Evaluation of NBS Solutions for Climate Resilience and Adaptation in the Sub-saharan Africa: The Case of Ghana's Ashanti Region

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Abstract. The new challenge of the century is the development of sustainable projects. It is crucial to consider integrated solutions to evaluate project consequences at the social, geographical, physical, ecological, and technological levels in a future where climate hazards will increase owing to anthropogenic activities. As a result, the topic of this paper is the creation of a hybrid methodology for evaluating the aforementioned implications. The "Okyena for a Free Future" project in Manso Abore, in Ghana's Ashanti region, is used as a case study for the methodology. OFF proposes the construction of a school hub that can accompany the entire community towards social and economic development while also taking climate resilience and adaptation measures into consideration. In this environment, perhaps more than in others, the necessity to provide actions that can contribute to community expansion without compromising the development of future generations is clear. The A'WOT model, together with other assessment methods like Stakeholder Analysis and Scenario Building, enables taking multiple factors into account at once to handle the world's increasing complexity. By doing so, it is feasible to highlight the perspectives of the key players and provide decision-makers with a logical foundation for choice dilemmas involving various, frequently at odds objectives. By assessing the viability of implementing NBS solutions, the model aims to facilitate the deployment of alternative techniques.

Keywords: Mixed-methods · A'WOT analysis · Nature-based solutions

1 Introduction

The most recent estimates, the global population might reach approximately 8.5 billion by 2030 and 9.7 billion by 2050. The population will peak at approximately 10,4 billion in 2080 and remain at that level until 2100 [1]. The proportion of world population in

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working age (from 25 to 64 years) is even more increasing. Nowadays, the greatest barrier to equitable growth is inequality, which may be measured using Gini index [2]. Over the past three decades, world inequality has increased as result of liberalist policies of privatization and deregulation [3]. In addition, new potential drivers of inequality, such as digital transformation and climate change, have emerged in recent years and are expected to have a negative impact on inequality if not supported by suitable countermeasures.

In general, Sub-Saharan Africa (SSA) in the last 10 years reported an increasing trendline of the Gini index, as a result of the growing disparity due to the socioeconomic gap between the communities within the SSA Countries. It is estimated that SSA will dominate global population growth until 2050. [2]. The change in age distribution appears to be an opportunity that Sub-Saharan Africa to accelerate economic growth per capita. According to the World Bank, Ghana's Gini index was 43,5 in 2016, indicating significant economic disparity within the nation [3].

Due to a variety of factors such as the increase in population, migration and uncontrolled urbanization, the potential of the African continent for a better quality of life remains untapped.

A commitment supports less developed nations, also through technical and financial aids, in the design and implementation of sustainable and resilient structures using local materials. In Ghana, the achievement of sustainability has stalled, as shown by both overall and average performances by SDG (Fig. 1). Its rank is in part in part due to the lack of special legislation. The target remains one of the major obstacles to ensure a sustainable future for the country's population.

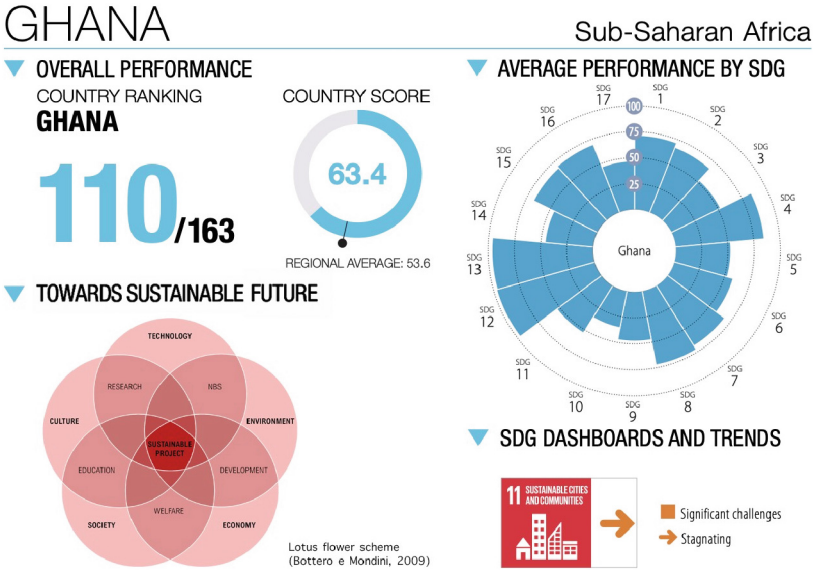

Fig. 1. Sustainable Development Report for Ghana, performance of goal 11 and lotus flower scheme for the problem under investigation.

Although the disparity with the global north countries, SSA countries are significantly moving for climate adaptation and provision of services to communities and with care of the environment. In this sense, SSA have found in Nature-Based Solutions (NBS) an opportunity to achieve sustainable and resilient challenges [2].

Specifically, NBS are defined as "actions to protect, sustainably manage, and restore natural or modified ecosystems, which ad- dress societal challenges in an effective and adaptive manner, while providing benefits for human well-being and biodiversity" [4]. NBS aim to support the achievement of Sustainable Development Goals (SDGs) [5–10], with a particular attention on Goal 11 "Making cities and communities more sustainable and resilient", as well as to protect human well-being by enhancing the resilience of ecosystems, their capacity for renewal, and their service provision. Their deployment is a comprehensive response to the environmental challenges faced by all those impacted by climate change (e.g., flooding, air and water pollution, among others).

The term NBS was first used by the World Bank in 2008 [11], and then adopted by the International Union for Conservation of Nature (IUCN) in 2012 [12, 13].

More recently, the World Resources Institute (WRI) partnered with the World Bank and the African Development Bank to conduct in SSA a regional inventory to collect projects that implemented NBS in the decade 2012–21 [14].

The paper aims to explore the current challenge of NBS implementation in SSA nations, through the development of a multi-methodological proposal to evaluate the feasibility of alternative NBS scenarios. This proposal is composed by a Stakeholders Analysis, a SWOT + STEEP Analysis, and Scenario Building to frame the decision problem, and by the multicriteria ranking technique "A'WOT" for the problem assessment and solution.

The purpose is to provide to public administrations, financiers, and developers a model for the development of a coherent and integrated decision-making process that can facilitate the NBS design, assessment and, implementation in global-south countries to respond effectively to climate resilience uncertainty and socio-economic issues.

2 Integrated Multi-level Methodology

The proposed multi-methodological approach is structured by considering specific evaluation phases that can favor the addressing of sustainability and resilience paradigms. Each phase can be associated to an evaluation tool (or more than one), depending on the complexity to reach the evaluation goal. [8]. In this multi-level method, specific evaluation tools are highly recognized and shared in the literature to support the evaluation process (Table1).

Stakeholder analysis is included in the cognitive analysis phase because it is essential for understanding the engaged players to enhance decision-making process during the design and implementation of an intervention. The SWOT + STEEP Analysis can provide a photograph of the current state of the area in which the intervention should be located. Scenario building can develop narratives to envision alternative futures and thus support the assessment of alternatives.

The A'WOT model aims to analyze the alternatives developed via Scenario Building and to continue with project design through the monitoring phase.

Table 1. Phase of sustainability project and tools (Elab. From [16]).

Evaluation phases	Evaluation tools
1. Cognitive analysis	Stakeholders Analysis
2. Consultation	SWOT + STEEP Analysis
3. Definition of strategic framework	Scenario Building
4. Systemic evaluation	A'WOT Model
5. Monitoring	DPSIR Model

The research focuses on the application of these mixed methodologies to support the selection of the most sustainable design alternative according to the "Lotus flower model" [8].

2.1 Framing of the Problem

After completing the cognitive framework pertaining to the case study and context, it is essential to introduce the Stakeholders Analysis as the first decision-making tool. This analysis identifies the public and private actors capable of influencing the transformation of the urban fabric. In addition to the actors, consideration must also be given to the project's stakeholders, who, despite not necessarily being directly involved in project decisions, can influence the potential success/acceptance of the intervention [15, 16]. It is essential to identify the actors and stakeholders and their level of power/interest, as well as the exchanged relationships between them. A combination of Power Interest Matrix (P/I) and Social Network Analysis (SNA) is therefore proposed.

Power/Interest Matrix
The Power/Interest matrix (P/I) illustrates each stakeholder's power and interest levels in a particular decision-making process [16]. It permits stakeholders to be mapped according to their level of interest and decision-making authority. The identification of stakeholders is accomplished by evaluating the types of actors and cognitive resources possessed by each one. This generates as output a map based on qualitative evaluations converted to a numeric scale to produce a final ranking.

Social Network Analysis
SNA is a methodology that has evolved from sociology and anthropology. Within the decision-making process, the relationships between the various actors and the various types of resources they exchange with one another are taken into account. According to this strategy, it is possible to visualize the size and shape of the network, as well as the coalitions and key DMs. The relationships between stakeholders can affect the over- all performance of the decision-making process [17].

The combination of these two methods enables consideration of all involved parties and their interdependent relationships [18]. Thus, it will be possible to identify competing

interests during the ex-ante phase, while minimizing negative externalities during the in itinere and ex-post phases.

SWOT + STEEP Analysis

The SWOT analysis is a decision-making tool that helps to rationalize decision-making processes. It is a well-known technique that was developed in the 1960s [19] to analyze the strengths (S), weaknesses (W), opportunities (O), and threats (T) of a given problem. This appears like a four-quadrant matrix that identifies the context's endogenous (strengths and weaknesses) and exogenous (opportunities and threats) fac- tors. Since the 1980s, its usage was extended to other fields, such as business economics, and founded a fertile arena in public sector to analyze and support policy decisions. This tool well fits when is combined with STEEP analysis, which considers the following factors: (i) Society; (ii) Technology; (iii) Environment; (iv) Economy; (v) Policy. In this contribution, the STEEP analysis has been adapted to fit the rural context, since the specificity of the case study, thus resulting in the following components:

1. Socioeconomic factors to assess sociological components and economic dynamics in the rural area;
2. Urban infrastructure and services to evaluate the availability of services and infrastructure;
3. Ecology and environment to understand the health state of the environment and plan land management;
4. Governance and policy to assess the presence/absence of plans, programs, projects or funds and to understand the hierarchy of the power in the community;
5. Construction and craftsmanship to evaluate the local potential related to traditional techniques.

The SWOT + STEEP analysis generates a four-quadrant diagram in conjunction with the adapted STEEP components to analyze the site-specific characteristics of the case study and its complex dynamics.

Scenario Building

To support policy decisions effectively, scenario building plays an important role in modeling plausible future conditions. A scenario is defined as "a set of hypothetical future events constructed to clarify a possible chain of causal events and their decision points" [20].

Thus, traditional planning has given way to strategic planning, which is founded on a long-term, place-based, multidisciplinary approach. By considering the interests of all parties, this method makes it possible to strengthen political consensus [21, 22]. Scenario planning stimulates strategic thinking, enables the identification of alternative futures, and supports decision-making under conditions of uncertainty [23].

In the relevant literature, a reasonable number of three-five scenarios is generally suggested, including in this range the zero-option (or inertial scenario), which provides the same services and resources without any change over time. Its inclusion in the evaluation favors more propensity of the DMs in accepting scenarios comparison. Thereby, an operational transition towards sustainable integrated spatial planning is possible.

2.2 Evaluation of the Problem

The systemic evaluation phase allows for the assessment of the optimal design alternative considering the previous analyses. Starting with a SWOT analysis and Scenario Building, the Multicriteria Analysis technique (MCA) is implemented, which is a useful tool for resolving uncertain problems [24]. MCA can be combined within integrated frameworks owing to its qualitative-quantitative methodology [8, 18]. Particularly, it is used as an umbrella term to collect a series of evaluation techniques that attempt to explicitly take into account multiple criteria simultaneously. The goal is to bring out the points of view of the involved actors and provide DMs with a rational basis for choice problems that are increasingly characterized by a multiplicity of often conflicting objectives/criteria [25]. The A'WOT method, which combines SWOT analysis and the AHP technique, is suitable to achieve the sustainability objective [26, 27].

A'WOT

The A'WOT model is a hybrid approach that overcomes certain AHP and SWOT analysis limitations [28–30]. It enables the evaluation of the best alternative in a decision-making process on the basis of the SWOT analysis's highlighted contextual characteristics. The following steps characterize the method:

- Contextual cognitive synthesis;
- Drafting SWOT analysis;
- Cascade structuring according to the AHP decomposition principle;
- Evaluation and weighting of the elements according to the principle of comparative judgements by means of surveys/questions or desk judgements;
- Synthesis of local and global priorities;
- Sensitivity analysis, for instance using the "What-if?" method [31].

The cascade configuration is typical of AHP and is distinguished by [32]:

- Goal: to determine the most sustainable alternative among the generated scenarios;
- Criteria: strengths, weaknesses, opportunities, and threats;
- Sub-criteria: SWOT items subdivided into strengths, weaknesses, opportunities, and threats;
- Alternatives: definition of a finite set of scenarios. They are described in Sect. 3.

The evaluation model can be developed by using dedicated software such as SuperDecisions by CreativeFoundations. Utilizing pairwise comparison and Saaty's scale, the weighting of the elements is determined. Saaty's scale is a nine-score comparison scale that is used by DMs in expressing the intensity of the elements within a hierarchy through pairwise comparison [33]. There are three levels of comparison: (i) At the level of criteria; (ii) At the level of sub- criteria; and (iii) At the level of alternatives.

The following steps must be taken to determine the weight of each alternative:

- Solve the principal eigenvector and normalize the result;
- Weight the eigenvector according to the priority of the element with which it was compared. In this way, a ranking of all the hierarchy priorities is obtained;

- Sum all weighted eigenvectors. This step allows to synthesize the priorities previously obtained in the considered scenarios, thus obtaining the final ranking.

To ensure consistency of judgements, the Consistency Ratio must be always $\leq 10\%$. A survey can be developed by choosing a participatory or a desktop modality via questionnaires, interviews, workshops, and so on. In the second scenario, picking a key stakeholder is crucial to preventing subjectively affecting the outcomes.

Local priorities and global priorities are elicited at the level of sub-criteria and alternatives, respectively, and are distinguished in the summary of priorities. Thus, it is possible to determine which project strengths, weaknesses, opportunities, and threats will require the most consideration.

Lastly, the sensitivity analysis is helpful to examine the stability of the results and thus of the evaluation model when the weights of the criteria are altered. However, due to the limited space, this was not incorporated into the paper.

3 Application

3.1 Case Study: The Ashanti Region of Ghana

The study area is affected by environmental issues such as Galamsey sites, deforestation, and flooding, which requires the consideration of the role of nature-based solutions (NBS) in the characterization of the scenarios.

"Okyena for a Free Future" (OFF) is a public project developed within the framework of Italian educational institutions, construction holdings and local public authorities, which aims to promote the construction of a vocational school complex in the rural area of Manso Abore, in the Ashanti region of Ghana.

The government-designated intervention area encompasses approximately 19 hectares and is characterized by a vast expanse of virgin forest and a small portion contaminated by illegal mining (Fig. 2). As there are no local, territorial, or government

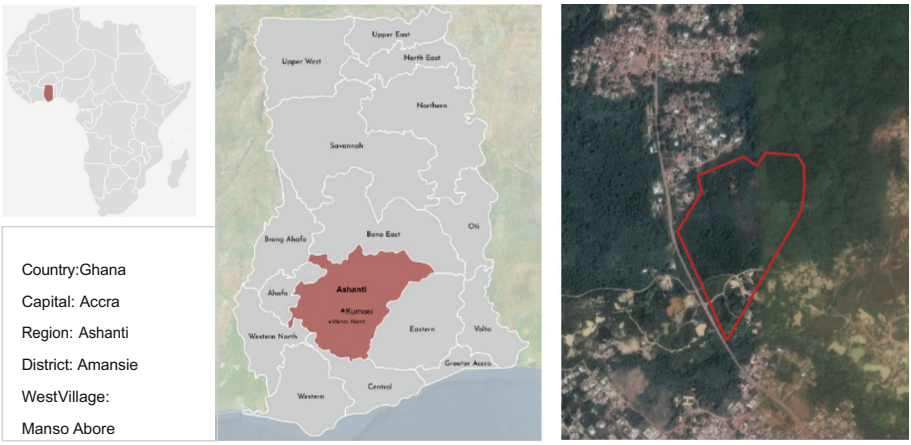

Fig. 2. Map of the intervention plot in Manso Abore, Ghana.

plans with clear indications regarding the area's transformation, these characteristics serve as the starting point for reflection.

Due to the absence of a long-term urban planning forecast, the multi-level methodology is here employed to support the design of a long-term strategy. Particularly, the objective will be to determine the optimal scenario for promoting the region and the community from a social, economic, and environmental standpoint, with a focus on sustainability and climate resilience. The integrated method is then applied to the plot and the surrounding rural territory, beginning with the cognitive analysis and concluding with the scenario selection. Managing the inherent area's complexity and contradictions is the most difficult aspect of the decision-making process.

3.2 Stakeholders Analysis

Once the key stakeholders were identified, they were categorized based on their degree of influence and level of interest using the Power/Interest matrix [17]. According to the SNA model, the above analysis was supplemented by an analysis of the existing and potential relationships between the various stakeholders [18]. The picture below

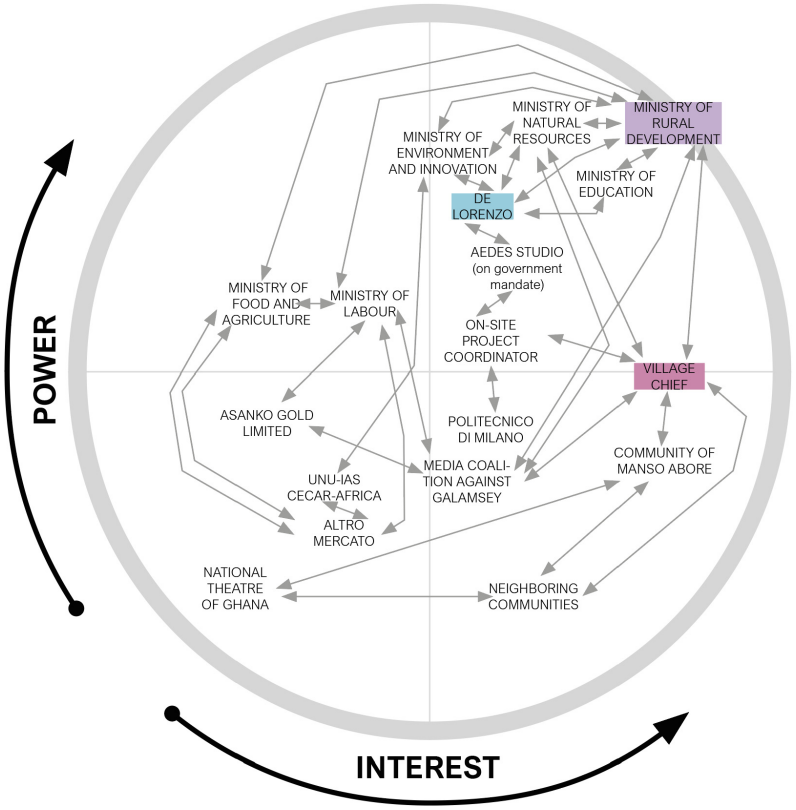

Fig. 3. The output od SNA combined with P/I for the problem under investigation.

depicts the outcomes of the applied mixed method (Fig. 3). The analysis demonstrates that the Ministry of Rural Development is the most influencing public actor. Similarly, a leading Italian company in design, development, and production of technical and vocational training equipment, represents the major private developer as the project's primary funder. The village chief is the central intermediary between the Manso Abore local community, the neighboring communities, and the highest institutional offices.

All other actors and stakeholders must be involved in the decision-making process, more or less actively depending on the quadrant they fall into, to guarantee the highest level of transparency and promote the acceptance of decisions by all parties.

Only by implementing this strategy will it be possible to minimize and mitigate conflicts resulting from divergent opinions and thereby increase the intervention's chances of success.

3.3 SWOT + STEEP Analysis

The SWOT analysis coupled with the STEEP analysis enabled the identification of the intervention area's defining characteristics. According to Table 2, the environmental theme, which is related to the themes of degradation and pollution, plays a crucial role in the region. In addition, education, strategic vision, and the durability of interventions emerged as additional topics.

Table 2. The output of SWOT + STEEP analysis for the problem under investigation.

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	TREATHS
Ecology & Environment	Availability of NBS materials Forest as flood protection element	Floods Environmental degradation due to illegal mining Loss of biodiversity Water contamination	Water projects for groundwater reclamation Land reclamation projects Converting mining areas to new economic horizons	Uncontrolled deforestation Non-compliance with ASM laws Lack of long-term environmental policies Climate change
Governance & Policy	Trust in the village headman	Lack of government control	Cooperation between communities and NGOs Capacity Building	Slow bureaucracy Potential political instability Government investment dependency

(*continued*)

Table 2. (*continued*)

	STRENGTHS	WEAKNESSES	OPPORTUNITIES	TREATHS
Construction & Craft	Widespread vernacular building Government project for building innovation	Unsustainable European construction techniques Products without certifications Use of materials with low durability	Traditional solutions for climate adaptation	Materials with poor resistance to harsh climatic events
Facilities & Services	Health Hub Civic center Primary school Main paved road	Distance between the two village cores Supply difficulties Unplanned construction Lack of infrastructure for public mobility	Government-sponsored rural development Project area as a hub between the two village cores	Absence of urban regulations Lack of long-term strategic vision Great distances without infrastructural development
Society & Economy	Local labour availability Economically active population equal to 77% Availability of mineral and agricultural resources	High illiteracy rate Inequalities in access to education Sanitary conditions Migration Social economic conflicts	Community value Collaboration with fair trade market	Economic policies with negative repercussions on the territory Cyclic poverty network

3.4 Scenario Building

Based on the state of the art as determined by the SWOT + STEEP analysis, alternative future scenario definitions were established. The case study presented the following scenarios:

- Scenario 0 is the inertial scenario, as predicated on maintaining the territory's current technological level. It must be considered to promote a conscious and rational choice that also includes the possibility of non-intervention;
- Scenario 1 is the trend scenario proposed by the Ghanaian government. It entails the construction of a vocational school center and services such as a market, residences, and agricultural areas;

- Scenario 2 envisions the strategic scenario. It proposes the incorporation of NBS solutions, such as the use of local materials, reforestation, reclamation of land degraded by Galamsey, and the implementation of rainwater harvesting strategies.

At this stage, storytelling is a valuable tool for facilitating the communication of the vision. The following comic (Fig. 4) depicts the narrative for Scenario 2.

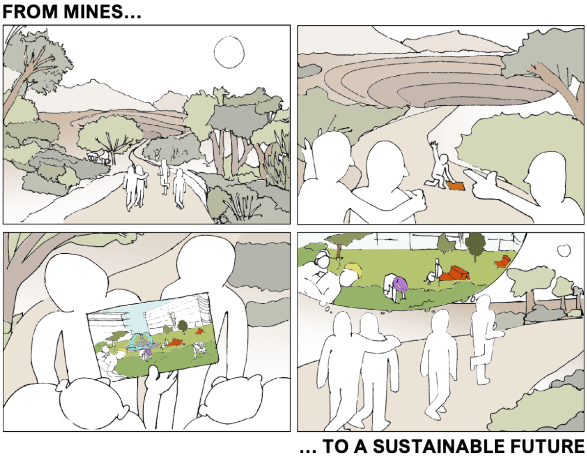

Fig. 4. Storytelling to support Scenario Building for the problem under investigation.

3.5 Development of A'WOT

The A'WOT methodology is implemented while taking into account the limitations im- posed by the geographical distance with respect to the case study. Nowadays, it is currently impossible to administer questionnaires to the involved parties, so the point of view assumed for the application is that of the Ministry of Rural Development, the key stakeholder identified by the Stakeholders Analysis.

The software SuperDecisions was employed for the implementation of the method. After completing the preliminary analysis and drafting the SWOT + STEEP Analysis, the cascade network was generated (Fig. 5).

The principle of decomposition is consistently applied. Criteria and sub-criteria meet the requirements for completeness, redundancy, operability, size, and diachronic impacts. The advantage of this mixed method lies in the ability to evaluate the key aspects that emerged during the state-of-the-art analysis in relation to the project alternatives, thereby proposing a coherent and rational methodology.

We then move on to the Saaty's scale principle of comparative evaluation. Since this evaluation can be conceived as a pre-test to be replicated subsequently with real actors and stakeholders, thanks to the evaluation tools applied before it has been easier to investigate public bodies interests and expectations with respect to rural development issue. The pairwise comparison at the criterion level assigns equal weight to each section

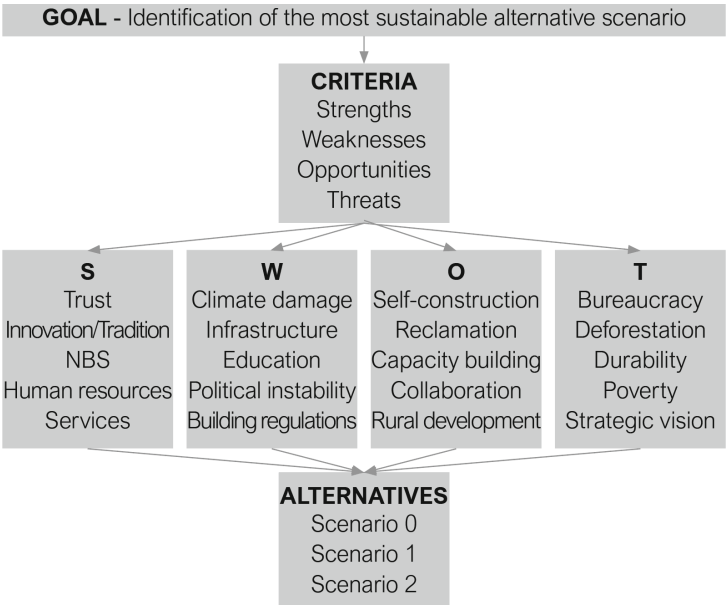

Fig. 5. Structuring of the decision problem through the A'WOT analysis and the AHP method.

of the SWOT analysis. Pairwise comparisons at the level of sub-criteria and alternatives were conducted taking into account the results of previous analyses (Fig. 6).

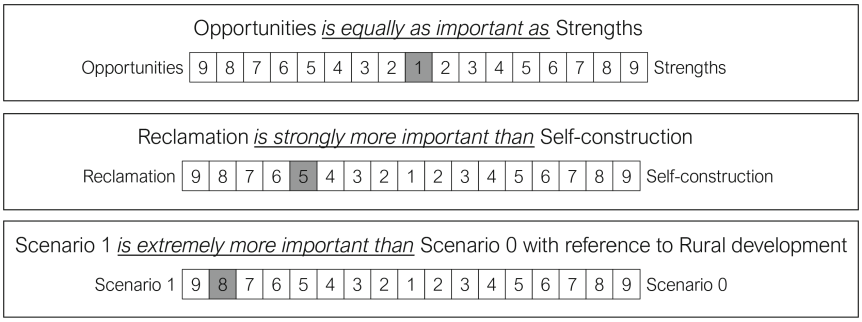

Fig. 6. Examples of pairwise comparison for criteria, sub-criteria and alternatives.

At this stage, it is necessary to ensure that the rate of inconsistency is below 10%.

The software then processes local (Fig. 7) and global priorities (Fig. 8) using the calculation method described previously.

The just-presented findings correspond with the major themes that emerged from the SWOT analysis. At the sub-criteria level, NBS solutions (49%) and the potential offered by the combination of technology and tradition (29%) appear to be the project's greatest strengths. As environmental degradation (37%) and a lack of building regulations (30%)

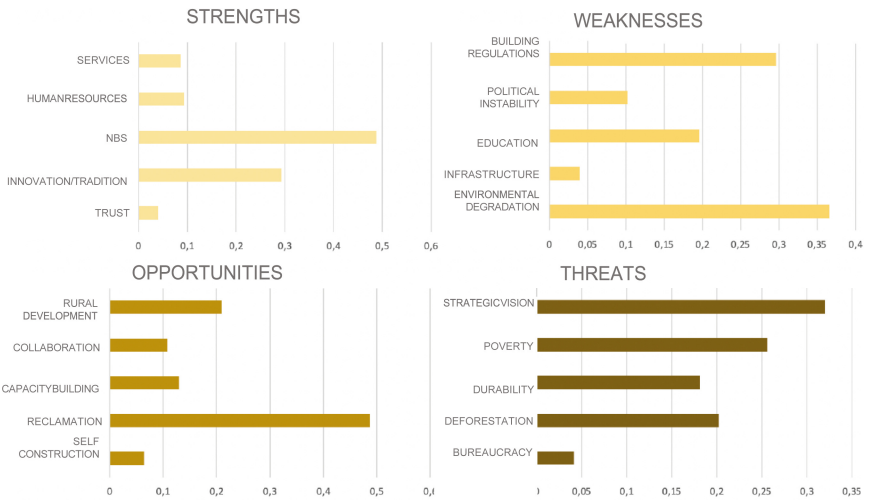

Fig. 7. Sub-criteria priority vectors.

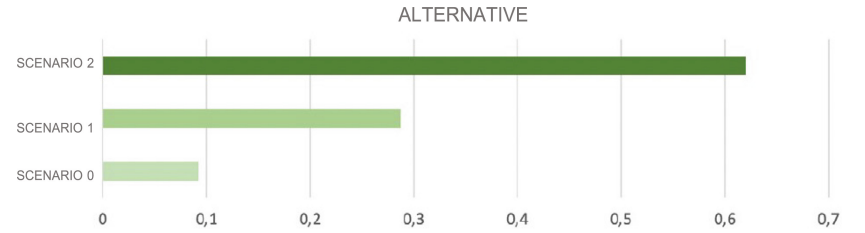

Fig. 8. Alternatives final ranking.

would exacerbate an already critical situation, special consideration must be given to these issues. The issue of land reclamation (49%) and rural development (21%) are highlighted as opportunities. Lastly, the absence of a strategic vision (32%), The just-presented findings correspond with the major themes that emerged from the SWOT analysis. At the sub-criteria level, NBS solutions (49%) and the potential offered by the combination of technology and tradition (29%) appear to be the project's greatest strengths. As environmental degradation (37%) and a lack of building regulations (30%) would exacerbate an already critical situation, special consideration must be given to these issues. The issue of land reclamation (49%) and rural development (21%) are highlighted as opportunities. Lastly, the absence of a strategic vision (32%), poverty (26%), and deforestation (20%) remain exogenous factors that must be man- aged. In terms of global priorities, Scenario 2 (62%) characterized by the implementation of NBS solutions is deemed preferable. Scenario 1 (29%) does not meet the actual needs of the community because it proposes short-term solutions that would not break.

4 Discussion and Conclusions

The proposed process, based on conventional evaluation tools, such as SWOT analysis and Scenario Building, and by mixed methodologies, such as the Stakeholders Analysis P/I and SNA and the A'WOT method, is an effective guideline for a decision- making process aimed at sustainability in its many facets (lotus flower). The article attempts to demonstrate the interconnected nature of the phases of the sustainability project [8], emphasizing their strict relationships.

Specifically, the SWOT analysis generated during the cognitive phase served as the foundation for the systemic assessment phase, establishing a solid chain of relationships between knowledge and decisions.

Promote innovative strategies to enhance decision-making is a process fraught with complexity, as it involves a multitude of variables, including various actors with opposing and frequently competing interests. Sustainability requires a multidimensional and interdisciplinary approach [34], which is why the A'WOT method is especially useful in this field. It enables the simultaneous evaluation of multiple variables, beginning with the state of the art on the territory and culminating in a consensus decision.

In contexts such as SSA, where long-term strategic vision is frequently lacking, the development of an integrated, multi-level methodology is even more crucial to envision potential development scenarios. In fact, the application of a multi-methodological model can support the planning process to be more place-based and to guarantee a multi-level governance as well. This achievement could guarantee safe, inclusive, and sustainable quality of life, while protecting and valorising both cultural and natural heritage.

However, the process should not be considered complete. The implementation of the sensitivity analysis is the first step to ensure the consistency of the results. Secondly, the model is supposed to be replicated with real actors and stakeholders to compare the results. Furthermore, no monitoring tool is addressed in the paper. Specifically, this phase is necessary for both the ex-ante and ongoing evaluations of the project's development, as well as for making any necessary adjustments as the project progresses. The presented case study facilitates the employment of a monitoring tool by using the DPSIR model. The DPSIR can identify determinants, pressures, status, impacts, and societal responses to changes in the environment [35].

The proposed methodology, supplemented by future research on monitoring, is intended to serve as a guideline for the promotion of sustainable projects towards the attainment of the SDGs, with regard to Goal 11 for the resilient and sustainable development of human settlements, with an eye on future generations.

Integration of the A'WOT with the biophysical and economic assessment of the eco- system services that NBS solutions can provide as response to climate shocks and disturbances [36–38], strategic management [39, 40] as well as the investigation of the interdependencies between dependent and independent variables, is an additional area of research. In this sense, various development scenarios are envisioned, including the extension of the multicriteria hierarchical model into a network [33], the application of the Dynamic SWOT [41], and regression analysis [42]. An additional promising step is the combination of the A'WOT with Geographic Information Systems (GIS) and thus allowing to produce suitability maps for the localization of NBS solutions in the territory under investigation [26].

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