Scientific Research Publishing

Open Journal of Applied Sciences, 2024, 14, 833-848
https://www.scirp.org/journal/ojapps
ISSN Online: 2165-3925
ISSN Print: 2165-3917

A Systems Approach to Assessing Sustainability Capacity in Kalobeyei Refugee Settlement in Turkana County, Kenya

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How to cite this paper: Adjahossou, A. (2024) A Systems Approach to Assessing Sustainability Capacity in Kalobeyei Refugee Settlement in Turkana County, Kenya. *Open Journal of Applied Sciences*, **14**, 833-848.
https://doi.org/10.4236/ojapps.2024.144056

Received: March 8, 2024
Accepted: April 7, 2024
Published: April 10, 2024

Abstract

Refugee settlements face several challenges in transitioning from a temporary planning approach to more sustainable settlements. This is mainly due to an increase in the number of forcibly displaced people over the last few decades, and the difficulties of sustainably providing social services that meet the required standards. The development of refugee settlements assumed that forcibly displaced people would return to their places or countries of origin. Unfortunately, displacement situations are prolonged indefinitely, forcing these people to spend most of their lives in conditions that are often deplorable and substandard, and therefore unsustainable. In most cases, the establishment of refugee settlements is triggered by an emergency caused by an influx of forcibly displaced people, who need to be accommodated urgently and provided with some form of international assistance and protection. This leaves little or no time for proper planning for long-term development as required. In addition, the current approach to temporary settlement harms the environment and can strain limited resources with ad hoc development models that have exacerbated difficulties. As a result, living conditions in refugee settlements have deteriorated over the last few decades and continue to pose challenges as to how best to design, plan, and sustain settlements over time. To contribute to addressing these challenges, this study proposes a new methodology supported by Model-Based Systems Engineering (MBSE) and a Systems Modeling Language (SysML) to develop a typical sustainable human settlement system model, which has functionally and operationally executed using a Systems Engineering (SE) approach. To assess the sustainability capacity of the proposed system, this work applies a matrix of crossed impact multiplication through a case study by conducting a system capacity interdependence analysis (SCIA) using the MICMAC methodology (Cross-impact matrix multiplication applied to classification) to assess the interdependency that exist be-

tween the sub-systems categories to deliver services at the system level. The sustainability analysis results based on capacity variables influence and dependency models shows that development activities in the settlement are unstable and, therefore, unsustainable since there is no apparent difference between the influential and dependent data used for the assessment. These results illustrate that an integrated system could improve human settlements' sustainability and that capacity building in service delivery is beneficial and necessary.

Keywords

Humanitarian Settlement, Systems Engineering (SE), Sustainability, Capacity Assessment, Model-Based Systems Engineering (MBSE), Systems Modeling Language (SysML)

1. Introduction

Refugee settlements can refer to any kind of human settlements where refugees and other forcibly displaced people live, and which exert significant social, economic, environmental and security impacts on the communities that host them, due to the dynamic interactions that are naturally created between the two communities. According to the United Nations High Commissioner for Refugees (UNHCR)'s Global Appeal 2023, more than 117.2 million people were forcibly displaced or stateless in 2023, representing around 1% of the world's population, and the average lifespan of a humanitarian settlement is between 17 and 26 years [1]. However, it's worthy to note that the impacts of refugee settlements are so important as highlighted in the World Bank's report on "*A Social Impact Analysis for Kakuma Town and Refugee Camp Turkana County, Kenya*[1]" in November 2016. In the World Bank report [2] [3], "…the refugees of Kakuma have a significant positive impact on the host community in Turkana due to economic and social interactions that result in greater access to food and nutritional well-being and the presence of relief services that serve the Turkana in addition to the refugees". However, their programming and management still rely on temporary approaches rather than long-term and sustainable perspectives. Current approaches, which fail to incorporate sustainable parameters at the planning and design stage, are unsustainable and prevent truly integrated, sustainable development. Refugee settlements must be designed and developed with a view to long-term development, given the multiple benefits that refugees bring to the regions where they settle and the benefits that communities can derive from them. To achieve this goal, a refugee settlement must be conceived as a system of systems, and designed, developed, and managed as such to provide

[1]For more information, the Word Bank Report: "*A Social Impact Analysis for Kakuma Town and Refugee Camp Turkana County, Kenya*", is available at: https://documents1.worldbank.org/curated/en/359161482490953624/pdf/111309-REVISED-PUBLIC-Turkana-Social-Impact-Analysis-December-2016.pdf

more sustainable capabilities to the communities it serves. In this paper, the application of Systems Engineering is considered an effective solution to the current challenges experienced in refugee settlements as it offers opportunities to overcome the difficulties encountered in contemporary settlements due to the poorly decentralized approach. In addition, Systems Engineering (SE) facilitates a systematic organization of most, if not all, of the singular elements of a refugee settlement, making it possible to systematically consider how a refugee settlement might be conceptualized and approached differently.

Assessing sustainability capacity in a refugee settlement is important for enlightening the decision-making needed to plan and provide sustainable services. This work assesses the capacity of the Kalobeyei refugee settlement to sustainably deliver certain services and provide lasting benefits, as well as preserving existing resources to ensure long-term sustainability. This is achieved through a case study that focuses on the structural analysis of key factors and the role of each element in the Kalobeyei settlement system, and on the formulation of a strategy. The study applies the sustainability analysis technique, *i.e.*, the MICMAC analysis methodology. To examine the system's functionality and potential adaptability, it assesses the refugee settlement system's capacity to achieve a certain threshold of sustainability in the provision of water, energy and housing among other services required through its thematic areas of development or subsystems. The integration of the settlement as an overall system cannot function sustainably if the system is unable to achieve greater sustainable outcomes. For this study, the sustainability of the refugee settlement is analyzed from a systemic point of view, and the sustainability of the system is represented by a non-decreasing evaluation function of the capabilities to deliver outcomes of interest for the system under consideration [4]. To this end, capacity assessment and MICMAC analysis are applied to achieve the objective of this study.

2. Settlement System Sustainability Concept

A review of the literature reveals that, from an economic point of view, sustainability can be defined as the achievement of equity and balance between generations and a constraint on economic growth by (Hackett, Steven C., Moore, (2011) [5]. According to Hackett, ecologists argue that a sustainable society is based on the integrity of the ecosystem (settlement) in which they live and the capacity to transform natural capital into man-made capital. In light of these views, sustainability is understood as a process of generating and sharing meaningful data and information needed to make sustainable decisions that could contribute to people's empowerment, sustainable service delivery and security, as well as wider employment opportunities over the long term. Another point of view from Læssøe [6], sustainability involves equitable governance of resources and a series of transformative processes that protect the environment and safeguard people's ecology and well-being in a variety of fields that are integrated, interdependent, and mutually influencing, including urban planning, social services, economics and finance, good governance, ecology, and the environment.

For this research, the concept of sustainability is defined as the system's capacity to make the most of the influence and independence of its various integrated subsystems (or areas of development in the settlement), to process useful operational data optimally and to provide the required services sustainably over the long term, according to the three pillars of sustainability proposed by Viederour (1993): economy, people, settlement or town and environment, widely accepted as the sustainable core elements of the community.

2.1. System Capacity Concept

The concept of capacity is critical in the human settlement system, and it's defined as the ability of different systems' components and its stakeholders to achieve specific goals and satisfy certain agreed-upon requirements. As noted by Lavergne and Saxby [7], capacity can take multiple forms, tangible ones, such as infrastructure and institutions, and less tangible ones, such as skills, social fabric, values and motivations, habits, attitudes, tradition, culture, etc. Building on this definition, this paper demonstrates the capacity of the settlement's system and its six sub-systems to produce specific data and deliver satisfactory services over time. It defines the overall state of settlement capacity, its multiple patterns of behavior, and its structural components.

2.2. Case Study—Kalobeyei Integrated Refugee Settlement

The Kalobeyei integrated refugee settlement, located in Turkana County, Kenya, is the study area for this work because of its context perfectly suited to the application of the integrated system approach, and is one of the recent examples of UNHCR's attempt to transition from traditional planning approaches. According to the Kalobeyei settlement advisory development plan [8], the settlement is integrated and developed on 1500 hectares of land in Kalobeyei town, Turkana West Sub-County, in accordance with an agreement between UNHCR, the national government, the County government of Turkana, and the host community of Kalobeyei. This agreement was tied to a commitment that the implementation would restructure refugee assistance programming, emphasizing socio-economic integration, in an accessible, vibrant, and functional settlement, complete with adequate social and physical infrastructure and a diversity of economic opportunities [7]. Based on the Kalobeyei integrated socio-economic development plan (KISEDP)[2], the design framework was structured within eight complementary and mutually reinforcing components [9] which are closely aligned to some extent with the six sub-systems of a typical settlement system model. Each component has its own sectoral objectives, and indicators that directly contribute to one or more of the strategic objectives. As of 31 December 2023, the settlement was home to about 38,000 refugees, including people from South

[2]The Kalobeyei Integrated Socio-Economic Development Plan (KISEDP) was initially devised to support a new approach aimed at establishing a settlement in a place called Kalobeyei in Turkana West, where both refugees and host populations would live together, rather than a separate refugee camp. It provides a framework and tool to manage the presence of some 180,000 refugees (40% of the population of Turkana West) in a manner that is of benefit to both the refugees and their hosts.

Sudan, Ethiopia, Somalia, Burundi, and other countries and members of the host community[3].

3. Sustainability in Kalobeyei Refugee Settlement

A recent study [10] revealed that the Kalobeyei refugee settlement continues to face several challenges and threats with regard to achievements in sustainability or, more precisely, self-reliance. Alexander B., Naohiko O. and Olivier S, in a comparative study carried out in 2020, [11] examined refugee policies and the approach to humanitarian and development programs implemented in Kalobeyei and found that self-sufficiency achievements, as factors promoting sustainability, such as environment, assets, networks, markets and public goods, are unsatisfactory and even similar to those of the Kakuma refugee camp, located just 3 km away and established since 1992 on the basis of ad hoc development models, despite the different aid model promoted for Kalobeyei settlement. Refugees continue to struggle with many problems, including lack of access to reliable and affordable energy, lack of clean water for domestic use and poor sanitary conditions, limited access to childcare services, food insecurity, which can be seen as the ultimate consequence of a lack of conditions and resources for self-reliance. The lack of forward-looking, large-scale agricultural options and the complex relationship between policy and implementation were also mentioned.

Furthermore, the development of the conurbation seems to present an incompatible amalgam between a vision of development based on integration, mobility, and economic development, to be achieved in a very restricted and economically difficult environment [11].

Data Collection in Kalobeyei Settlement

A household survey carried out in the Kalobeyei settlement in October 2023 [12] (see **Figure 1**) revealed that the water supply is insufficient to meet daily needs and required standards of minimum of 20 liters per person per day (UNHCR), including for agricultural or livestock activities. The capacity to provide affordable housing solutions also remains a challenge. In terms of energy, the settlement still lacks reliable access to electricity, and only 5% of households have access to electricity, with firewood being the main source of energy. The main market for firewood is estimated at 12,046 metric tons per year, and together with charcoal, it is the main source of cooking fuel for 62.7% and 37.3% of households, respectively [13][4].

[3]Refugees and residents' study, play and live together at Kalobeyei Integrated Refugee Settlement | UN-Habitat. https://unhabitat.org/refugees-and-local-residents-study-play-and-live-together-at-kalobeyei-integrated-refugee-settlement, Retrieved 2 December 2023.

[4]From a study conducted by the Moving Energy Initiative (MEI) a partnership between Energy 4 Impact, Chatham House, Practical Action, the Norwegian Refugee Council and the UNHCR, on prices, products, and priorities of clean, safe and affordable energy in Kakuma refugee camp. Published on 14/02/2018. Available at: https://energy4impact.org/news/moving-energy-initiative-brings-clean-energy-and-improves-livelihoods-kakuma-refugees.

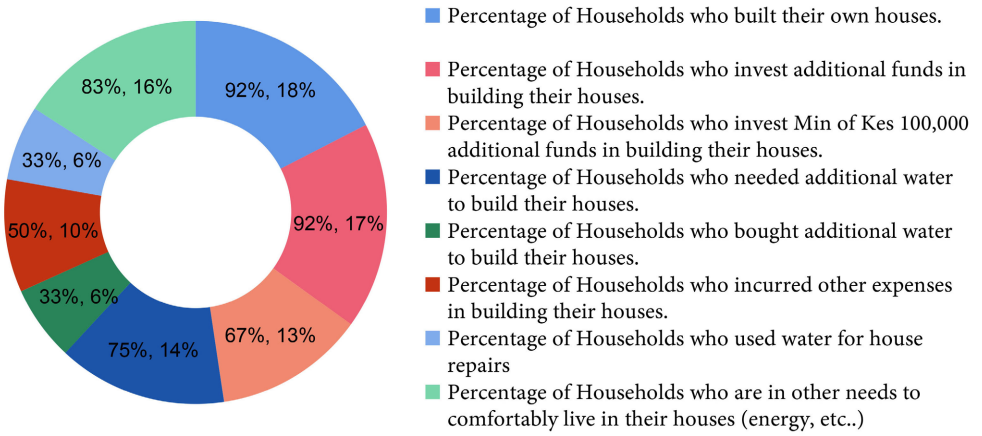


Figure 1. Household water consumption in kenyan refugee settlements (Kakuma Camp and Kalobeyei Settlement).

In conclusion, there are significant shortcomings that point to a growing demand for a more systemic and holistic approach to exploring possible synergies and trade-offs, and capturing the linkages between settlement elements that would trigger sustainable service delivery. For instance, how would building one form of capacity to achieve a specific goal such as providing basic services (e.g., water, energy, housing, etc.) affect achieving another goal associated with a different type of service from other sectors over time. Likewise, how does the interaction between various components at the system level (e.g., institutional and governance, social, spatial planning and infrastructure, ecology and environmental, economic, and financial, and the populations of concern, etc.) contribute to the system overall sustainability over time?

4. Kalobeyei Settlement Programmatic Framework

According to the Kalobeyei settlement programmatic outline [9], the planning and development of the Kalobeyei settlement would be led by the County government and coordinated through eight thematic areas of intervention which include health; education; water, sanitation, and hygiene; protection; spatial planning & infrastructure development; agriculture, livestock & natural resources; sustainable energy solutions and private sector & entrepreneurship. The Kalobeyei integrated development program [9] presents the settlement programmatic framework as shown in **Table 1**, which provides the platform for information sharing, design, implementation, and monitoring mechanisms to strengthen the humanitarian and development nexus approach, to ensuring a sustainable settlement development.

From a systems perspective and based on the above settlement coordination structure, this paper determines potential alignment with the typical integrated human settlement system[5] logical structure. As such, **Table 2** presents a pro-

[5]A typical integrated human settlement is a system of systems derived from stakeholder requirements that process input-data from all subsystems to work together on an integrated platform, to enable the production of an efficient, uninterrupted flow of data and information, and the services required in real-time to serve displaced populations better.

posed structural alignment between the two approaches.

5. Methodology

This paper focuses on structurally analysis of the thematic areas of development of Kalobeyei settlement and their roles in the delivery of services sustainability in the settlement. To do this, this work formulates a methodology process using a modified version of the UVC to assess the system's capacity coupled with a qualitative approach with the MICMAC sustainability analysis technique. The diagram below briefly describes the methodological process used for this study.

Table 1. Kalobeyei settlement programmatic framework (Adapted from [9]).

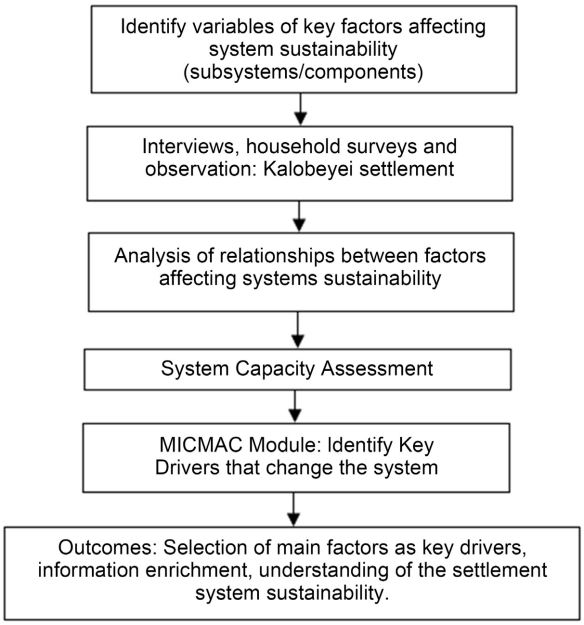
Thematic areas of intervention	Settlement's requirements
Steering Committee: Government-led initiative	A steering committee to provide oversight and guidance on policy matters. The committee is co-led by the Turkana County government and UNHCR. Members are humanitarian community, and representatives of NGOs.
Thematic One to Three: Sustainable Integrated Service Delivery & Skills Development	Supports cost-effective and sustainable social services, including education, housing, health, and water, sanitation, and hygiene which will benefit host communities.
Component Four: Protection	Supports systems and services in line with the national legal framework for the protection communities through a comprehensive approach.
Thematic Five: Spatial Planning & Infrastructure Development	Facilitates the spatial planning of the settlement to guide the area's development approach and the transformation of the refugee camps into sustainable urban areas.
Thematic Six: Agriculture, Livestock, and Natural Resources Management	Supports the development of a commercially viable agriculture and livestock sector, and improved natural resource management.
Thematic Seven: Sustainable Energy Solutions	Enhances access to affordable, reliable modern energy services including the expanded use of renewable energy which will boost further the existing opportunities for economic growth and improve the wellbeing of communities.
Thematic Eight: Private Sector & Entrepreneurship	Outlines a range of activities to support the development of the private sector and encourage entrepreneurship and job creation.

Table 2. Potential alignment between kalobeyei settlement components (Adapted from [9]) and a typical integrated human settlement system.

Typical human settlement model integrated system	Alignment	Kalobeyei settlement thematic areas
Sub-system One: institutional & governance	↔	Steering Committee
Sub-system Two: social & basic services	↔	Component One: health Component Two: education Component Three: water, sanitation, and hygiene
Sub-system Six: populations (displaced and host communities)	↔	Component Four: Protection
Sub-system Two: urban planning & infrastructure	↔	Component Five: spatial planning & infrastructure development
Sub-system Five: ecology & environment	↔	Component Six: agriculture, livestock, and natural resource management Component Seven: Sustainable Energy Solutions
Sub-system Four: economy & finance.	↔	Component Eight: private sector & entrepreneurship

5.1. Methodology Process

The below diagram summarized the methodological process in carrying out the system capacity assessment:



5.2. System Capacity Assessment

Assessing capacity to measure a settlement's potential to achieve specific objectives is at the heart of the general debate on humanitarian and development programs [14]. In order to assess the system's capacity to achieve a certain sustainability threshold, this work applies a modified version of UVC framework, which was developed by researchers at the University of Virginia [14] [15]. The UVC framework [15] considers eight categories of capacity involved in providing services to the community at different levels, and each category consists of several requirements. These categories could be service level, institutional, human resources, technical resources, economic and financial resources, energy, environment, and social and cultural resources. For each category, a capacity factor is calculated as the weighted sum of its requirement scores [15]. The framework is applied to analyze the capacity to deliver services in the Kalobeyei settlement system, considering the eight thematic areas of intervention defined above.

This work considers the eight thematic areas of intervention in the Kalobeyei settlement to count for the interdependency that exist among different categories of capacity. All categories and their respective requirements are assumed to be interconnected and contribute to the overall capacity for example, the processing of data and services. **Figure 2** shows an adaptation of the framework that considers the six sub-systems of a typical human settlement system aligned with the eight Kalobeyei settlement components for processing data and providing specific services in the system.

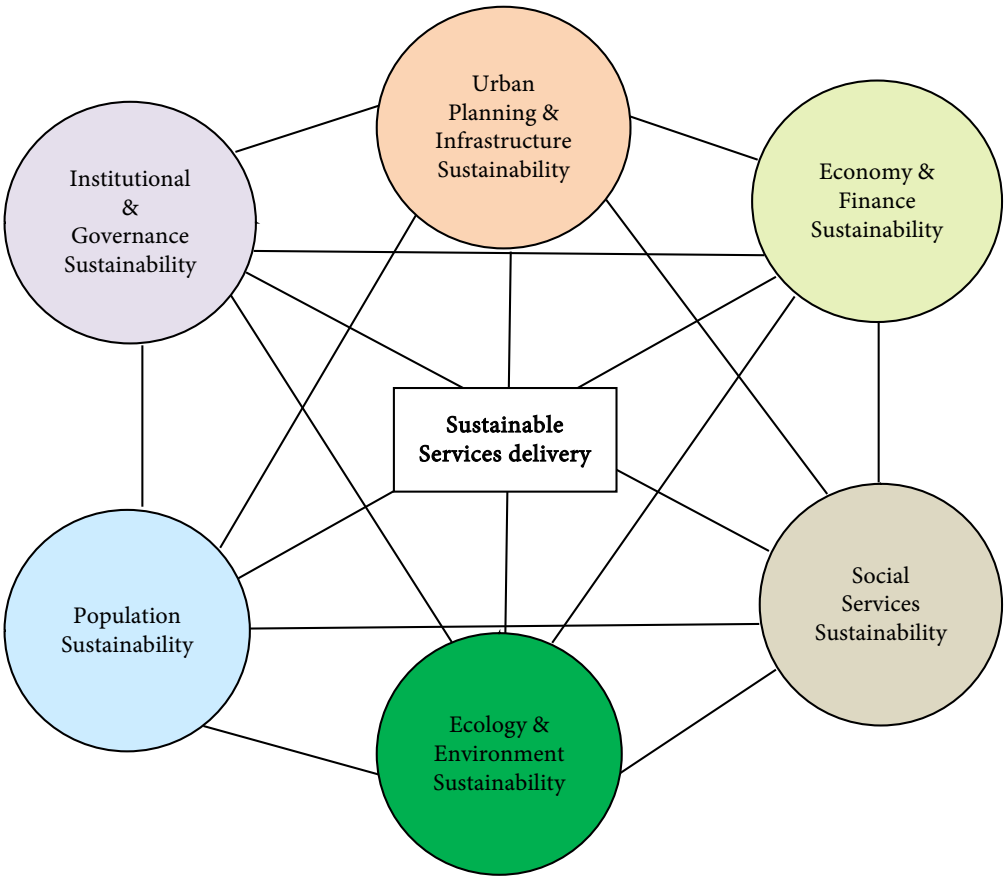


Figure 2. Representation of the six categories interconnected subsystems (Adapted from [9]).

Applying the modified UVC framework [15], to account for the six system requirements in determining the system capability assessment (CA), a (X_i, i = 1 - 6) requirement must be satisfied for each capacity category, as shown in **Figure 2**. Based on the weakest link criterion recommended by Bouabid [15], the system capacity assessment is determined by a formula that accounts for the various feedback mechanisms between the different capacity categories, as shown below:

$$C_A = \text{Minimum}\left(CaFt_i; i = 1\text{-}6\right) \tag{1}$$

And each capacity factor $CaFt_i$ (i = 1 - 6) is equal to

$$CaFt_i = \sum_{j=1}^{N_i} Ca_{ij} w_{ij} \tag{2}$$

where Ca_{ij} and w_{ij} (j = 1 - X_i) represent the requirements scores and weights associated with the ith capacity factor $CaFt_i$ (i = 1 - 6) respectively. Each capacity factor $CaFt_i$ in Equation (1) is assumed to depend somehow on the other six ($CaFt_k$, $k \neq i$). Likewise, in Equation (2) each requirement score Ca_{ij} is assumed to depend somehow on all other possible requirement scores (C_{kl}, $k \neq i$, $l \neq j$). Considering the Kalobeyei settlement as the study area, the researcher identifies the types of capacity and their requirements in processing operational data and delivering all types of services, as listed in **Table 3** below.

Table 3. List of capacity types and requirements (Adapted from [14] [15]).

Combined Capacity types	System sustainability description	Kalobeyei settlement requirements
Institutional & Governance (Steering Committee)	Advocates for policy and legislation, promoting strong institutional models, good governance, transparent collaboration, and partnerships.	Provides oversight and guidance on policy matters. Government leadership. Data processing and information sharing are key responsibilities in delivering sustainable services.
Social Services delivery (health, education, energy, water, hygiene, housing, etc…)	Addresses social and sustainable integrated services delivery, including equity, access to opportunities, and greater mobility. Ensures diversity, protection, culture, and heritage.	Supports cost-effective and sustainable social services, including education, housing health, and water, sanitation, and hygiene, which will benefit the entire populations.
Populations (refugees and their hosts)	Labor available to provide services (management, operation, and maintenance) and workers levels of training, etc..	Supports systems and services in line with legal framework. Addresses protection risks through a comprehensive approach.
Urban Planning & Infrastructure (Spatial planning & infrastructure development).	Ensures sustainable urban and spatial development which promotes access to water, renewable energies, and affordable housing, and green infrastructure.	Facilitates spatial planning to guide the area's development approach and the transformation into sustainable urban areas.
Ecology & Environment (agriculture, livestock, and natural resource)	Streamlines climate action and environment, land use and natural resources management, including ecology.	Supports development of a commercially viable agriculture and livestock sector and improved natural resource management.
Economy & Finance (private sector & entrepreneurship)	Mainstreams partnerships that promote local economic growth and financing structures, entrepreneurship, jobs creation and livelihoods opportunities.	Supports a range of activities to support the development of private sector and entrepreneurship.

6. Matrix of Crossed Impact Multiplication Applied to a Classification (MICMAC)

The MICMAC methodology is used to carry out the sustainability analysis of the settlement system. The MICMAC method was developed by Godet *et al.* (1994) and applied to sustainability analyses by Fauzi, 2019 [16]. It was used in [17] to carry out a sustainability analysis of the small-scale Vannamei shrimp farming enterprise. It was also applied by Dr. Amadei B. [18] in his work to study a capacity assessment of a small village in Morocco. The process applied by Fauzi [16], MICMAC begins with problem definition, identification of internal and external variables, analysis of the relationship between variables and weighting of dependence between variables [19].

As a suitable method for sustainability analysis, the present work applies the methodological process presented above. The first step was to identify the key factors affecting the sustainability in the Kalobeyei settlement. Then the methodology is used to carry out a structural analysis of inter-variable interactions of subsystems as drivers of sustainability service delivery.

6.1. Cross-Impact Analysis

Cross-impact analysis is an analytical methodology developed by Theodore Gor-

don and Olaf Helmer in 1966 [20] to investigate how relationships between events can impact on the resulting events and reduce uncertainty in the future. The various formulations of cross-impact analysis differ in how the interrelationships between system components are formulated, and whether a qualitative, quantitative, or mixed approach is used to describe causalities. Cross-impact analysis is used in this study to analyze how the six capacity categories influence and depend on each other. For the settlement system composed of x interacting variables, cross-impact analysis is represented by an (x*x) matrix with zero diagonal terms and x^2-x off-diagonal terms. The off-diagonal terms define the double causality between the n interacting variables, the way in which each variable or row directly influences the other variables, and the way in which each variable or column depends on, or is sensitive to, the other variables. The cross-impact matrix is also called the direct influence matrix (DIM) by Godet [14] and is not necessarily symmetrical, as shown in Table 4 below.

6.2. Data for Cross-Impact Analysis

In October 2023, as part of this research, a data collection survey [12][6] is carried out in Kalobeyei refugee settlement and Kakuma refugee camp in Kenya. A group of twenty refugee households and community representatives were interviewed by informants from the UNHCR office, Site Planning Unit in Kakuma. The surveys were carried out simultaneously as part of the general study on the sustainability of water, energy, and housing service provision. The answers provided by each group were recorded and scored on the questionnaire templates used by the interviewers. The subsequent analysis of the scores, brainstorming and consensus-building among members of the refugee community resulted in the scores indicated for each of the 30 off-diagonal terms of the double causality matrix in Table 4.

Table 4. Matrix Direct Influence (MDI) for kalobeyei settlement sustainability analysis.

	1. Inst/Gov.	2. Populations	3. Urban Planning	4. Soc/Services	5. Eco/Fin.	6. Env/Ecolo.	**Net Influence**
1. Inst/Gov.	0	3	2	2	1	2	10
2. Populations	3	0	1	2	1	1	8
3. Urban Planning	1	2	0	3	3	3	12
4. Soc/Services	1	2	3	0	2	2	10
5. Eco/Fin	2	2	2	0	0	3	9
6. Env/Ecolo.	1	2	3	2	1	0	9
Net Dependence	8	11	11	9	8	11	58
Average Dependence	1.33	1.83	1.83	1.5	1.33	1.83	9.65

[6]Kalobeyei settlement and Kakuma camp surveys result analysis available at: Kalobeyei Responses on Shelter, Water and Energy. https://www.sciencedirect.com/science/article/pii/S0016718523001690.

Accordingly, Table 4 presents 6 × 6 variables as the direct influence matrix (DIM) for the capacity of delivery water, energy and housning services in the settlement. The diagonal of the MDI represents the possible feedback mechanisms and links that exist when two categories of capability interact interdependently. Influences range from 0 to 3, with the possibility of identifying potential influences: 0: No influence; 1: Weak; 2: Moderate influence; 3: Strong influence. On the basis of the results of the interviews conducted in Kalobeyei, the scores are retained and used for analysis.

Based on the MICMAC methodology, Table 4 is used to calculate each capability category's net direct influence or impact on the other five and the net direct dependence (sensitivity) of each capacity type on the other five. The scores are summed by rows and columns, respectively. The net influence values represent how each capacity category affects the system as a whole, while the net dependence values represent the effect of the system on each capacity type. For ease of analysis, the Direct Influence/Dependence diagram is generated by plotting the degree of dependence and influence values on a single graph of influence (x) versus dependence (y), as shown in Figure 3. The average value of direct influence and dependency for all domains is 9.65. According to Godet in his book [14], and following the pattern formed by the Direct Influence/Dependence diagram, the capability categories can be separated into four quadrants. These four quadrants are as follows:

- Influential variables (quadrant I) with high influence and low dependence.
- Excluded variables (quadrant II) with low influence and dependence.
- Relay variables (quadrant III) with high influence and dependence.
- Dependent variables (quadrant IV) with low influence and high dependence.

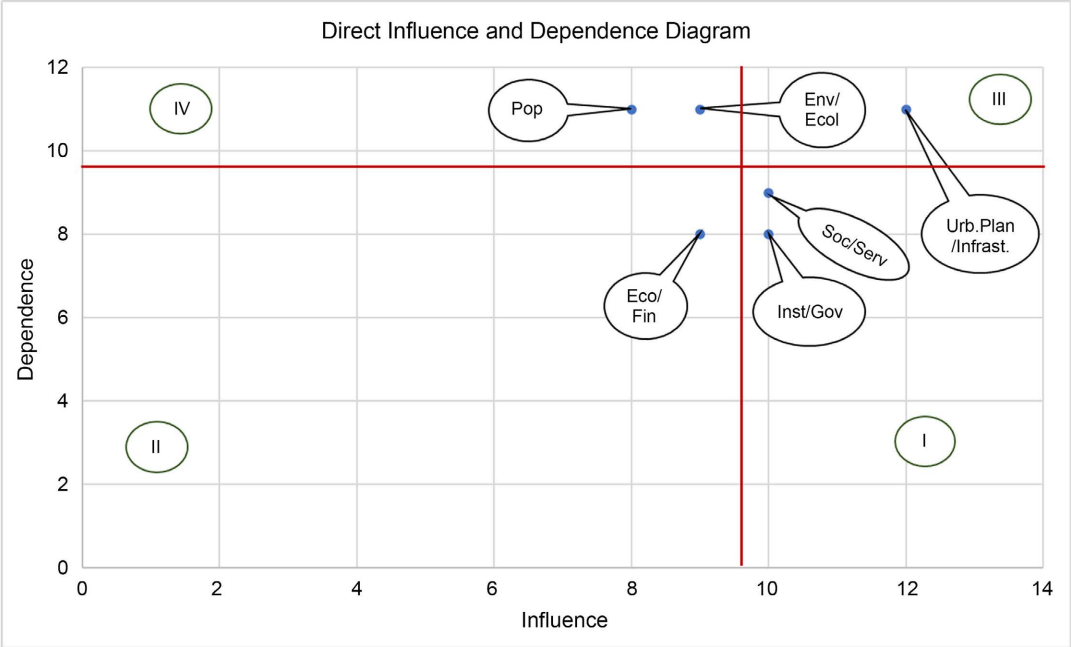


Figure 3. Sustainability variables diagram by influence and dependence.

6.3. Results Analysis

Figure 3 presents the influence and dependence diagram highlighting the system's capacity to deliver sustainable services of water, energy, and housing. It was apparent that the Institutional capacity and Social Services delivery capacity were in quadrant I with high influence and low dependence. Quadrant I fell into influential variables that demonstrated that these two systems' capacities have higher leverage and dominance among all types of capacity in the system. Previous studies also reveal similar results because of the full engagement of the Kenya government and local leadership in the settlement development and that the refugee populations and their hosts refugees were to rely on traditional humanitarian assistance to cover their immediate social and basic needs (food, shelter, and health care) [10]. The Economy and Finance capacity was in quadrant II, which fell into excluded variables, constituting the low influence and dependence. This capacity was categorized into factors that reflect the system's instability as revealed in the Mans Fellesson's [10] study on the KISEDP published in February 2023. Thus, according to [10], since the launch of the KISEDP in 2018, the implementation has only been partial and as stated in a recent official report [21], "the funding requirement for July 2019 to June 2021 was USD 217.9 million of which only USD 127.4 million was received, … and partners purported to have only received 43% of their budgeted funds". The report states that "…more effort will be required to strengthen resource mobilization and advocacy with potential donors and through new prospective partners, including the private sector, to ensure the success of the settlement development Program and the need for the planned objectives. Gaps in funding will negatively impact on KISEDP's implementation and risk delaying progress in Turkana West achieving self-reliance and socio-economic development". Consequently, any improvement in the Economic and Finance capacity may cause relatively important effects on the other variables and on the system at large in achieving the sustainability goals.

On the other hand, Urban Planning and Infrastructure Development capacity was in quadrant III, which fell into the relay variables group, constituting the influencing variable but with high dependence. This capacity shows more challenging to address since its influence and dependence cannot be separated through feedback mechanisms. The challenging state of this capacity can be understood through the study [10] that pointed out the undisputed fact that the geographical conditions of the settlement's location present challenges for the best suitable urban planning and infrastructure development at this time. More than 80% of the Turkana County is categorized as either arid or very arid and rain patterns and distributions are erratic. The settlement's location is within the latter category, presenting close to desert-like conditions. Consequently, a strategy focusing on urban planning, access to critical services and infrastructure, including agricultural production as a basis for self-sufficiency must, in the first instance, find innovative and sustainable solutions to the critical issue of access to water.

More importantly, a recent report from the UN-Habitat [22] provides similar arguments highlighting several challenging circumstances facing the Kalobeyei settlement such as natural hazard vulnerability, insufficient infrastructure and facility provision, and very limited employment opportunities.

Finally, Populations and Environment capacities were in quadrant IV, of which conditions reflect the Dependent variables with low influence and high dependence. These subordinate domains are strong indicators of the "health" of the entire system of variables. Despite the low influence of these capacities, this nevertheless demonstrates the preponderance of people's dependence on the environment and ecosystem in which they depend, and the weakness of their influence may be a signal of their lack of real participation in settlement governance and, thus, in decision-making processes, including in other capacities. It is obvious that most of the population is largely dependent on aid, as also noted in the report [10] that brought to the fore the intimate relationship between aid and economic development: "Without the aid system, most businesses in Kalobeyei settlement would collapse".

7. Discussion

This work attempts to investigate how different levels of Kalobeyei settlement system capacity could influence the sustainability over time. Through this case study, this work performs a sustainability analysis using a qualitative approach, the MICMAC analysis technique. This applies the systems approach adapted from UVC's capability analysis framework, which uses different categories of capability to analyze the provision of one or more services. The case study analyzed the sustainability of the settlement system and assessed the capacity to reach a certain threshold of sustainability. The results showed that the current level of subsystem development activities in Kalobeyei settlement is unstable and, therefore, unsustainable since there is no clear difference between the influential and dependent variables. It is, therefore, necessary to simultaneously improve the settlement's current capacity in all subsystems and plan for their long-term sustainability, particularly in delivery of water, energy, and housing. The challenge is to develop an action plan for sustainability at different scales. For this study, the sustainability of the settlement was analyzed from a systemic point of view and was represented by a non-decreasing evaluation function. Understanding the capacities of the Kalobeyei settlement and their variations over time enables the United Nations High Commissioner for Refugees (UNHCR) and decision-makers, including other stakeholders, to implement solutions and strategies adapted to current conditions. Such an action plan or strategy to ensure the overall sustainability of settlement management will be part of a future work. Regardless of scale and context, the systems engineering approach applied to humanitarian operations requires a detailed assessment of the settlement's sustainability capabilities to be effective. In addition, decision-makers and stakeholders involved in the development of the Kalobeyei settlement must be pre-

pared to adopt systems mindset from the outset of planning, design, and implementation, and to work in partnership with other stakeholders.

8. Conclusion

This work presents the results of the sustainability analysis of the Kalobeyei settlement in its current state of development, in the sectors considered of water, energy and housing. Based on the model formed by the inner quadrant system presented in **Figure 2**, sustainability variables by influence and dependency were determined and according to Godet (2006) in his book [14], the development activities of the Kalobeyei settlement's subsystems are unstable and therefore unsustainable, since there is no clear difference between the influential and dependent variables.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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