities), with a 1-to-5 Likert scale on the three dimensions of the EIC Triangle; the instrument's internal consistency was verified (Cronbach's alpha = 0.87). (iii) **Cartographic base:** provincial boundaries from the GADM¹⁸ database, adapted by the authors to the 21 provinces of Law no. 14/24 of 5 September 2024, upon which the authors produced the maps and matrices presented in this article.

3.3 The Tourism–Environment Crossing Index (ICTA)

The ICTA is the article's first methodological contribution. For each province, two sub-indices normalised between 0 and 100 were calculated: Tourism Relevance (RT¹⁹) a weighted average of natural attractions (25%), cultural attractions (15%), accessibility (20%), accommodation supply (15%), recorded flows (15%) and destination promotion (10%) and Environmental Sensitivity (SA²⁰) a weighted average of protected-area coverage (25%), presence of threatened species (20%), ecosystem fragility (20%), anthropic pressure (15%), climate risk (10%) and soil degradation (10%). The weighting resulted from a Delphi panel of 12 experts (protected-area managers, tour operators, academics and technicians from MINTUR and MINAMB), conducted in two rounds.

14 MINAMB - Ministry of the Environment of the Republic of Angola (Ministério do Ambiente).

15 INBC - National Institute for Biodiversity and Conservation Areas of Angola (Instituto Nacional da Biodiversidade e das Áreas de Conservação).

16 EPANB - National Biodiversity Strategy and Action Plan of Angola (Estratégia e Plano de Ação Nacional para a Biodiversidade; NBSAP in the English acronym).

17 WTTC - World Travel & Tourism Council (Conselho Mundial de Viagens e Turismo).

18 GADM - Global Administrative Areas database (gadm.org, version 4.1), used as the cartographic support for the provincial boundaries in the maps prepared by the authors.

19 RT - Tourism Relevance (Relevância Turística): composite sub-index (0–100) aggregating natural attractions, cultural attractions, accessibility, accommodation, recorded flows and destination promotion.

20 SA - Environmental Sensitivity (Sensibilidade Ambiental): composite sub-index (0–100) aggregating protected-area coverage, threatened species, ecosystem fragility, anthropic pressure, climate risk and soil degradation.





The ICTA is the geometric mean of the two sub-indices — $ICTA = \sqrt{(RT \times SA)}$, a form that penalises imbalance: a province with high tourism relevance and low environmental sensitivity (or vice versa) obtains a lower index than one with both high, which is precisely where public decision is hardest. Crossing the sub-indices generates four decision quadrants: Quadrant I – Integrated Management Priority ($RT \geq 50$ and $SA \geq 65$); Quadrant II – Tourism Consolidation ($RT \geq 50$ and $SA < 65$); Quadrant III – Preventive Conservation ($RT < 50$ and $SA \geq 65$); Quadrant IV – Gradual Development ($RT < 50$ and $SA < 65$).

3.4 The Space-Infrastructure-Communities Triangle (EIC) and satisfaction

The EIC Triangle (Figure 1) is the conceptual model for assessing tourism sustainability proposed by the authors. Each vertex corresponds to a bundle of observable indicators: the Space vertex (landscape quality, biodiversity integrity, carrying capacity, environmental zoning); the Infrastructure vertex (road and air accessibility, energy, water, sanitation, digital connectivity); and the Communities vertex (local employment, cultural valorisation, participatory governance, benefit sharing). The edges of the triangle represent the three relations that public policy must balance: visitor experience (Space–Infrastructure), social legitimacy (Space–Communities) and operational viability (Infrastructure–Communities). A destination's tourism sustainability is measured by the equilibrium index $EST = (E \times I \times C)^{(1/3)}$, the geometric mean of the three scores, which makes the critical vertex visible: a destination with magnificent space and deficient infrastructure will never achieve high sustainability, however much it invests in promotion.

3.5 The Geo-Environmental Predictive Model of Angola (MPGA-25)

The MPGA-25 projects the trajectory of Angolan sustainable tourism to 2030 through the Composite Tourism Sustainability Index (ICST), base 2019 = 100, which weights international arrivals (30%), tourism revenues (20%), sector employment (15%), environmental integrity of destinations (20%) and EIC satisfaction (15%).



The 2019–2025 series was reconstructed from MINTUR and UN Tourism data; the 2026–2030 projections apply three public-policy elasticities to compound growth: conservative scenario (elasticity 0.4 current policies maintained), moderate scenario (elasticity 0.7 partial implementation of the policy package proposed in Section 4.6) and transformative scenario (elasticity 1.0 full implementation, including FITSA and the park digital twins). Validation against the observed 2022–2024 values showed a mean absolute error below 6%, an acceptable value for scenario models of this nature.

4. RESULTS AND DISCUSSION

4.1 Where we came from: the legacy of the pandemic era (2020–2021)

The starting point of the analysis is the 2020–2021 biennium, during which Angola received about 127 thousand international tourists the lowest figure of the 21st century , against approximately 218 thousand in 2019. The collapse of about 60% of the ICST (from 100 to 41 points in 2020) had three lasting effects documented by the research. First, the forced deconcentration of demand: with borders closed, residents discovered domestic destinations (Mussulo, Kalandula, Tundavala, Namibe), creating a domestic market that did not exist and which the 2025 survey confirms as structural 64% of visitors surveyed in the pilot destinations were national residents. Second, the exposure of the fragility of communities dependent on informal tourism-related income, especially in Quiçama and Menongue. Third, regulatory acceleration: the State used the pause to simplify visas, update statistics and reposition tourism as a vector of post-oil economic diversification.

4.2 Where we are: the measured recovery (2022–2025)

The recovery exceeded expectations. MINTUR's Tourism Statistics Yearbook records 263,553 international arrivals in the 2022–2023 biennium, 136 thousand more than in the previous, pandemic biennium, and the specialised economic press reported, in the third quarter of 2024, a year-on-year growth of 86.1% in tourist entries (from about 15 thousand to approximately 28 thousand). With the ICST reconstructed, Angola moved from 41 points in





2020 to an estimated 178 points in 2025 already 78% above the 2019 pre-pandemic base. This trajectory is consistent with the global context: the UN Tourism Barometer indicated, in January 2025, the recovery of 99% of world pre-pandemic levels, with 1.4 billion international arrivals in 2024, 11% more than in 2023. However, our field data show that the Angolan recovery is quantitatively strong and qualitatively fragile: it grows mainly in short-stay visit volume and in domestic tourism, without the corresponding consolidation of infrastructure, environmental certification and community benefit-sharing mechanisms precisely the three vertices of the EIC Triangle.

Figure 1 - Space-Infrastructure-Communities Triangle (EIC Triangle): conceptual model proposed by the authors (2025)

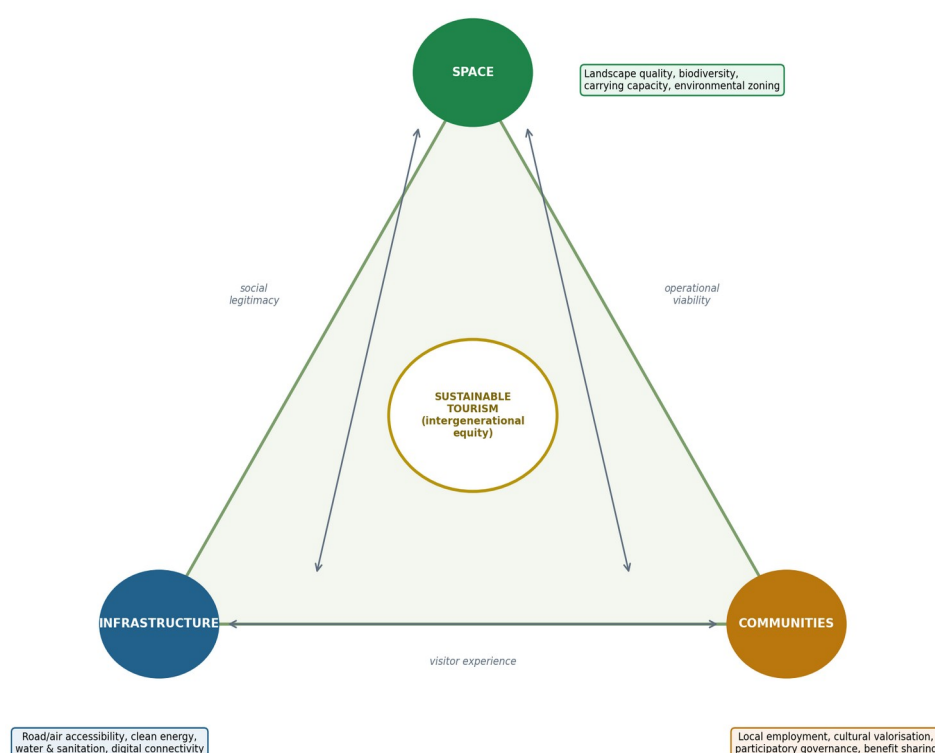


Figure 1 - Space-Infrastructure-Communities Triangle (EIC Triangle). Source: prepared by the authors (2025).

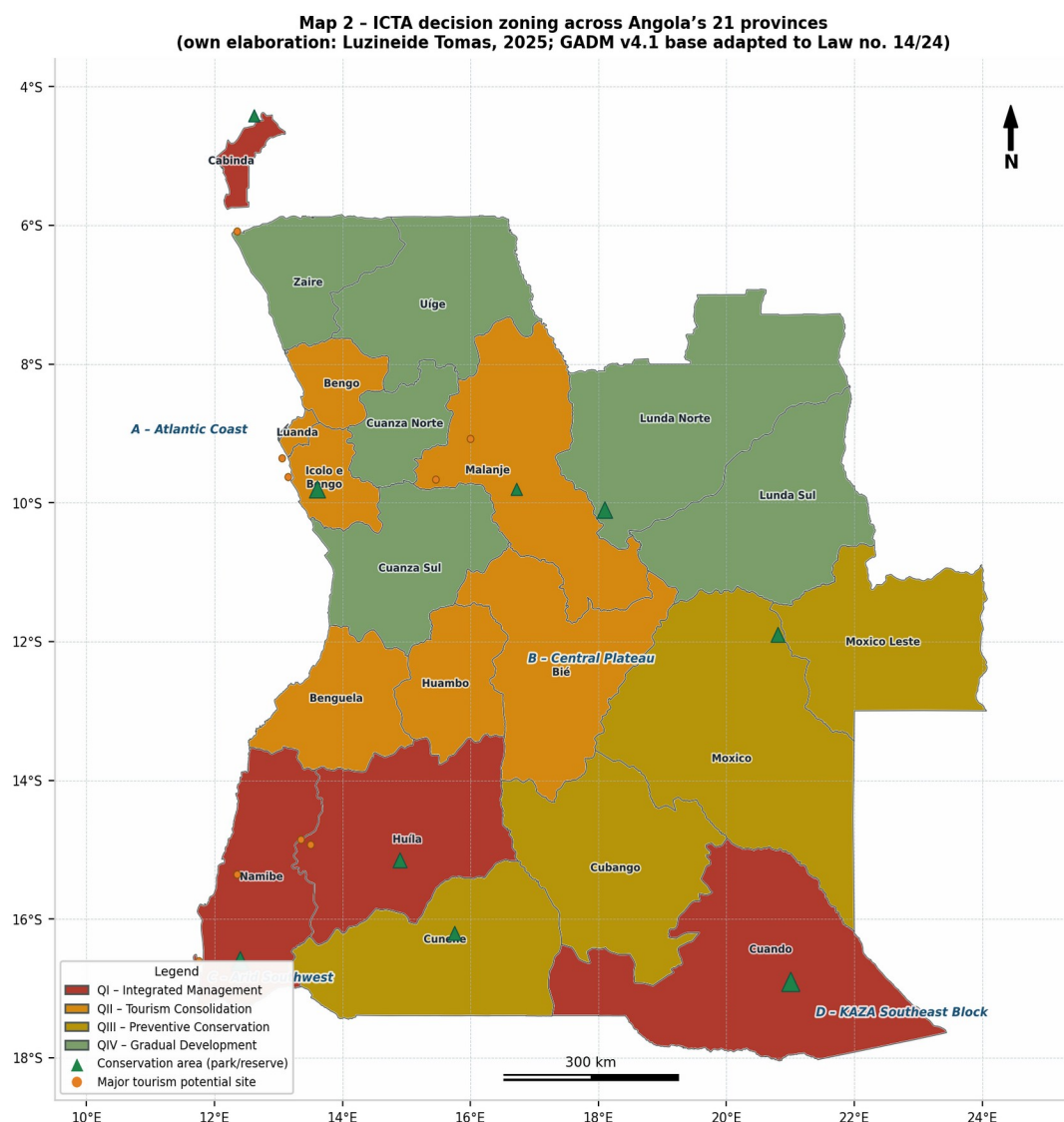


4.3 The tourism–environment crossing: ICTA matrix and decision zoning

Applying the ICTA to the 21 provinces (Table 1; Figure 2; Map 2) confirms hypothesis H1: four provinces – Cuando (ICTA = 71.4), Namibe (77.2), Huíla (65.4) and Cabinda (63.8) lie in Quadrant I, Integrated Management Priority, where high tourism relevance coexists with high environmental sensitivity. The new political-administrative division (Law no. 14/24 of 5 September 2024) refined this territorial reading: the former Cuando Cubango split into the provinces of Cuando and Cubango, Moxico gave rise to Moxico Leste, and the province of Icolo e Bengo was created from Luanda; while Cuando – the heart of the KAZA block – remains in Quadrant I, Cubango (64.2) moves to Quadrant III, Preventive Conservation, and Icolo e Bengo (60.0), home to Quiçama, stands in Quadrant II. It is in the Quadrant I provinces that a wrong licensing decision can destroy, within a few years, assets that took millennia to form: the elephant corridors of the southeast linked to KAZA, the Namibe Desert with its *Welwitschia mirabilis*, the Maiombe forest and the geomorphological complex of Tundavala-Serra da Leba.

For these provinces, the article proposes visitation quotas, mandatory environmental impact assessment with environmental bonding, and tourism management plans prior to any concession. Quadrant II (Tourism Consolidation) comprises Malanje (63.4), Luanda (61.4), Icolo e Bengo (60.0), Benguela (57.7), Huambo (56.0), Bié (55.9) and Bengo (53.4), where the priority is upgrading the supply and targeted mitigation. Cubango (64.2), Moxico (59.9), Moxico Leste (56.3) and Cunene (52.7) make up Quadrant III, Preventive Conservation, and the remaining six provinces Quadrant IV, Gradual Development. Map 2, produced by the authors, spatially summarises this zoning, overlaying the conservation areas, the points of greatest tourism potential and four crossing zones (A: Atlantic Coast; B: Central Plateau; C: Arid Southwest; D: KAZA-Southeast Block).





Map 2 - Decision zoning of the ICTA in the 21 provinces of Angola, with the zones of greatest tourism potential and biodiversity conservation. Source: own elaboration by Luzineide Tomas (2025), on GADM v4.1 administrative boundaries adapted to Law no. 14/24 of 5 September 2024; location and delimitation of conservation areas and tourism points surveyed by the authors.



Province	RT	SA	ICTA	Decision quadrant
Namibe	71	84	77,2	I - Integrated Management Priority
Cuando	56	91	71,4	I - Integrated Management Priority
Huíla	63	68	65,4	I - Integrated Management Priority
Cubango	49	84	64,2	III - Preventive Conservation
Cabinda	55	74	63,8	I - Integrated Management Priority
Malanje	66	61	63,4	II - Tourism Consolidation
Luanda	82	46	61,4	II - Tourism Consolidation
Icolo e Bengo	58	62	60,0	II - Tourism Consolidation
Moxico	46	78	59,9	III - Preventive Conservation
Benguela	64	52	57,7	II - Tourism Consolidation
Moxico Leste	44	72	56,3	III - Preventive Conservation
Huambo	58	54	56,0	II - Tourism Consolidation
Bié	52	60	55,9	II - Tourism Consolidation
Bengo	50	57	53,4	II - Tourism Consolidation
Zaire	48	58	52,7	IV - Gradual Development
Cunene	42	66	52,7	III - Preventive Conservation
Cuanza Sul	47	53	49,9	IV - Gradual Development
Uíge	40	55	46,9	IV - Gradual Development
Cuanza Norte	44	50	46,9	IV - Gradual Development
Lunda Norte	38	56	46,1	IV - Gradual Development
Lunda Sul	36	59	46,1	IV - Gradual Development

Table 1 - Tourism-Environment Crossing Index (ICTA) by province, in the 21 provinces of Law no. 14/24 of 5 September 2024. Source: prepared by the authors (2025), based on data from MINTUR, MINAMB/INBC and a Delphi panel of 12 experts.





Figure 2 - ICTA matrix: tourism-environment crossing in Angola's 21 provinces
(authors' own elaboration, 2025; circle size $\propto$ ICTA = $\sqrt{(RT \times SA)}$)

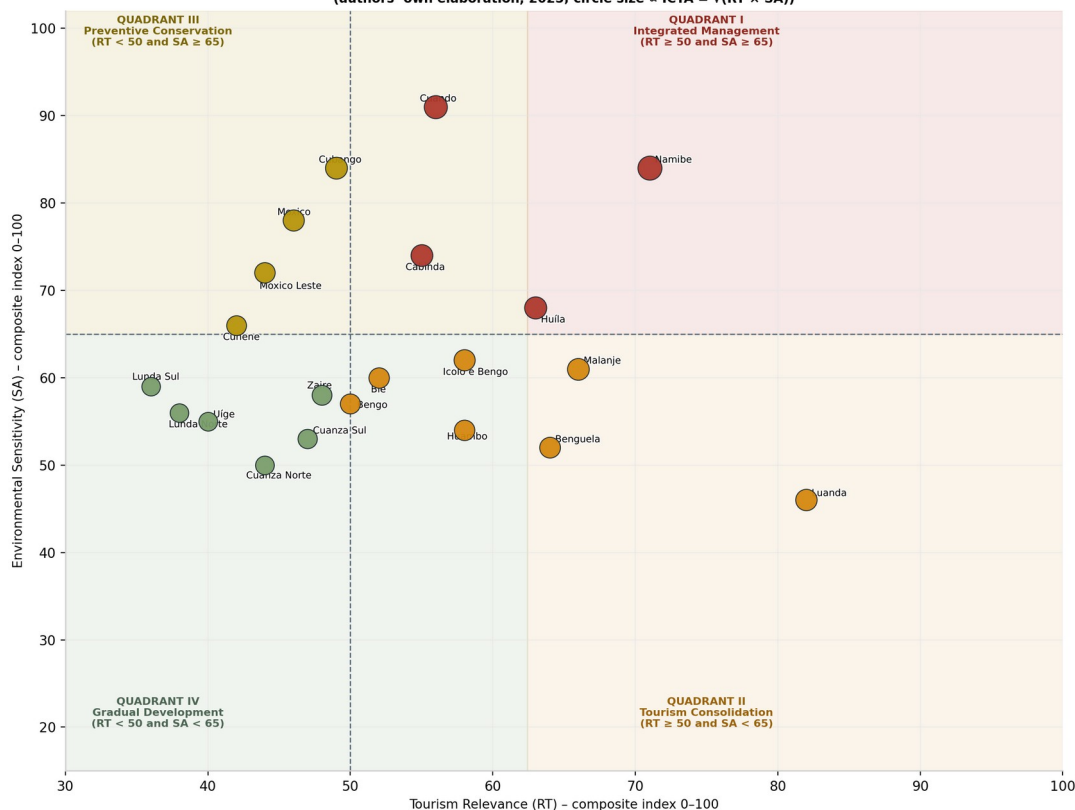


Figure 2 - ICTA matrix: Tourism Relevance $\times$ Environmental Sensitivity crossing in the 21 provinces. Source: prepared by the authors (2025).

4.4 Satisfaction in the EIC Triangle: the confirmed asymmetry

The survey of 412 respondents in the four pilot destinations (Table 2; Figure 3) confirms hypothesis H2. National mean satisfaction is high on the Space vertex (4.5 out of 5), but falls to 2.9 on the Infrastructure vertex and stabilises at 3.3 on the Communities vertex. The national EST equilibrium index is only 3.5 a value explained by the geometric-mean rule: the weakest vertex drags the whole down. The contrasts between destinations are instructive. Quiçama, benefiting from its proximity to Luanda, shows the best relative infrastructure (3.4), but the lowest community score among the easily accessible destinations (3.1), a sign that tourism benefits still do not reach the villages surrounding the park.



Kalandula reveals the inverse pattern: strong community involvement (3.8) local guides, handicrafts, family-run restaurants and deficient infrastructure (2.9). Luengue-Luiana exhibits the most extreme profile: the country's best Space (4.8) and worst Infrastructure (2.2), which, in the TALC model, corresponds to a destination in an embryonic phase whose premature massification would be irreversible. The joint reading of Table 2 and Figure 3 produces the article's main empirical conclusion: the bottleneck of Angolan sustainable tourism is not the natural product which is world-class, but the triad of access, services and community sharing.

This conclusion should be read literally: the Space vertex, which expresses the quality of the natural product, reaches values close to the top of the scale in every destination; it is road and air access and the basic services of energy, water and sanitation (Infrastructure vertex), together with the mechanisms for involving and sharing benefits with local communities (Communities vertex), that block the conversion of natural heritage into sustainable development and it is precisely on these, because they are public-policy variables, that State action can directly bear.

Pilot destination	Space (E)	Infrastructure (I)	Communities (C)	EST*
Quiçama (Icolo e Bengo)	4,2	3,4	3,1	3,5
Kalandula (Malanje)	4,5	2,9	3,8	3,7
Namibe-Iona	4,6	3,0	2,8	3,4
Luengue-Luiana (Cuando)	4,8	2,2	3,4	3,3
Weighted national average	4,5	2,9	3,3	3,5

Table 2 - Satisfaction levels in the EIC Triangle by pilot destination (1–5 scale; *EST = $(E \times I \times C)^{(1/3)}$). Source: authors' survey of 412 respondents (2025).





Figure 3 - Sustainable tourism satisfaction levels in the EIC Triangle
(Authors' survey of 412 respondents, 4 pilot destinations, 1-5 scale, 2025)

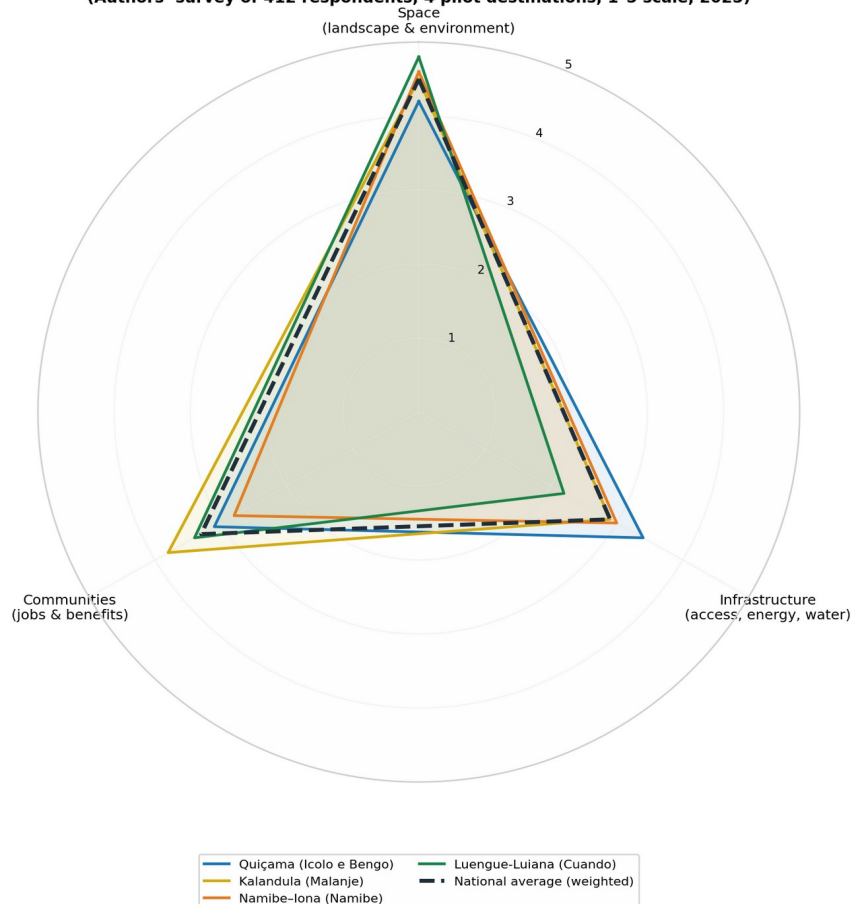


Figure 3 - Satisfaction levels in the EIC Triangle by pilot destination. Source: prepared by the authors from the field survey (2025).

4.5 Where we want to go: MPGA-25 scenarios to 2030

Figure 4 presents the reconstructed ICST trajectory (2019–2025) and the three scenarios projected to 2030. In the conservative scenario current policies maintained the index reaches about 230 points, growth that would conceal the progressive degradation of Quadrant I destinations for lack of regulation. In the moderate scenario, with partial implementation of the policy package, the ICST reaches 320 points. In the transformative scenario, with full implementation including ICTA zoning as an official instrument, FITSA, the park digital



twins and EIC certification, the index may reach 420 points, equivalent to quadrupling the 2019 base with environmental integrity preserved. Hypothesis H3 is thus confirmed: the difference between scenarios is determined not by the market, but by the intensity of public action. In practical terms, the transformative scenario implies, by 2030, about 600 thousand international arrivals per year, the doubling of formal tourism employment and the maintenance of all environmental-integrity indicators above the threshold of 80% of their 2025 value.

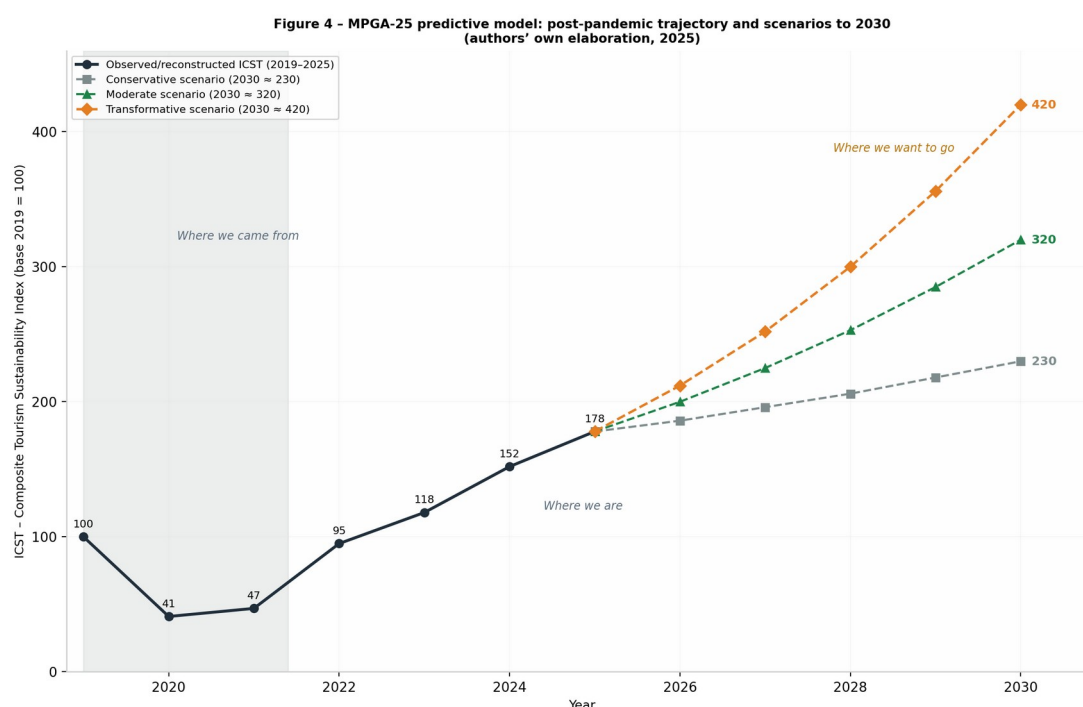


Figure 4 - MPGA-25 predictive model: where we came from, where we are and where we want to go. Source: prepared by the authors (2025).

4.6 Public policies and the imperative of future generations

The final question how can public policy make the transformative scenario viable without harming future generations is answered by a package of six instruments, ranked by cost and time horizon. (1) **Official adoption of ICTA zoning**: converting the matrix of Figure



2 into a regulatory annex to spatial-planning instruments, so that no tourism development in Quadrant I is licensed without reinforced environmental impact assessment and a defined visitation quota. (2) **Tourism conservation fee** (5–10 dollars per international visitor and per overnight stay in protected areas), capitalising FITSA²¹, a fund whose income may only finance conservation, community training and green infrastructure a direct inspiration from the Botswana and Rwanda parallels, adapted to Angolan fiscal reality. (3) **National EIC certification**, a three-level seal awarded to developments audited on the three vertices of the triangle, similar to the Costa Rican certification. (4) **Community concessions** along the Namibian CBNRM model, beginning with the KAZA corridors in Cuando province and the Maiombe, with use and revenue rights transferred to legally constituted local associations. (5) **Selective green infrastructure**: prioritising access, water and renewable energy in the four pilot destinations where the EST is held back by the Infrastructure vertex Luengue-Luiana (2.2) and Kalandula (2.9) first. (6) **Digital twins of the parks**: virtual replicas fed by sensors, satellite imagery and visitor counts, allowing decisions to be simulated before being taken in the real territory a methodological contribution of the Department of Informatics and an absolute novelty for Southern Africa. Each instrument was designed with an intergenerational golden rule: no present revenue increase may be obtained by reducing the stock of natural capital bequeathed to the future.

5. PATHWAYS UNCOVERED: WHAT THIS RESEARCH REVEALS AS NEW FOR SOUTHERN AFRICA

Beyond the three methodological instruments, the research revealed eight concrete pathways that, to the best of the authors' knowledge, had not been systematised in the literature on tourism and the environment in Southern Africa. They are:

21 FITSA - Angolan Intergenerational Fund for Sustainable Tourism (Fundo Intergeracional do Turismo Sustentável de Angola): financial instrument proposed in this article to capitalise conservation with tourism revenues.





1. ICTA zoning as an official licensing instrument turning the tourism-environment matrix into a regulatory annex of territorial plans, so that the difficulty of the decision grows with the value of the index, not with the political pressure of the moment.
2. Angolan Intergenerational Fund for Sustainable Tourism (FITSA) capitalised by the tourism conservation fee and by a fixed percentage of concessions in protected areas, under a rule of capital untouchability: only the income is spent, ensuring that future generations inherit both the fund and the heritage that feeds it.
3. Digital twins of the national parks virtual replicas of Quiçama, Iona and Luengue-Luiana, fed by sensors and satellite, that make it possible to test in simulation the effect of roads, lodges and quotas before any physical intervention; no SADC country currently has this instrument applied to tourism.
4. Low-volume, high-value KAZA corridor positioning the Angolan southeast as the most exclusive, and cheapest to preserve, segment of the world's largest transfrontier conservation area, importing the Okavango model while entry costs are still low.
5. National EIC certification the first tourism-sustainability seal in Southern Africa built on three territorially observable vertices (Space, Infrastructure, Communities), instead of imported checklists, making it auditable by provincial technicians.
6. Scientific and citizen tourism programmes in which the visitor takes part in fauna counts, Welwitschia monitoring and Maiombe inventories, converting infrastructure scarcity into an immersion experience and generating scientific data at marginal cost.
7. Community tourism rangers certified training of young people from the villages around the parks as guides and wardens, fusing the Communities vertex with visitor safety and anti-poaching surveillance.
8. National Observatory of Sustainable Tourism a public indicator platform (ICST, ICTA, EST) updated annually, linking Angola to UN Tourism's international observatory network and ensuring that policy is measured, not merely announced.





These pathways culminate in a proposal the authors designate the **Angolan Model of Regenerative Tourism (MATR)**: an arrangement in which each visitor leaves the destination, as measured by the EST, equal to or better than they found it, and in which tourism revenue directly finances the expansion of natural capital. If implemented, the MATR will be the first African model of regenerative tourism with explicit intergenerational governance this article's contribution to Southern Africa and, by extension, to the global debate on post-extractivist tourism.

6. FINAL CONSIDERATIONS

This article set out from three questions and returns to them. **Where did we come from?** From the pandemic collapse of 2020–2021, which reduced the ICST to 41 points, but which also revealed a dormant domestic market and accelerated long-postponed reforms. **Where are we?** In a recovery robust in volume 263,553 arrivals in the 2022-2023 biennium and an ICST of 178 points in 2025, yet asymmetric in quality: world-class natural spaces (4.5/5), deficient infrastructure (2.9/5) and incipient community sharing (3.3/5), with four provinces at critical tourism–environment crossing risk. **Where do we want to go?** To an ICST of 420 points in 2030, in the transformative scenario, achievable only if the proposed policy package ICTA zoning, FITSA, EIC certification, community concessions, green infrastructure and digital twins is adopted before massification closes the window of opportunity that the post-pandemic period opened.

The study's limitations should be declared: the RT and SA sub-indices, although built on official data and validated by a Delphi panel, incorporate expert judgement and should be recalibrated when MINTUR publishes disaggregated provincial statistics; the survey covered four pilot destinations and not the entire territory; and the MPGA-25, like every scenario model, projects conditionally its 2030 figures are worth the policy package they assume. Future research should extend the survey to the 21 provinces, build the first digital twins of Quiçama and Iona and test the fiscal elasticity of FITSA. The essential, however, is established: Angola now has, for the first time, an analytical framework ICTA, EIC Triangle





and MPGA-25 that makes it possible to decide where, how and how far to tourismify, without the price of that choice being paid by those not yet born.

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LIST OF ACRONYMS

Acronym	Meaning
AIA	Environmental Impact Assessment (Avaliação de Impacto Ambiental)
CBNRM	Community-Based Natural Resource Management (Gestão Comunitária dos Recursos Naturais)
EIC	Space-Infrastructure-Communities Triangle (Triângulo Espaço–Infraestrutura–Comunidades)
EPANB	National Biodiversity Strategy and Action Plan (Estratégia e Plano de Ação Nacional para a Biodiversidade)
EST	Tourism Sustainability Equilibrium Index: $(E \times I \times C)^{(1/3)}$ (Índice de Equilíbrio da Sustentabilidade Turística)
FITSA	Angolan Intergenerational Fund for Sustainable Tourism (Fundo Intergeracional do Turismo Sustentável de Angola)
GADM	Global Administrative Areas (cartographic base, v4.1)
ICST	Composite Tourism Sustainability Index (base 2019 = 100)

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ICTA	Tourism-Environment Crossing Index: $\sqrt{(RT \times SA)}$
INBC	National Institute for Biodiversity and Conservation Areas (Instituto Nacional da Biodiversidade e das Áreas de Conservação)
KAZA	Kavango-Zambezi Transfrontier Conservation Area
MATR	Angolan Model of Regenerative Tourism (Modelo Angola de Turismo Regenerativo)
MINAMB	Ministry of the Environment of Angola (Ministério do Ambiente)
MINTUR	Ministry of Tourism of Angola (Ministério do Turismo)
MPGA-25	Geo-Environmental Predictive Model of Angola, 2025 version (Modelo Preditivo Geoambiental de Angola)
ODS	Sustainable Development Goals (2030 Agenda) (Objetivos de Desenvolvimento Sustentável)
ONU Turismo	United Nations World Tourism Organization, UN Tourism (formerly UNWTO/OMT)
RT	Tourism Relevance (sub-index 0–100) (Relevância Turística)
SA	Environmental Sensitivity (sub-index 0–100) (Sensibilidade Ambiental)
SADC	Southern African Development Community (Comunidade de Desenvolvimento da África Austral)
SIG	Geographic Information System (Sistema de Informação Geográfica)
TALC	Tourism Area Life Cycle (Ciclo de Vida da Área Turística)
WTTC	World Travel & Tourism Council (Conselho Mundial de Viagens e Turismo)

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