Sustainable MED Cities

Integrated tools and methodologies for sustainable Mediterranean cities

D5.2.3 Evaluation of results

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1. Introduction

The Assessment methodology and the Tools were tested on **3 pilot urban areas** in:

- Sousse (Tunisia),
- Moukhtara (Lebanon) and
- Irbid (Jordan)

with the objective to define a strategic concept and plan for optimising the sustainability of buildings and neighborhoods. Each pilot testing activity is thoroughly presented in a detailed report of the results (D2.2.1.8 – WP5 BOOKLET. Decision-Making and Sustainability Assessment System: Case Studies in the MED area. Version: 2023-A).

The aim of the pilots was to provide an opportunity to the participating municipalities and their experts to use the multi criteria assessment systems, along with the nationally adapted tools, i.e. SMC-SBTool and SMC-SNTool, to support the process aimed to define the optimal retrofitting concept to improve the sustainability of selected buildings and urban areas.

The test process is detailed in the initial Road Map that is organized according to the 7 steps of the Decision-Making process described in (D4.1.1 - Decision-Making Methodology for Sustainable Cities, A. Moro, E. Bazzan, Sep 2022). All the tasks that must be carried out are listed in a chronological order. The decision-making methodology is articulated in a series of consecutive steps starting from a diagnosis of the current state of the selected buildings and urban area, and concludes with the preparation of the optimal retrofitting concept.

The Road Map supported the pilot tests, specifying all the steps that the three municipalities had to accomplish during the entire process. Accordingly, the methodology is completed in seven phases:

1. Initiation, where all relevant stakeholders that can have an influence on the project should be involved;

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2. Preparation, where the Sustainable Med Cities SMC-Tools should be adapted to the local requirements and the specific retrofitting project;
3. Diagnosis, where the current performance and relative level of sustainability of the building or urban area should be assessed using the SMC-Tools;
4. Strategic definition, where clear and measurable targets for the retrofitting concept should be defined;
5. Retrofit scenarios, where possible alternative retrofit scenarios for the specific buildings, urban area or city should be developed and assessed using the SMC-Tools;
6. Decision making, where the assessed scenarios should be evaluated and ranked;
7. Retrofit concept, where the selected scenario should be elaborated, illustrating the retrofit strategies, the performance improvement and the cost benefit analysis, in order to be ready to be implemented.

The Phase 2 - Preparation is articulated in three steps:

Step 1: Selection of the active criteria

The first step is the selection of the Issues, Categories and Indicators that will be used to carry out the assessment. The indicators are selected from the exhaustive (complete) list of the Generic Framework Tool, on the basis of the local sustainability priorities and strategic policies. There isn't a fixed number of indicators that should be selected, except for a core set of Key Performance Indicators (KPI), which are mandatory for all cases, since they represent a minimum amount of information for addressing sustainability (C.A. Balaras, K.D. Droutsa, E.G. Dascalaki, S. Kontoyiannidis, A. Moro, E. Bazzan, Auditing and Rating Sustainability of Mediterranean Buildings, Neighborhoods and Cities, Energies 17(1), https://doi.org/10.3390/en17010082).

Step 2: Benchmarking of the active criteria

Benchmarking is also necessary for the definition of the scoring scale for each selected indicator. The benchmark is a quantification of the indicator's value ranging from the minimum to a maximum value. For each indicator, the lower value is set at zero that corresponds to the minimum acceptable performance and the maximum value is set at five that corresponds to the excellent performance at regional-local level.

Step 3: Weighting of the active criteria

The final step is the assignment of a weight to each indicator, category and issue. The weight reflects the relative importance of the various characteristics compared to the others.

The Phase 3 - Diagnosis and Phase 5 - Retrofit scenarios include the definition of each selected Indicator, either as a numerical value (e.g. use design data, measurements, calculated data) or as a qualitative description. The defined values or descriptions are then normalized in a common interval from -1 up to 5. Values that fall below minimum standard requirements are all assigned to -1. As stated above, excellent performance is assigned at the value of five. Then the indicators' normalized scores are aggregated to produce the total sustainability score for the different Categories, Issues and the final score of the project.

In this report, the results of the pilots were analysed to identify necessary improvements of WP3 and WP4 outcomes.

2. Pilot Studies

The assessment method as well as the national tools were validated through a series of pilot applications in buildings (residences, schools, offices, etc.) and neighborhoods in the three South-East Mediterranean cities. The pilots were performed in Irbid (Jordan), Moukhtara (Lebanon) and Sousse (Tunisia).

The location of each city as well as their climatic profiles are presented in Figure 1 and Table 1.

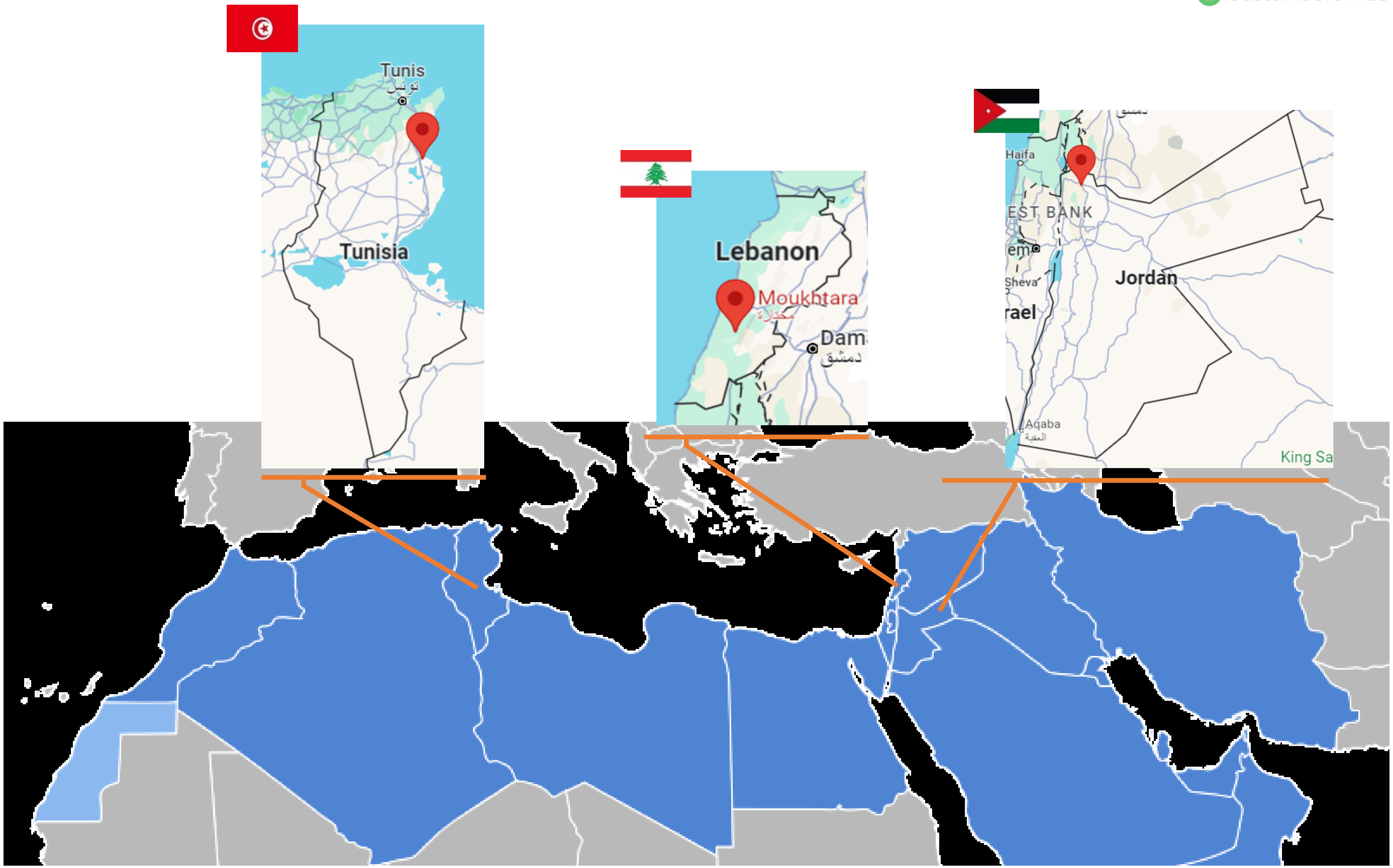

Figure 1. Location of the three cities.

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Table 1. Climatic profile of the three cities.

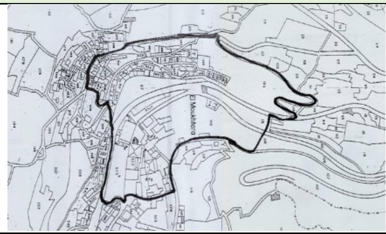
Parameter	Irbid, Jordan	Moukhtara, Lebanon	Sousse, Tunisia
Annual Mean Temperature (°C)	18.3	20	20.1
Winter Mean Temperature (°C)	16	14	13.1
Summer Mean Temperature (°C)	28	25	26.8
Mean speed of wind (m/s)	2.8	2	4.4
Annual mean amount of rainfall (mm)		60.6	330
Heating season Design Temperature (°C)	20-22	30	12.7
Summer season Design Temperature (°C)	24-28	16	28.6
Average relative humidity during warm season (%)	54	65	70
Average relative humidity during cool season (%)	65	50	65
Average difference, max-min. diurnal temps in warm season, (°C)	11	11	32-28
Solar irradiance on horizontal surface (kWh/m^2 / year)	5.8	4.86	1650

3. Pilot Studies: Urban Area

The three participating municipalities selected one urban area in order to test the SMC methodology and the national SMC-SNTool. The main characteristics of the audited urban areas are summarized in Table 2.

According to the SMC decision-making methodology at least two scenarios should be assessed for each pilot in order to be able to follow the proposed methodology according to which the assessed scenarios should be rated and then the most suitable scenario should be selected. However, the Municipality of Moukhtara elaborated only one scenario. As a result, there was no ranking of the scenarios and, therefore, the SMC methodology could not be followed precisely and the selection of the final retrofit scenario was biased.

Table 2. Overview of the urban areas assessed in Irbid, Moukhtara and Sousse.

	Irbid, Jordan	**Moukhtara, Lebanon**	**Sousse, Tunisia**
	Al-Nozha	*Al Shouf*	*Sahloul 3*
			
Short description	*Part of the latest expansion of Irbid, including various utilities such as schools, public services, single and multiple housing units. Mix public and private ownerships. Local and immigrant population with moderate to low income*	*Rural area with traditional buildings. it has many services and infrastructure that serves the nearby areas Agriculture and tourism are the main economic activities. Mix public and private ownerships.*	*This is a typical neighborhood developed by the public housing agency AFH. The district also features a wide range of urban components. (individual housing, collective housing, administration, green spaces, ...).*
Area	*0.960 km²*	*0.076 km²*	*0.600 km²*
Scenario 1	*<u>THE GREEN SCENARIO</u>.* *Introduction of renewable energy. Improvement of water and waste management. Enhancement of green spaces. Promotion of green transportation. Development of green-oriented spaces Encouragement of economic benefits.*	*<u>RENEWABLE ENERGY FOR ALL (REFA).</u>* *The purpose of this scenario is to provide access to clean energy to Moukhtara residents and give them the basic right to affordable, reliable, sustainable, and modern energy for all electricity as per the sustainable development goal 7 (SDG 7). The REFA scenario include Installation of solar PV panels to 116 houses; Installation of solar water heaters for 39 houses and Installation of 185 solar streetlights.*	*<u>THE ECOQUARTIER SAHLOUL 3</u>.* *Development of green areas and vegetation. Introduction of energy sobriety and promoting renewable energy. Encouragement of eco-construction. Optimization of water resource management. Introduction of selective sorting and intelligent management of solid waste. Reduction of air pollution. Promotion of soft mobility.* *Encouragement of new green urban governance.*
Scenario 2	*<u>SMART ENERGY SCENARIO</u>.*	*N/A*	*<u>AN INNOVATIVE AND ATTRACTIVE NEIGHBORHOOD</u>.*

	Promotes renewable energy, reduces carbon emissions, addresses water conservation, improves solid waste management, focuses on enhancing global mobility, addresses financial inclusion and encourages social participation and community involvement in planning.		*The concept of the 15-minute city translated into the following renovation axes: An innovative neighborhood anchored in the area and the city. A complete, diverse, connected and inclusive living environment. A policy of active and collective mobility, based on a neighborhood open to the city. A network of integrated green and public spaces. An urban identity of the place renovated.*
Selected Scenario	*Smart Energy Scenario (Scenario2)*	*Renewable Energy for All (REFA) (Scenario1)*	*The Ecoquartier Sahloul 3 (Scenario1)*
Justification of Selection	*Selection was based on the best sustainability Score*	*Only one scenario was developed and assessed*	*Selection was based on unanimous vote of the partners during a LPC meeting*

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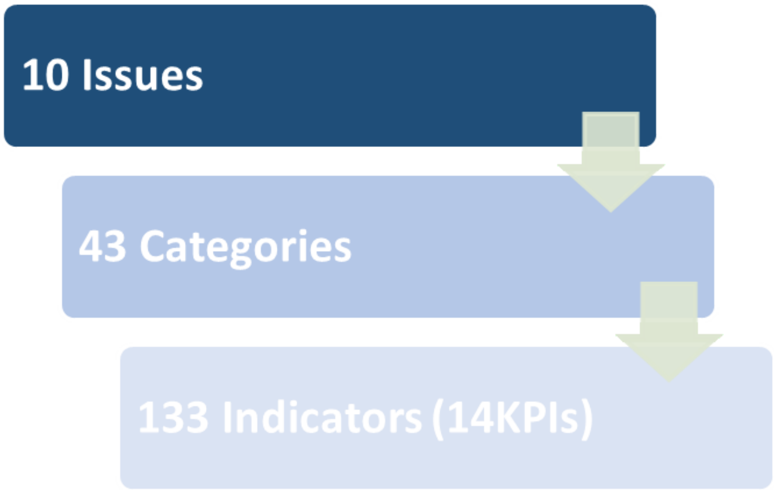
3.1. SMC SNTool (Neighborhood Scale)

The Generic Framework SNTool is organized as follows:



Issues

The **number of active Issues** in the three national SNTools were:

- Ten (10) Issues for SNTool-Irbid,
- Eight (8) Issues SNTool-Moukhtara, and
- Nine (9) Issues SNTool-Sousse.

It is worth mentioning that Issue Economy (H) was not taken into account in Moukhtara and Sousse national tools. In addition, the Issue Governance (J) was not active in SNTool-Moukhtara.

Analysing the priorities of the various Issues, only **Energy (B) is of the highest priority** among the three national tools (Figure 2). Even between SNTool-Irbid and SNTool-Moukhtara there are not many commonly ranked issues, although Jordan and Lebanon are neighbouring countries.

SNTOOL	IRBID	MOUKHTARA	SOUSSE
1		F, G, I	
2	J	A, E	
3	A, E, I	C, D	E, F, G, J
4	C, F, G	B	A, B, C, D, I
5	B, D, H		

Figure 2. Priorities of active Issues for SNTool-Irbid, SNTool-Moukhtara and SNTool-Sousse (1: low, 5: high).

Categories

The **number of active Categories** that were assessed range between 35% - 70%, with SNTool-Moukhtara having the lowest number. In total, **eleven Categories from the Generic Framework were not selected** and not assessed in any of the three pilots, including:

- Biodiversity and ecosystems (A3)
- Noise (E2)
- Environmental impacts (E4)
- Health (G7)
- Food security (G8)
- Culture and Heritage (G9)
- Employment (H2)
- Innovation (H3)
- Adaptation to the climatic hazard: wildfire(I6)
- Climatic hazard: wind (I7)

- Management and community involvement (J2)

Indicators

The **three national tools include 25%-55% of the indicators of the Generic Framework** SNTool, with the SNTool-Sousse having the least. The number of active indicators per Issue in the three national SNTools are illustrated in Figure 3.

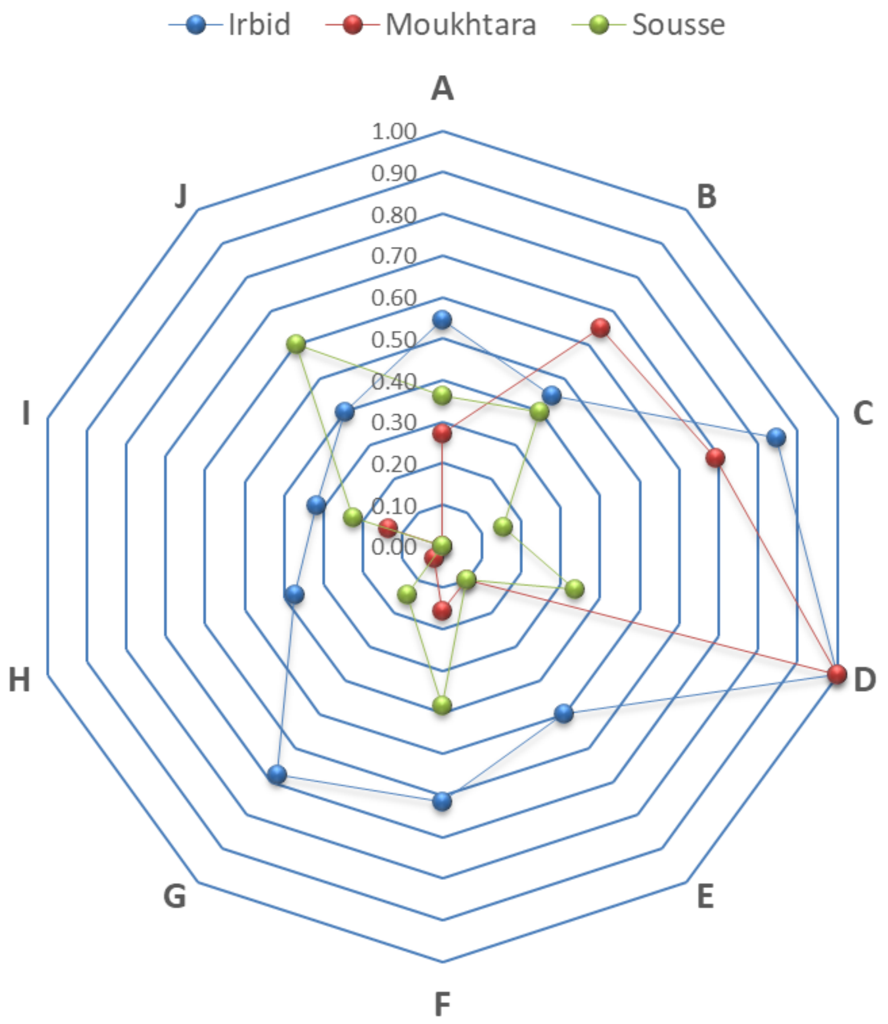


Figure 3. Ratio of active Indicators per Issue with regard to the Generic Framework SNTool in the three national SNTools

The **total number of active Indicators** in the three national tools are illustrated in Figure 4. Issue G (Social Aspects) has the highest number of indicators in the Generic

Framework SNTool. However, in the SNTool-Moukhtara, Issue G has the smallest number of active indicators. For the SNTool-Irbid, the Issue I (Climate Change: mitigation and adaptation) has the lowest number of active indicators, while for the SNTool-Sousse it is Issue E (Environmental quality) that has the lowest number of Indicators. The three national SNTools are summarized in Table 3.

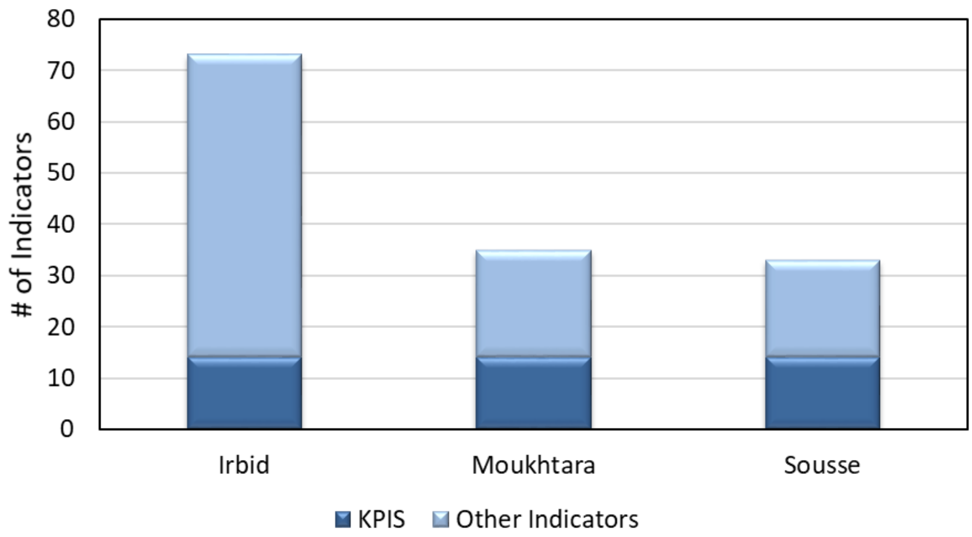


Figure 4a. Total number of active Indicators in the three national SNTools.

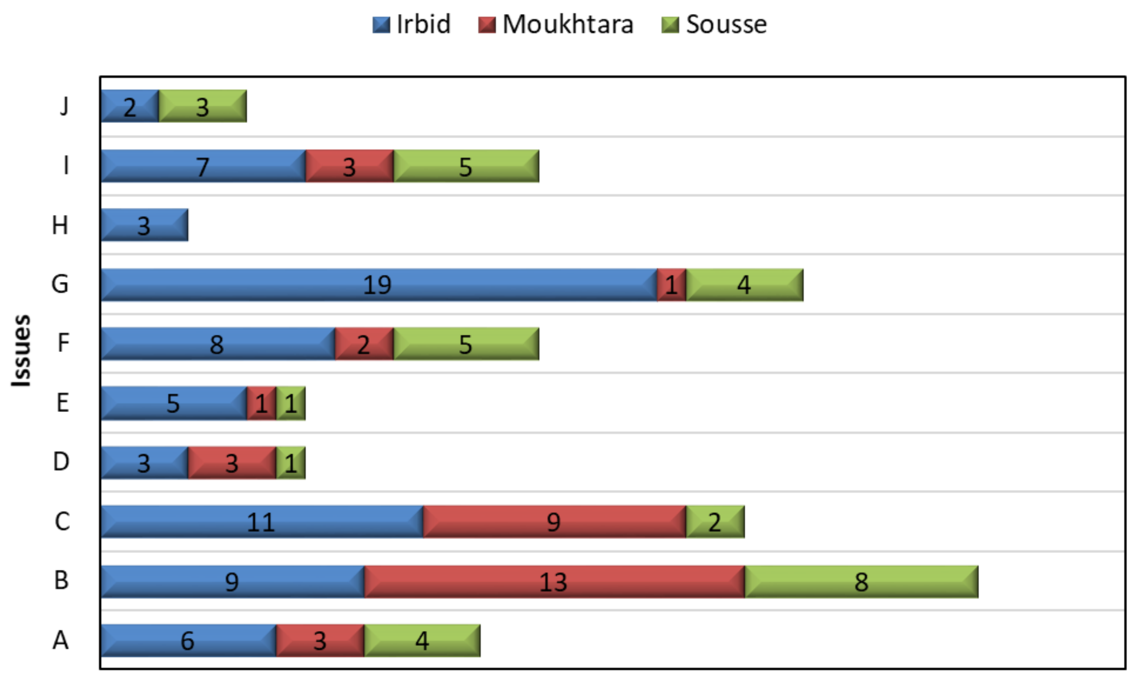


Figure 4b. Number of active Indicators per Issue in the three national SNTools.

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Table 3. The three national SBTools in numbers.

	Issues	Categories	Indicators
SBTool-Irbid	10	30	73
SBTool-Moukhtara	8	15	35
SBTool-Sousse	9	22	33

A **total of nineteen Indicators are common in the three national SNTools**, including the KPIs. The common Indicators per Issue in the three national tools are illustrated in Figure 5, identifying the most popular ones. Beyond the fourteen KPIs, a total of **five Indicators were selected by all three pilots**, which reveals their popularity. Accordingly, the **most popular indicators** are assigned to three issues, namely:

- **A2.1** Proportion of all vegetated areas within the neighborhood boundaries in relation to the total area,
- **A2.2** Total area of green in the city divided by neighborhood's total population,
- **B1.1** Percentage of households with authorized access to electricity,
- **B2.10** Total electricity consumption of public street lighting divided by the total distance of streets where street lights are present and
- **C1.2** Percentage of buildings within the neighborhood that are served by wastewater collection.

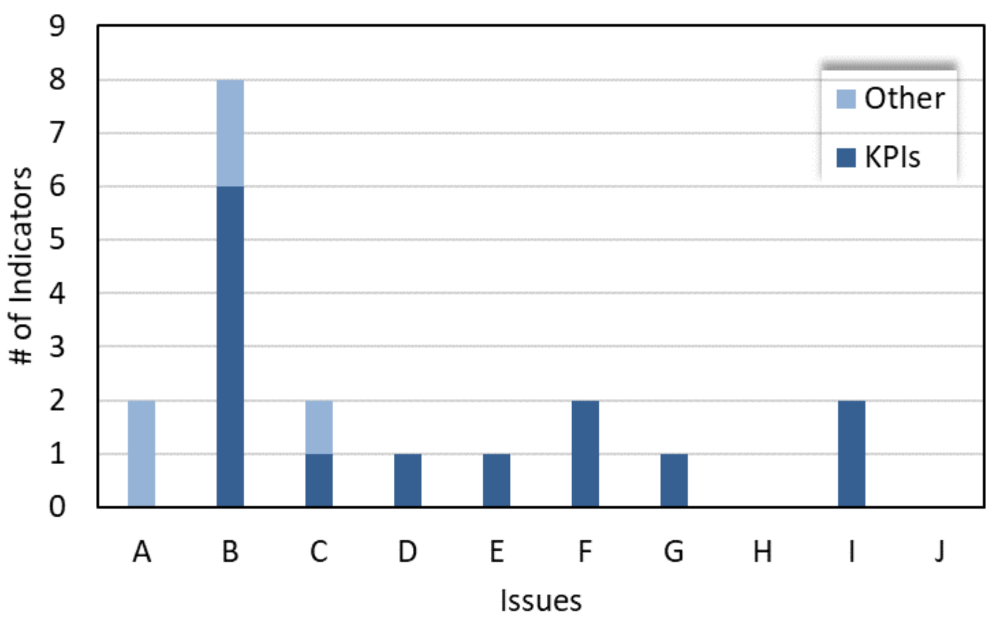

Figure 5. Common Indicators in the three national SNTools.

The Generic Framework SNTool included indicative **benchmarks** for all indicators. According to the SMC method, each national tool could either retain these benchmarks or adapt them on the basis of the local sustainability priorities and strategic policies. From the three national tools, the SNTool-Irbid had the most modified benchmarks (77%), followed by SNTool-Moukhtara (47%), while SNTool-Sousse had the least number of modifications (36%). In some cases, the national benchmarks differ significantly from the Generic Framework SNTool and in several cases they also differentiate between the national SNTools (even by an order of magnitude). The **Indicators for which the benchmarks have the most significant differences** either with the Generic Framework SNTool or between the national SNTools, include:

- **A1.1.** Population density,
- **A2.2.** Green areas in relation to the neighborhood population,
- **B2.10.** Energy consumption of public lighting,
- **C1.1.** Availability of a public municipal water supply,
- **C2.1.** Total water consumption,
- **D2.1.** Access to solid waste and recycling collection points,
- **D2.2.** Access to solid waste and recycling collection points,
- **I2.1.** Albedo,
- **J3.1.** Public buildings sustainability.

From the common active Indicators, **six (6) have retained the original benchmarks** from the Generic Framework, either because the local sustainability priorities and strategic policies are in agreement or due to lack of relative national-regional-local information. These indicators include:

- **B2.4.** Total final electrical energy consumption for building operations
- **B3.7.** Share of renewable energy on-site, relative to total primary energy consumption for building operations
- **F1.1.** Performance of the public transport system
- **F2.3.** Bicycle network
- **G3.1.** Availability and proximity of key services

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- **I3.3.** Permeability of land

The **benchmarks** for the common Indicators in the three national SNTools, are summarized in Table 4. The underlined values in Table 4 indicate that the benchmark is identical to the Generic Framework SNTool. It is important to note that the specific values of the benchmarks influence the score of each Indicator; a lower benchmark value will result to a higher score for the same value of an indicator.

- In the SNTool-Irbid nine of the common Indicators had different benchmarks compared to the Generic Framework SNTool, seven with more relaxed limits and two with more strict.
- In the SNTool-Moukhtara six of the common Indicators had different benchmarks, three with more relaxed limits and three more strict.
- In the SNTool-Sousse only two of the common Indicators had differentiated benchmarks, all with more relaxed limits.

Table 4. Benchmarks for the common Indicators in the three national SNTools. Underlined values indicate that the benchmark is identical to the Generic Framework SNTool.

Indicators		**Benchmarks**		
		Irbid	**Moukhtara**	**Sousse**
A2.1. Proportion of all vegetated areas within the neighborhood boundaries in relation to the total area (%)	**0:** **5:**	15 20	60 70	30 40
A2.2. Total area of green in the city divided by neigborhood's total population (m^2/inhabitant)	**0:** **5:**	0.48 11.25	500 1000	5 50
B1.1 Percentage of households with authorized access to electricity (%)	**0:** **5:**	98 100	89 100	89 100
*B2.1. Aggregated annual total final thermal energy consumption per aggregated indoor useful floor area (kWh/m^2/year)	**0:** **5:**	100 30	170 100	100 30
*B2.4. Aggregated annual total final electric energy consumption per aggregated internal useful floor area (kWh/m^2/year)	**0:** **5:**	25 5	25 5	25 5
*B2.7. Aggregated annual total primary energy consumption per aggregated indoor useful floor area (kWh/m^2/year)	**0:** **5:**	50 15	170 100	300 80
B2.10. Total electricity consumption of public street lighting divided by the total distance of streets where street lights are present (kWh/km/ year)	**0:** **5:**	38616 14771	50 20	15000 8000

*B3.1. Total consumption of final thermal energy generated from renewable sources on-site divided by total final thermal energy consumption (%)	0: 5:	25 90	30 100	30 100
*B3.4. Total consumption of final electric energy generated from renewable sources on-site divided by total final electric energy consumption (%)	0: 5:	35 75	30 100	30 100
*B3.7. Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption (%)	0: 5:	30 100	30 100	30 100
C1.2. Percentage of buildings within the neighborhood that are served by wastewater collection (%)	0: 5:	63 80	95 100	95 100
*C2.3. Annual potable water consumption per occupant (Liters/day/person)	0: 5:	250 60	250 100	250 60
*D2.2. Percentage of inhabitants with access to solid waste and recycling collection points within 400 meters walking distance (%)	0: 5:	0 19	75 95	75 95
*E1.2. Number of days within a year that PM10 concentration exceeds the daily limit (days/ year)	0: 5:	10 5	15 11	15 11
*F1.1. Percentage of inhabitants that are within 400 meters walking distance of at least one public transportation service stop (%)	0: 5:	30 70	30 70	30 70
*F2.3. Aggregate length of bicycle paths in the city per inhabitant (m/inhabitant)	0: 5:	5 40	5 40	5 40
*G3.1. Percentage of inhabitants that are within 800 meters walking distance of at least 3 key services (%)	0: 5:	50 100	50 100	50 100
*I1.1. Total amount of greenhouse gases generated over a calendar year divided by the current neighborhood population (Tons CO2 eq. / inhabitant)	0: 5:	5 2	2 1	5 2
*I3.3. Share of the urban area that is permeable to water(%)	0: 5:	20 100	20 100	20 100

* identifies the KPIs

The **assessment scores** for the **existing condition** of the **urban areas** range **from 0.82** (Sousse pilot) **to 2.60** (Moukhtara pilot). About one third of the Issues assessed in Irbid and Moukhtara pilots have scores above 4, while in Sousse pilot there are no Issues above 3. On the other hand, about one fourth of the Issues in Moukhtara and Sousse pilots have scores below the minimum acceptable (score 0). The distribution of assessed Issues scores is presented in Figure 6. Issues C (Water) and E (Environmental quality) have the assessment score above 4 in two out of three pilots (Irbid and Moukhtara), while Issue D (Solid Waste) is assessed with score below minimum acceptable level in Irbid and Sousse pilot.

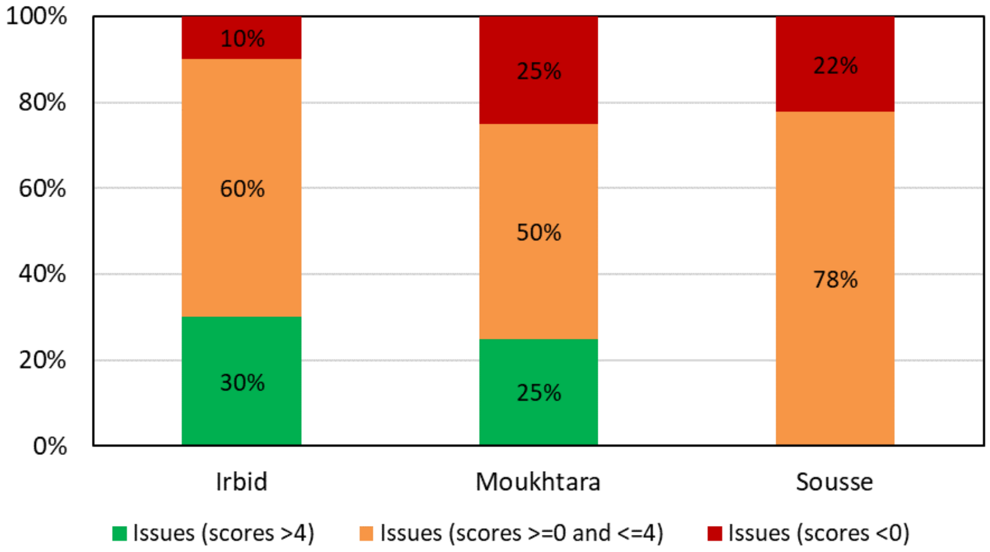

Figure 6. Distribution of Issues to various scores in the three national SNTools.

Analysing the assessment scores of the various Categories, 7% of them have reached high scores (above 4) in the Moukhtara pilot, while in the Irbid pilot the highest Category score is 3.57 and in the Sousse pilot the value is 1.82. On the other hand, 23%-36% of the Categories have scores below 0 (Figure 7), which means that they are below the minimum requirements. Category F2 (Green mobility) has negative scores in all pilots, while B3 (Renewable energy) in two pilots (Irbid and Sousse).

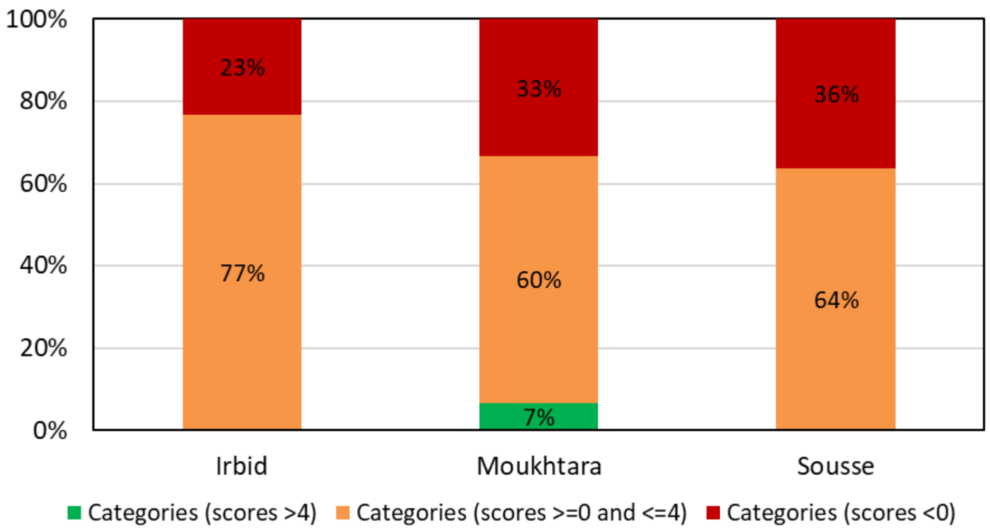

Figure 7. Distribution of Categories to various scores in the three national SNTools.

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In the Sousse pilot, fifty-five percent (55%) of the assessed Indicators have scores below the corresponding minimum acceptable level, while in Moukhtara pilot and Irbid the corresponding percentages are 43% and 36%. Indicators with high scores are 37%, 29% and 21% for Irbid, Moukhtara and Sousse pilot respectively, as illustrated in Figure 8.

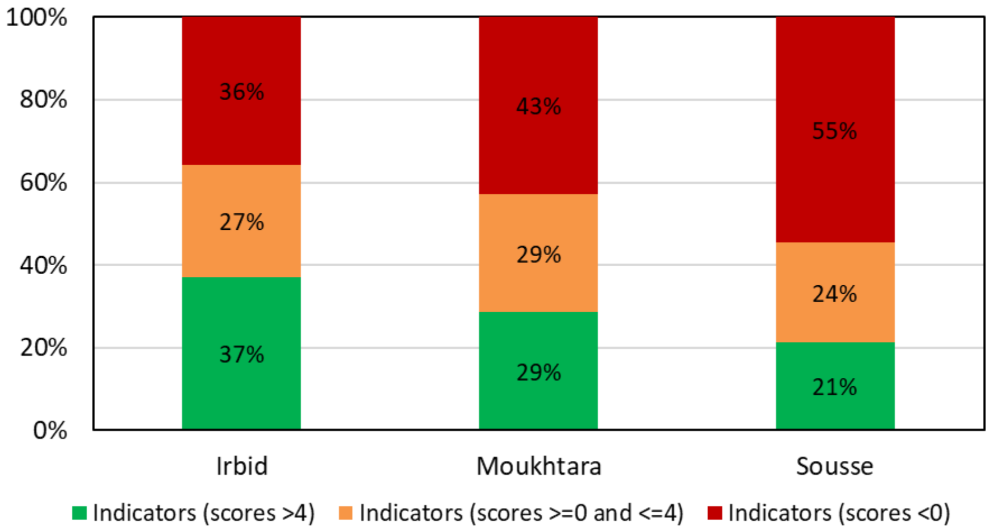

Figure 8. Distribution of Indicators to various scores in the three national SNTools.

Finally, **the majority of KPIs have negative scores in all three national SNTools**. **Energy related KPIs that have scores below the minimum acceptable requirements** in all three pilots, namely:

- **B2.7** Aggregated annual total primary energy consumption per aggregated indoor useful floor area,
- **B3.1** Total consumption of final thermal energy generated from renewable sources on-site divided by total final thermal energy consumption and
- **B3.7** Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption.

The **KPIs with the highest scores** (above 4) range between 7%-36% in the three pilots (Figure 9). Three KPIs have highest scores in two out of three SNTools, namely:

- **B2.1** Aggregated annual total final thermal energy consumption per aggregated indoor useful floor area in the Irbid and Sousse pilots,

- **E1.2** Number of days within a year that PM10 concentration exceeds the daily limit in the Irbid and Moukhtara pilots and
- **F1.1** Percentage of inhabitants that are within 400 meters walking distance of at least one public transportation service stop in the Irbid and Sousse pilots.

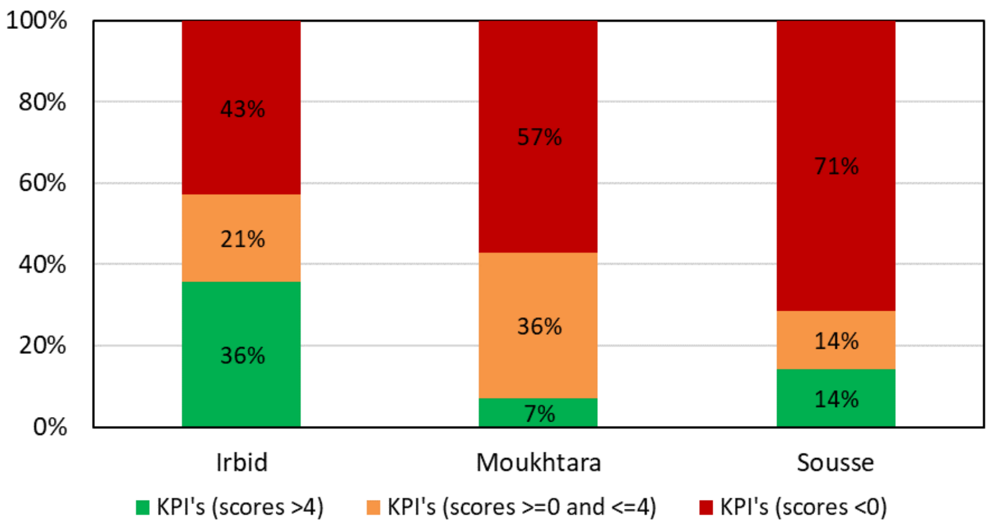

Figure 9. Distribution of KPI’s to various scores in the three national SNTools.

The vast majority (71%) of the common active Indicators have different and often significantly different assessment scores. Specifically, **the highest assessment scores** (5) in all three pilots were reported for:

- **B1.1** Percentage of households with authorized access to electricity, which implies that all households have access to this basic amenity;
- **C1.2** Percentage of buildings within the neighborhood that are served by wastewater collection, which implies that there is very good basic city infrastructure for handling wastewater from buildings.

On the other hand, the **lowest assessment scores** (-1) in all three pilots were reported for:

- **B2.7** Aggregated annual total primary energy consumption per aggregated indoor useful floor area, which implies very high primary energy consumption and a potential for significant energy savings;

- **B3.1** Total consumption of final thermal energy generated from renewable sources on-site divided by total final thermal energy consumption, which implies that there is very limited exploitation of renewables like on-site solar thermal collectors;
- **B3.7** Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption, which again implies that there is very limited exploitation of renewables like photovoltaics for power generation;
- **F2.3** Aggregate length of bicycle paths in the city per inhabitant, which reveals that there is no good infrastructure for supporting alternative transportation modes and safe use of bicycles.

The assessment scores and the corresponding values of the common Indicators, for the three pilot studies are summarized in Table 5.

Table 5. Scores and values for the common Indicators in the three pilots.

Indicators	Score (Value)		
	SNTool-Irbid	SNTool-Moukhtara	SNTool-Sousse
A2.1	-1.00 (9.28)	5.00 (79.40)	-1.00 (5.66)
A2.2.	-1.00 (0.20)	5.00 (1022)	0.27 (7.42)
B1.1	5.00 (100)	5.00 (100)	5.00 (100)
*B2.1.	4.91 (31.2)	-1.00 (197)	5.00 (19.42)
*B2.4.	-1.00 (32.84)	1.09 (20.64)	2.79 (13.87)
*B2.7.	-1.00 (85)	-1.00 (217.64)	-1.00 (53.24)
B2.10.	5.00 (7,625.2)	-1.00 (12392)	2.60 (11424)
*B3.1.	-1.00 (0)	-1.00 (29)	-1.00 (4.3)
*B3.4.	-1.00 (8)	0.43 (36)	-1.00 (6.9)
*B3.7.	-1.00 (3)	-1.00 (1.11)	-1.00 (0)
C1.2.	5.00 (100)	5.00 (100)	5.00 (100)
*C2.3.	4.74 (70)	2.33 (180)	2.11 (169.84)
*D2.2.	0.00 (0)	-1.00 (22)	-1.00 (0)
*E1.2.	5.00 (0)	5.00 (1)	-1.00 (42)
*F1.1.	5.00 (93.3)	-1.00 (0)	5.00 (80)
*F2.3.	-1.00 (0)	-1.00 (1)	-1.00 (0.02)
*G3.1.	5.00 (100)	3.00 (80)	-1.00 (25)
*I1.1.	3.67 (2.8)	-1.00 (2.49)	5.00 (1.06)
*I3.3.	1.09 (37.4)	2.69 (63)	-1.00 (7.86)

* identifies the KPIs

3.2. Neighborhood in Irbid

Name of the urban area	*Al-Nozha*
Brief Description	*The pilot was performed in an area within the latest expansion of Irbid, with many different buildings like schools, public services, single and multiple housing units*
Surface area	*0.96 km²*
Building density	*9.28 m³/m²*
Total land area occupied by buildings, streets, parking and parkland in the local area	*0.84 km²*
Total land surface area used for residential purposes	*0.57 km²*
Aggregate gross area of housing units	*572973 m²*
Aggregate gross area of office buildings	
Aggregate gross area of retail commercial buildings	*57767 m²*
Aggregate gross area of public buildings	*67323 m²*

Data sources used to collect all the necessary information for the assessment included:

- *Physical visits and observation*
- *Department of Statistics (DOS)*
- *GIS Mapping*
- GIM
- Building bills sample *(electricity and* water)
- *Questionnaire Survey*
- *Ministries (Ministry of Energy and Mineral Resources, Ministry of Environment, Ministry of Education)*
- *Civil Defense Department*
- *Electricity Company,* Water Company, *National Telecommunication Company*

All ten Issues are included in the SNTool-Irbid. Among them, Category G includes the highest number of indicators, while Category J has the lowest number of indicators (Figure 10).

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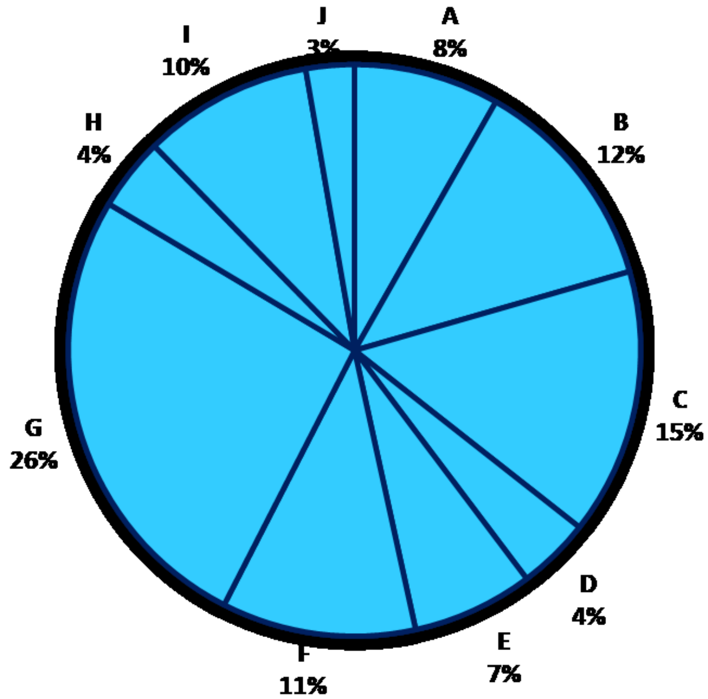

Figure 10. Distribution of Indicators in SNTool-Irbid.

From the 43 Categories in the Generic Framework SNTool, 13 are not used in the Irbid pilot study. The Issues of Energy (B), Solid Waste (D) and Economy (H) have been assigned the highest priority (5), while the Issue of Governance (J) has the lowest priority (2). (Figure 11).

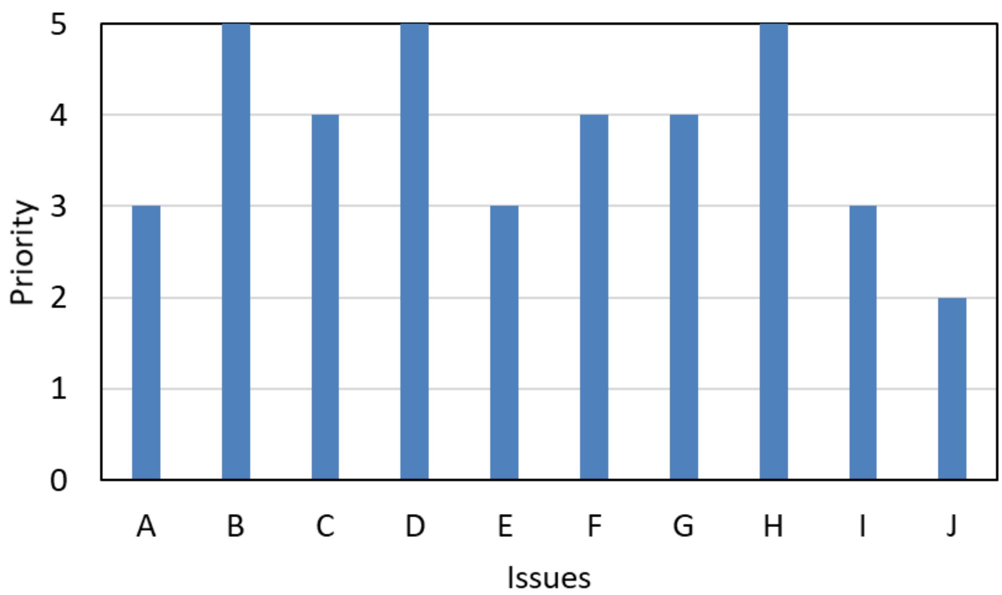

Figure 11. Priority of active Issues in SNTool-Irbid (1:minor, 5:major).

In the SNTool-Irbid most of the Indicators (70%) have different benchmarks compared to the Generic Framework SNTool, out of which 58 have lighter limits and 13 stricter. Most of the Indicators (37%) have assessment scores above 4, while 34% of the Indicators have assessment scores below minimum acceptable performance (0), as shown in Figure 12.

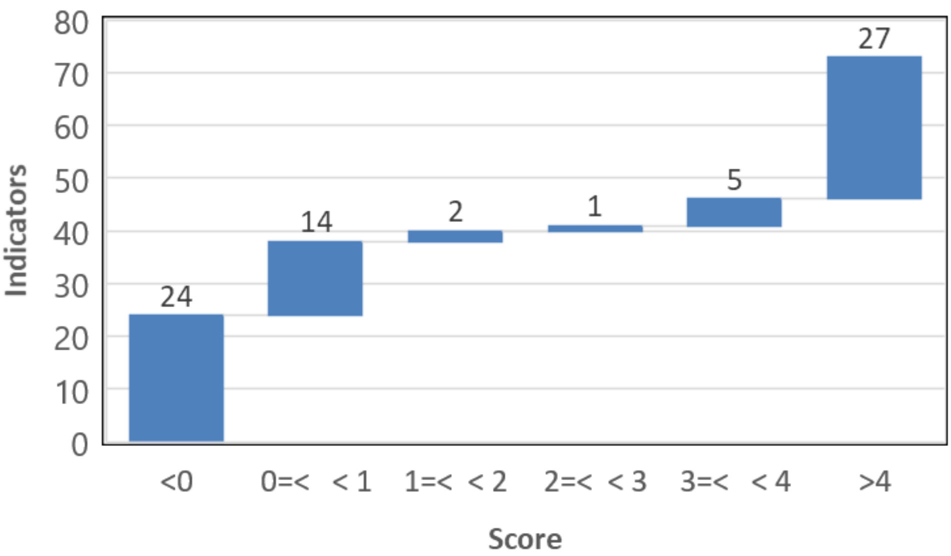

Figure 12. Distribution of Indicators in the 6 different score levels in SNTool-Irbid.

The details of the active Indicators, the benchmarks, the priorities and weighting factors, as well as the scores and actual values for the existing condition and the two proposed scenarios are presented in Table 6.

Table 6. Assessment of Al-Nozha (SNTool-Irbid), in existing condition and in two scenarios (S-1 and S-2). For the scenarios, only the modified Indicators are presented, the others remain the same with the existing condition. Underlined values indicate that the benchmark is identical to the Generic Framework SNTool.

Code	Indicator	Units	Benchmark		Priority (weight)	Score (value)		
			(0)	(5)				
						Existing	S-1	S-2
					Urban Area	2.26	2.77	2.83
A	Use of land and biodiversity				3 (8%)	0.64	1.18	1.18
A1	Use of land				3 (43%)	1.21	1.21	1.21
A1.1	Population density in built-up areas (neighborhood area minus green and blue)	Inhabitants / km²	15000	60000	50%	0.67 (21016.55)		

A1.2	Relation between the usable space of the buildings (volume) and the urban space (area)	m³/ m²	2	3	50%	5.00 (4.12)		
A2	**Green urban areas**				**4 (57%)**	**-0.57**	**-0.04**	**-0.04**
A2.1	Proportion of all vegetated areas within the neighborhood boundaries in relation to the total area	%	15	20	25%	-1.00 (9.28)	0.00 (15)	0.00 (15)
A2.2	Total area of green in the city divided by neigborhood's total population	m^2/ inhabitant	0.48	11.25	25%	-1.00 (0.20)	0.75 (2.1)	0.75 (2.1)
A2.3	Number of inhabitants living with 300m of a publicly accessible green space of at least 0.5ha divided by the total number of neighborhood inhabitants	%	48	100	25%	-1.00 (14.54)	0.00 (48)	0.00 (48)
A2.4	Density of green spaces within the area	%	15	20	25%	-1.00 (0.58)	-1.00 (6.30)	-1.00 (6.30)
B	**Energy**				**5 (13%)**	**1.47**	**2.31**	**2.31**
B1	**Energy infrastructure**				**5 (33%)**	**1.67**	**1.67**	**1.67**
B1.1	Percentage of households with authorized access to electricity	%	98	100	100%	5.00 (100)		
B2	**Energy consumptions**				**5 (33%)**	**0.13**	**0.66**	**0.66**
*B2.1	Aggregated annual total final thermal energy consumption per aggregated indoor useful floor area	kWh/m^2/yr	100	30	20%	4.91 (31.2)		
*B2.4	Aggregated annual total final electric energy consumption per aggregated internal useful floor area	kWh/m^2/yr	25	5	20%	-1.00 (32.84)	0.00 (25)	0.00 (25)
B2.5	Aggregated annual final electrical energy consumption of residential buildings per aggregated indoor useful floor area	kWh/m^2/yr	15	5	20%	-1.00 (27.46)	0.00 (15)	0.00 (15)
*B2.7	Aggregated annual total primary energy consumption per aggregated indoor useful floor area	kWh/m^2/yr	50	15	20%	-1.00 (85)	0.00 (50)	0.00 (50)
B2.10	Total electricity consumption of public street lighting divided by the total distance of streets where street lights are present	kWh/Km/yr	38.616	14.771	20%	5.00 (7,625.2)		
B3	**Renewable energy**				**5 (33%)**	**-0.33**	**-0.02**	**-0.02**
*B3.1	Total consumption of final thermal energy generated from renewable sources on-site divided by total final thermal energy consumption	%	25	90	33.3%	-1.00 (0)	-1.00 (10)	-1.00 (10)
*B3.4	Total consumption of final electric energy generated from renewable sources on-site	%	35	75	33.3%	-1.00 (8)	0.63 (40)	0.63 (40)

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	divided by total final electric energy consumption							
*B3.7	Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption	%	30	100	33.3%	-1.00 (3)	0.21 (33)	0.21 (33)
C	**Water**				**4 (11%)**	**4.65**	**4.69**	**4.69**
C1	**Water infrastructure**				**4 (31%)**	**1.54**	**1.54**	**1.54**
C1.1	Percentage of the buildings within the neighborhood that are served by a municipal water supply	%	99	100	50%	5.00 (100)		
C1.2	Percentage of buildings within the neighborhood that are served by wastewater collection	%	63	80	50%	5.00 (100)		
C2	**Water consumption**				**5 (38%)**	**1.58**	**1.62**	**1.62**
C2.1	Total amount of the area's water consumption divided by the total area population	Liters/day /person	135	80	18.8%	5.00 (57.4)		
C2.3 *	Annual potable water consumption per occupant	Liters/day /person	250	60	18.8%	4.74 (70)		
C2.4	Annual potable water consumption per occupant	Liters/day /person	50	20	18.8%	0.4 (22.4)		
C2.5	Annual potable water consumption per occupant	Liters/day /person	63	48	18.8%	5.00 (47)		
C2.6	Share of rainwater collected from roofs of residential buildings for reuse	%	0	30	12.5%	0.00 (0)	0.83 (5)	0.83 (5)
C2.7	Potable water used for irrigation purposes in public green spaces	m^3/m^2	5	0	12.5%	3.78 (1.22)		
C3	**Effluents management**				**4 (31%)**	**1.54**	**1.54**	**1.54**
C3.1	Total volume of wastewater collected for at least secondary treatment in centralized wastewater treatment facilities divided by the total volume of wastewater produced in the area	%	56	63	40%	5.00 (90)		
C3.2	Percent of public wastewater that is disposed or treated	%	56	63	40%	5.00 (80)		
C3.3	Percentage of households with access to basic sanitation facilities	%	98.8	100	20%	5.00 (100)		
D	**Solid Waste**				**5 (13%)**	**-0.50**	**0.16**	**0.66**
D1	**Solid waste collection infrastructure**				**5 (50%)**	**-0.50**	**-0.50**	**0.00**
D1.1	Percentage of buildings with regular solid waste collection	%	60	90	100%	-1.00 (40)		0.00 (60)
D2	**Solid waste management**				**5 (50%)**	**0.00**	**0.66**	**0.66**
D2.1	Proximity of the resident population to the solid waste and recycling collection point	%	0	19	50%	0.00 (0)	1.32 (5)	1.32 (5)
D2.2 *	Percentage of inhabitants with access to solid waste and	%	0	19	50%	0.00 (0)	1.32 (5)	1.32 (5)

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F	recycling collection points within 400 meters walking distance							
E	**Environmental quality**				**3 (8%)**	**5.00**	**5.00**	**5.00**
E1	**Air quality**				**5 (71%)**	**3.57**	**3.57**	**3.57**
E1.1	Number of days within a year that $PM_{2.5}$ concentration exceeds the daily limit	days y	3	0	33.3%	5.00 (0)		
E1.2 *	Number of days within a year that PM_{10} concentration exceeds the daily limit	days y	10	5	33.3%	5.00 (0)		
E1.3	Sum of daily concentrations (NO2) for the whole year divided by 365 days	μg/m³	40	20	33.3%	5.00 (0)		
E3	**EMF exposure**				**2 (29%)**	**1.43**	**1.43**	**1.43**
E3.1	Percentage of mobile network antenna sites in compliance with EMF exposure guidelines	%	80	100	50%	5.00 (100)		
E3.2	Percentage of buildings in the area located not respecting the safety distance from high voltage lines	%	50	5	50%	5.00 (0)		
F	**Transportation and mobility**				**4 (11%)**	**2.83**	**3.09**	**3.09**
F1	**Performance of mobility service**				**5 (36%)**	**1.79**	**1.79**	**1.79**
*F1.1	Percentage of inhabitants that are within 400 meters walking distance of at least one public transportation service stop	%	30	70	100%	5.00 (93.3)		
F2	**Green mobility**				**2 (14%)**	**-0.14**	**0.00**	**0.00**
F2.2	Electric vehicle charging stations per inhabitant	n/ inhabitant	0.01	0.05	50%	-1.00 (0)	0.00 (0.01)	0.00 (0.01)
*F2.3	Aggregate length of bicycle paths in the city per inhabitant	m/ inhabitant	5	40	50%	-1.00 (0)	0.00 (5)	0.00 (5)
F3	**Safety in mobility**				**5 (36%)**	**1.06**	**1.17**	**1.17**
F3.1	Percentage of the city designated as a pedestrian/car free zone	%	0	10	33.3%	0.00 (0)	1.00 (2.0)	1.00 (2.0)
F3.2	Percentage of roads' length that has dedicated sidewalks	%	50	100	33.3%	3.90 (89)		
F3.4	Traffic fatalities per 1,000 inhabitants.	n/1000 inhabitant s	10	0	33.3%	4.9 0(0.06)		
F4	**Urban morphology and transportation**				**2 (14%)**	**0.13**	**0.13**	**0.13**
F4.1	Cyclomatic number	number	30	100	75%	0.43 (36)		
F4.2	Number of intersections related to the overall surface area	number/ km²	54	154	25%	2.30 (100)		
G	**Social Aspects**				**4 (11%)**	**0.02**	**1.51**	**1.51**
G1	**Accessibility (disabled persons)**				**5 (19%)**	**-0.19**	**0.03**	**0.03**
G1.1	Percent of key public buildings that are accessible for use by physically disabled persons	%	2	80	33.3%	-1.00 (1.02)	0.19 (5)	0.19 (5)
G1.2	Percent of sidewalks and other pedestrian ways that are accessible for use by physically disabled persons	%	25	80	33.3%	-1.00 (0)		

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G1.3	Adequacy of barrier-free accessible public outdoor areas compared to the total public area	%	50	90	33.3%	-1.00 (0)	0.25 (52)	0.25 (52)
G2	**Housing**				**3 (11%)**	**0.20**	**0.31**	**0.31**
G2.1	Housing properties in the local area that are financially accessible to the lowest quintile of area population	%	5	30	33.3%	-1.00 (4.9)	1.00 (10)	1.00 (10)
G2.2	Percentage of the average salary of the lowest quintile of the population used for rental payments	%	50	30	22.2%	0.00 (50)	1.25 (45)	1.25 (45)
G2.3	Percentage of vacant residential units	%	8	20	11.1%	4.3 (18.4)		
G2.4	Percentage of inhabitants living in slums, informal settlements or inadequate housing	%	17	0.8	33.3%	5.00 (0)		
G3	**Availability of public and private facilities and services**				**3 (11%)**	**0.13**	**0.25**	**0.25**
G3.1 *	Percentage of inhabitants that are within 800 meters walking distance of at least 3 key services	%	50	100	20%	5.00 (100)		
G3.2	Percentage of population near a public primary school	%	50	87	20%	-1.00 (39.31)	0.68 (55)	0.68 (55)
G3.3	Percentage of population near a public secondary school	%	15	65	20%	3.67 (51.69)		
G3.4	Percentage of population near a children's' play facilities	%	16	30	20%	-1.00 (14.54)	1.43 (20)	1.43 (20)
G3.5	Average share of the built-up area of the neighborhood that is open space for public use	%	25	34	20%	-1.00 (5. 8)	0.56 (26)	0.56 (26)
G4	**Education**				**3 (11%)**	**0.27**	**0.27**	**0.27**
G4.1	Net primary enrolment rate	%	50	98	50%	4.31 (91.4)		
G4.3	Lower secondary completion rate	%	69	94	50%	0.59 (71.96)		
G5	**Social inclusion**				**4 (15%)**	**-0.06**	**0.13**	**0.13**
G5.1	Percentage of household unable to afford the most basic levels of energy (more than 10% of the income spent on energy bills)	%	10	7	50%	-1.00 (21.46)	1.67 (9)	1.67 (9)
G5.2	Share of persons with an equivalised disposable income below 60 % of the national median income	%	25	13	50%	0.14 (24.66)		
G6	**Safety**				**5 (19%)**	**-0.19**	**0.33**	**0.33**
G6.1	Number of police officers per 1,000 inhabitants.	n/1000 inhabitants	3	5	50%	-1.00 (1.24)	2.50 (4)	2.50 (4)
G6.2	Number of firefighters per 1,000 inhabitants	n/1000 inhabitants	0.75	0.99	50%	-1.00 (0)	1.04 (0.8)	1.04 (0.8)
G10	**Perceptual**				**4 (15%)**	**-0.15**	**0.19**	**0.19**

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G10.1	Perceived safety of public places and pedestrian routes, as determined by a sample of pedestrians	Score	1	5	100%	-1.00 (-1)	1.25 (2)	1.25 (2)
H	**Economy**				**5 (13%)**	**5.00**	**5.00**	**5.00**
H1	**Economic performance**				**4 (44%)**	**2.22**	**2.22**	**2.22**
H1.1	Average per-capita income of residents in the local area relative to that of the urban region as a whole	%	60	90	100%	5.00 (94.08)		
H4	**ICT infrastructure**				**5 (56%)**	**2.78**	**2.78**	**2.78**
H4.2	Percentage of the neighborhood served by wireless broadband (3G, 4G, 5G)	%	67	98	50%	5.00 (99.1)		
H4.4	Total number of mobile phone subscriptions in the area divided by one 1000th of the area's total population	n/1000 inhabitants	80	90	50%	5.00 (610)		
I	**CLIMATE CHANGE: mitigation and adaptation**				**3 (8%)**	**1.76**	**2.30**	**2.30**
I1	**Climate change mitigation**				**5 (28%)**	**1.02**	**1.02**	**1.02**
*I1.1	Total amount of greenhouse gases generated over a calendar year divided by the current neighborhood population	Tons CO_2 eq. /inhabitant	5	2	100%	3.67 (2.8)		
I2	**Adaptation to the climatic action: heatwaves and increase of temperature**				**5 (28%)**	**0.56**	**0.78**	**0.78**
I2.1	Mean Solar Reflectance Index of paved surfaces and roofs in the area	-	70	0	60%	3.36 (23)		
I2.3	Aggregate area of building roofs covered with vegetated material	%	0	5	40%	0.00 (0)	2.00 (2)	2.00 (2)
I3	**Adaptation to the climatic action: pluvial flood**				**3 (17%)**	**0.18**	**0.18**	**0.18**
*I3.3	Share of the urban area that is permeable to water	%	20	100	100%	1.09 (37.4)		
I5	**Adaptation to the climatic action: drought**				**5 (28%)**	**0.00**	**0.32**	**0.32**
I5.1	Share of buildings in the area with a rainwater collection system	%	0	15	33.3%	0.00 (0)	1.33 (4)	1.33 (4)
I5.2	Share of rainwater collected from paved (not permeable) surfaces in the area (excluding buildings' roofs and plots)	%	0	8	33.3%	0.00 (0)	1.25 (2)	1.25 (2)
I5.3	Share of building in the area with a greywater collection system	%	0	60	33.3%	0.00 (0)	0.83 (10)	0.83 (10)
J	**GOVERNANCE**				**2 (5%)**	**2.00**	**2.66**	**2.66**
J3	**Public buildings operation**				**4 (100%)**	**2.00**	**2.66**	**2.66**
J3.1	Percentage area of public buildings with recognized sustainability certifications for ongoing operations	%	0.13	0.44	50%	-1.00 (0)	0.32 (0.15)	0.32 (0.15)
J3.2	Aggregated annual operating energy cost per aggregated indoor useful floor area	€/m^2/yr	7	3.5	50%	5.00 (0.16)		

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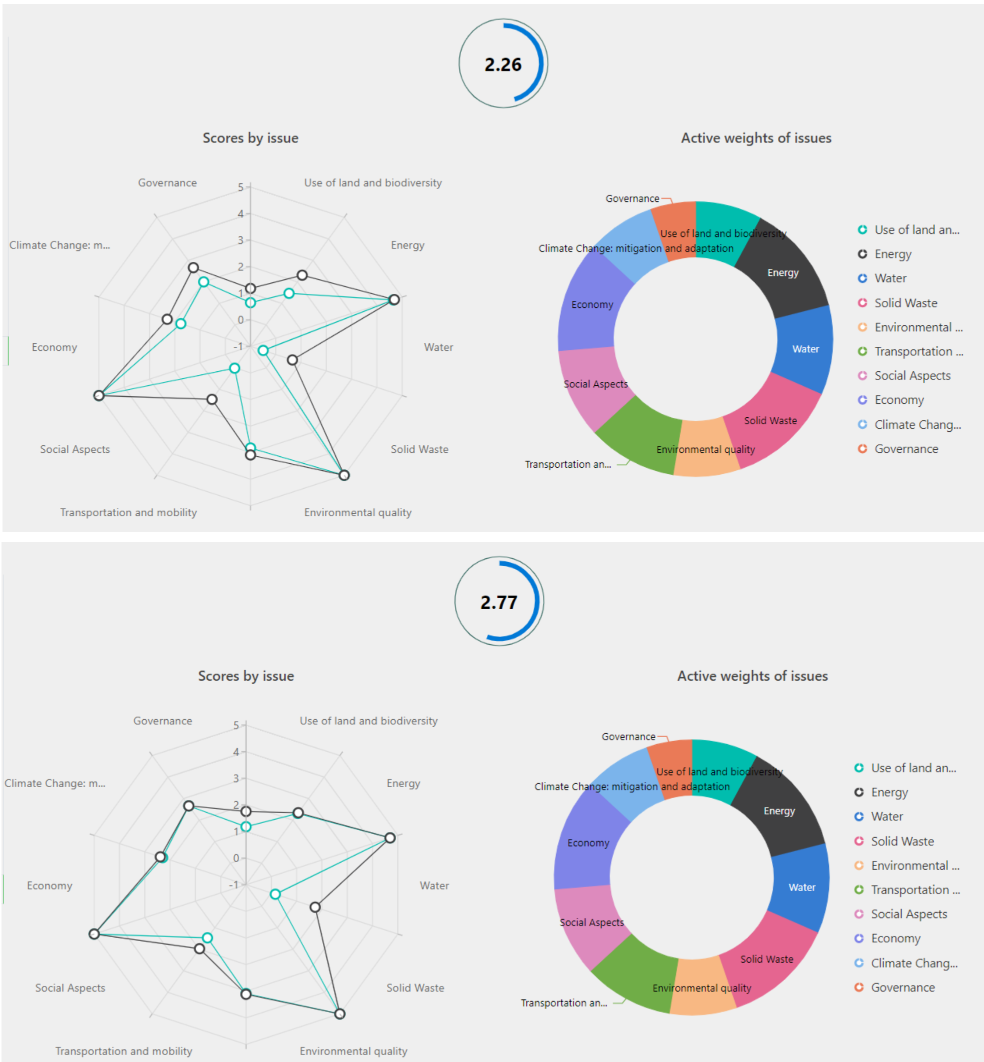
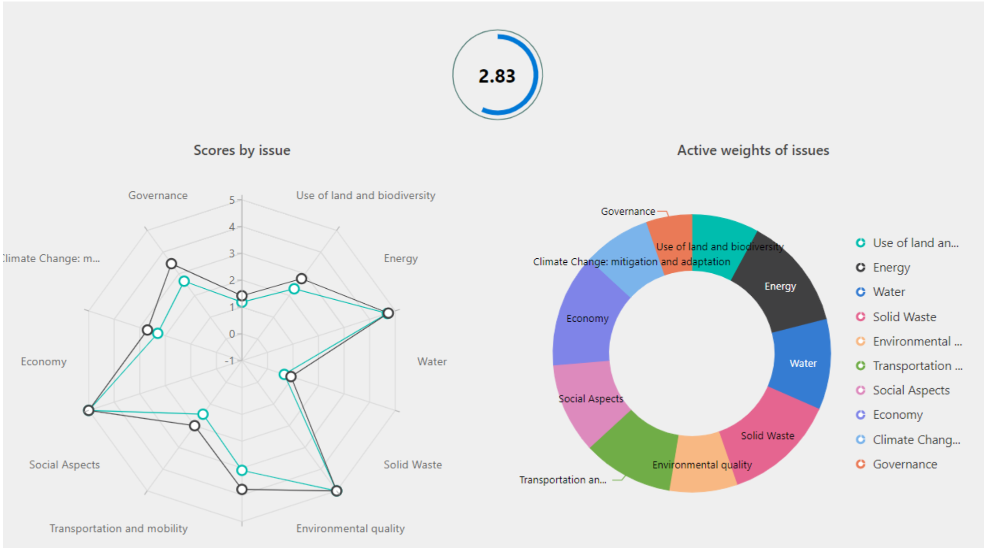
The **existing condition** of the **neighborhood** considered in this pilot reached a **sustainability score of 2.26** and it can be considered as a good sustainable area. The proposed retrofit actions in both Scenarios, were affecting eight out of ten Issues. The Issues that were not affected were Environmental quality (B) and Economy (H). Scenario 1 affects 32 out of 73 active Indicators, while Scenario2 affects 33 Indicators. The two Scenarios are identical, with the exception of D1.1, which is improved compared to the existing condition in Scenario 2. As a result, the sustainability score in Scenario 2 (2.83) is slightly improved with regard to Scenario1 (2.77). The sustainability score of Al-Nozha for the existing condition and for the two scenarios are presented in Figure 13. The sustainability score of the tested area increases by 23% in Scenario 1 and by 25% in Scenario 2.



(a)

(b)



(c)

Figure 13. Sustainability score of the tested area in the existing condition (a), under Scenario1 (b) and Scenario 2 (c).

Although the **differences are small**, the **selected scenario was Scenario2**, in which **eight Issues have improved** sustainability scores, as illustrated in Figure 14.

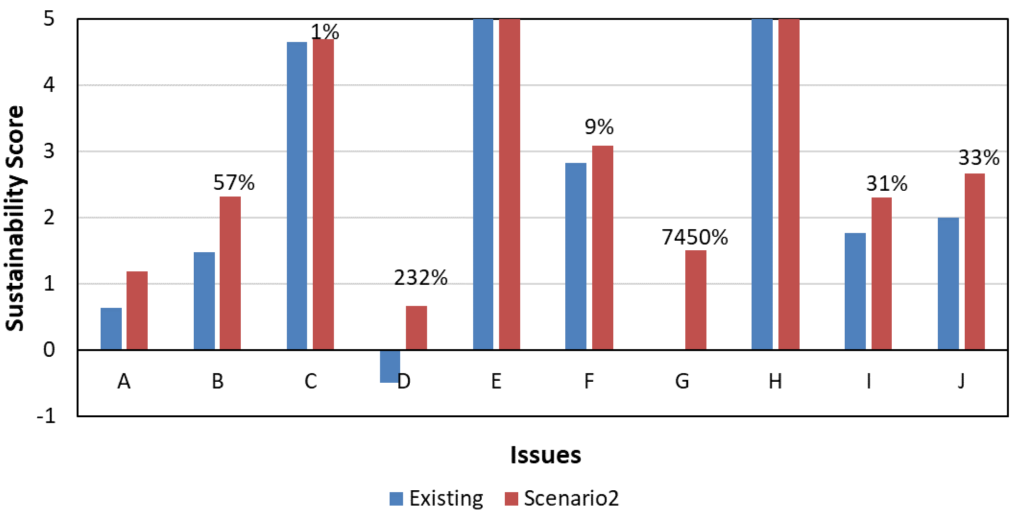


Figure 14. Issues sustainability scores of the tested area in the existing condition and in the selected Scenario 2.

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3.3. Neighborhood in Moukhtara

Name of the urban area	*Al Shouf*
Brief Description	*Moukhtara Central District*
Surface area	*0.076 km^2*
Building density	*40000 m^2*
Total land area occupied by buildings, streets, parking and parkland in the local area	*0.05 km^2*
Total land surface area used for residential purposes	*0.02 km^2*
Aggregate gross area of housing units	*1050 m^2*
Aggregate gross area of retail commercial buildings	*75 m^2*
Aggregate gross area of public buildings	*350 m^2*

Data sources

The Moukhtara Municipality Engineering team, led by the SMC team Coordinator, collected all the necessary data. Data verification and analysis was conducted by the SMC Team Lead and Quality Management consultants.

Eight Issues are included in the SNTool-Moukhtara. Among them, Category B includes the highest number of indicators, while Categories G and E have lowest number of indicators (Figure 15).

From the 43 Categories in the Generic Framework SNTool, 28 are inactive in the national SNTool. The Issues of Energy (B) and Solid Waste (D) have been assigned the highest priority (5), while the Issues with the lowest priority (3) are Use of land and biodiversity (A), Environmental quality (E) and Climate Change: mitigation and adaptation (I) (Figure 16).

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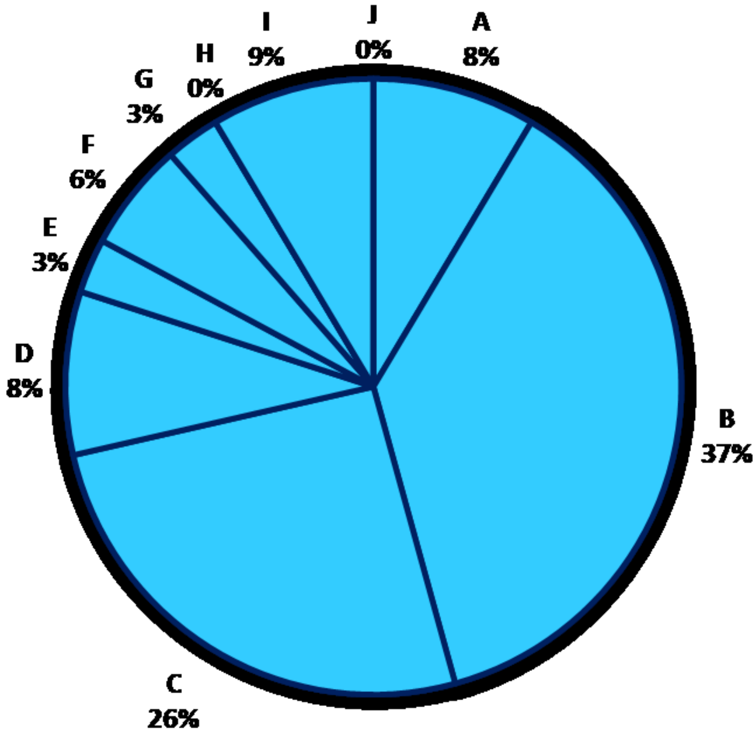

Figure 15. Distribution of Indicators in SNTool-Moukhtara.

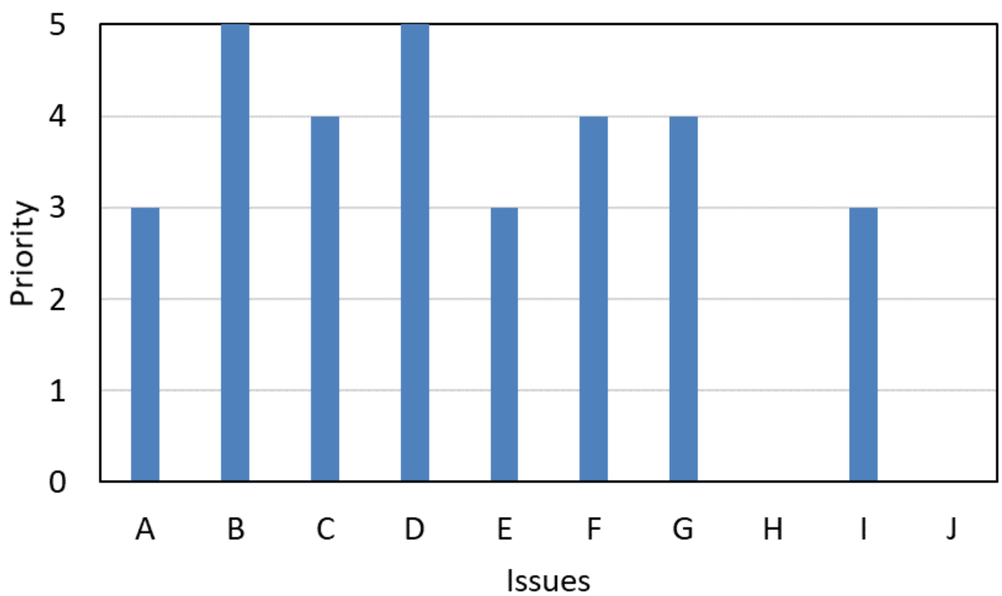

Figure 16. Priority of active Issues in SNTool-Moukhtara (1: minor, 5: major).

In the SNTool-Moukhtara the majority of Indicators (74%) have the same benchmarks with the Generic Framework SNTool. Five Indicators have stricter limits, while four have lighter benchmarks. Most of the Indicators (43%) have assessment scores below minimum acceptable performance (0), while 29% of the Indicators have assessment scores above 4, as shown in Figure 17.

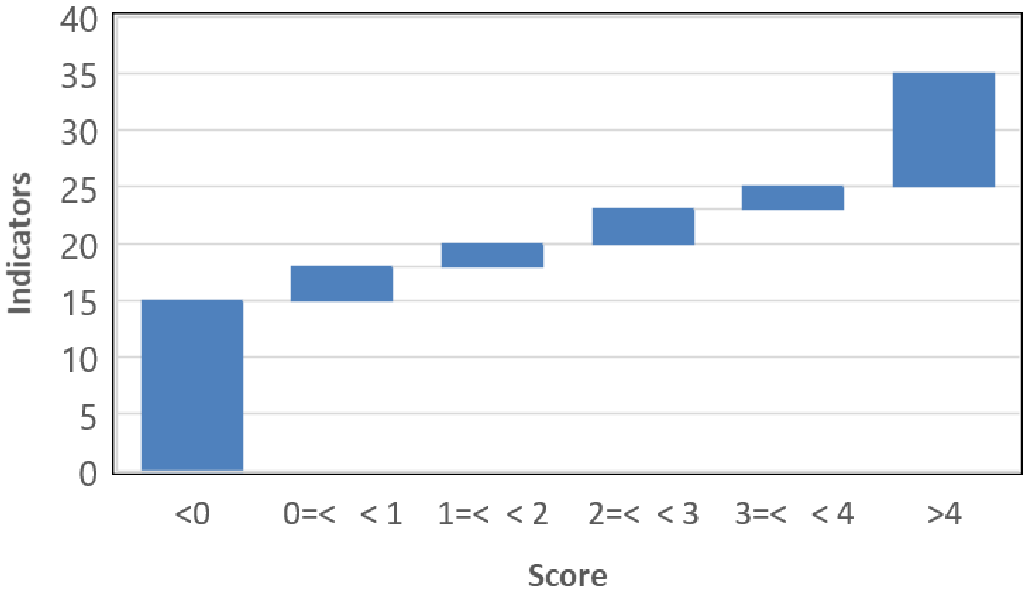

Figure 17. Distribution of Indicators in the 6 different score levels in SNTool-Moukhtara.

The details of the active Indicators, the benchmarks, the priorities and weighting factors, as well as the scores and actual values for the existing condition and the proposed scenario are presented in Table 7.

Table 7. Assessment of Al Shouf (SNTool-Moukhtara), in existing condition and in the scenario (S-1). For the scenario, only the modified Indicators are presented, the other remain the same with the existing condition. Underlined values indicate that the benchmark is identical to the Generic Framework SNTool.

Code	Indicator	Units	Benchmark		Priority (weight)	Score (value)	
			(0)	(5)		Existing	S-1
					URBAN AREA	2.60	3.11
A	**Use of land and biodiversity**				**2 (12%)**	**3.00**	**3.00**
A2	**Green urban areas**				**3 (100%)**	**3.00**	**3.00**
A2.1	Proportion of all vegetated areas within the neighborhood boundaries in relation to the total area	%	60	70	(33.3%)	5.00 (79.40)	
A2.2	Total area of green in the city divided by neigborhood's total population	m^2/inhabitant	500	1000	(33.3%)	5.00 (1022)	

A2.3	Number of inhabitants living with 300m of a publicly accessible green space of at least 0.5ha divided by the total number of neighborhood inhabitants	%	20	150	(33.3%)	-1.00 (0)	
B	**Energy**				**4 (24%)**	**0.71**	**2.70**
B1	**Energy infrastructure**				**1 (17%)**	**0.83**	**0.83**
B1.1	Percentage of households with authorized access to electricity	%	89	100	(100%)	5.00 (100)	
B2	**Energy consumptions**				**3 (50%)**	**-0.29**	**0.94**
*B2.1	Aggregated annual total final thermal energy consumption per aggregated indoor useful floor area	kWh/m^2 /year	170	100	(20%)	-1.00 (197)	0.21 (167)
*B2.4	Aggregated annual total final electric energy consumption per aggregated internal useful floor area	kWh/m^2 /year	25	5	(20%)	1.09 (20.64)	5.00 (2.06)
B2.6	Aggregated annual final electric energy consumption of public office and educational buildings per aggregated internal useful floor area	kWh/m2	25	10	(20%)	-1.00 (28.20)	
*B2.7	Aggregated annual total primary energy consumption per aggregated indoor useful floor area	kWh/m^2 /year	170	100	(20%)	-1.00 (217.64)	0.21 (167)
B2.10	Total electricity consumption of public street lighting divided by the total distance of streets where street lights are present	kWh/Km year	50	20	(20%)	-1.00 (12392)	5.00 (0)
B3	**Renewable energy**				**2 (33%)**	**0.16**	**0.92**
*B3.1	Total consumption of final thermal energy generated from renewable sources on-site divided by total final thermal energy consumption	%	30	100	(14.3%)	-1.00 (29)	0.50 (37)
*B3.4	Total consumption of final electric energy generated from renewable sources on-site divided by total final electric energy consumption	%	30	100	(14.3%)	0.43 (36)	4.29 (90)
B3.5	Total consumption of final electric energy generated from renewable sources on-site divided by total final electric energy consumption of residential buildings	%	30	100	(14.3%)	-1.00 (29)	4.29 (90)
B3.6	Total consumption of final electric energy generated from renewable sources on-site divided by total final electric energy consumption of public offices/educational buildings	%	30	100	(14.3%)	3.5 (79)	
*B3.7	Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption	%	30	100	(14.3%)	-1.00 (1.11)	

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B3.8	Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption of residential buildings	%	30	100	(14.3%)	-1.00 (1.11)	4.29 (90)
B3.9	Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption of public offices/educational buildings	%	30	100	(14.3%)	-1.00 (1.11)	3.5 (79)
C	**Water**				**3 (18%)**	**4.52**	**4.52**
C1	**Water infrastructure**				**3 (50%)**	**2.50**	**2.50**
C1.1	Percentage of the buildings within the neighborhood that are served by a municipal water supply	%	80	100	(50%)	5.00 (100)	
C1.2	Percentage of buildings within the neighborhood that are served by wastewater collection	%	95	100	(50%)	5.00 (100)	
C2	**Water consumption**				**1 (17%)**	**0.36**	**0.36**
C2.1	Total amount of the area's water consumption divided by the total area population	Liters/day/person	500	300	(21.4%)	2.50 (400)	
*C2.3	Annual potable water consumption per occupant	Liters/day/person	250	100	(21.4%)	2.33 (180)	
C2.4	Annual potable water consumption per occupant	Liters/day/person	50	20	(21.4%)	0.00 (50)	
C2.5	Annual potable water consumption per occupant	Liters/day/person	200	100	(21.4%)	1.80 (164)	
C2.7	Potable water used for irrigation purposes in public green spaces	m^3/m^2	5	0	(14.3%)	5.00 (0)	
C3	**Effluents management**				**2 (33%)**	**1.67**	**1.67**
C3.1	Total volume of wastewater collected for at least secondary treatment in centralized wastewater treatment facilities divided by the total volume of wastewater produced in the area	%	90	100	(66.7%)	5.00 (100)	
C3.3	Percentage of households with access to basic sanitation facilities	%	90	100	(33.3%)	5.00 (100)	
D	**Solid Waste**				**3 (18%)**	**3.29**	**3.29**
D1	**Solid waste collection infrastructure**				**2 (67%)**	**3.33**	**3.33**
D1.1	Percentage of buildings with regular solid waste collection	%	75	90	(100%)	5.00 (99)	
D2	**Solid waste management**				**1 (33%)**	**-0.04**	**-0.04**
D2.1	Proximity of the resident population to the solid waste and recycling collection point	%	75	95	(50%)	0.75 (78)	
*D2.2	Percentage of inhabitants with access to solid waste and recycling collection points within 400 meters walking distance	%	75	95	(50%)	-1.00 (22)	
E	**Environmental quality**				**2 (12%)**	**5.00**	**5.00**
E1	**Air quality**				**1 (100%)**	**5.00**	**5.00**

*E1.2	Number of days within a year that PM_{10} concentration exceeds the daily limit	days y	15	11	(100%)	5.00 (1)	
F	**Transportation and mobility**				**1 (6%)**	**-1.00**	**-1.00**
F1	**Performance of mobility service**				**1 (50%)**	**-0.50**	**-0.50**
*F1.1	Percentage of inhabitants that are within 400 meters walking distance of at least one public transportation service stop	%	30	70	(100%)	-1.00 (0)	
F2	**Green mobility**				**1 (50%)**	**-0.50**	**-0.50**
*F2.3	Aggregate length of bicycle paths in the city per inhabitant	m/inhabitant	5	40	(100%)	-1.00 (1)	
G	**Social Aspects**				**1 (6%)**	**3.00**	**3.00**
G3	**Availability of public and private facilities and services**				**1 (100%)**	**3.00**	**3.00**
*G3.1	Percentage of inhabitants that are within 800 meters walking distance of at least 3 key services	%	50	100	(100%)	3.00 (80)	
I	**CLIMATE CHANGE: mitigation and adaptation**				**1 (6%)**	**-0.08**	**0.56**
I1	**Climate change mitigation**				**3 (75%)**	**-0.75**	**-0.11**
*I1.1	Total amount of greenhouse gases in tonnes (equivalent carbon dioxide units) generated over a calendar year divided by the current neighborhood population	Tons CO_2 eq. / inhabitant	2	1	(50%)	-1.00 (2.49)	0.70 (1.86)
I1.2	Total amount of greenhouse gases in Kg (equivalent carbon dioxide units) generated over a calendar year per aggregated indoor useful floor area	$kgCO_2$ eq $/m^2$	120	30	(50%)	-1.00 (197)	
I3	**Adaptation to the climatic action: pluvial flood**				**1 (25%)**	**0.67**	**0.67**
*I3.3	Share of the urban area that is permeable to water	%	20	100	(100%)	2.69 (63)	

* identifies the KPIs

The **existing condition** of the **neighborhood** considered in this pilot reached a **sustainability score of 2.60** and it can be considered as a good sustainable area. The proposed retrofit actions were affecting only two Issues; Energy (B) and Climate Change (I). The sustainability score of the assessed scenario reaches 3.11, increased by 20%. The sustainability score of the tested area for the existing condition and for Scenario 1 is presented in Figure 18.

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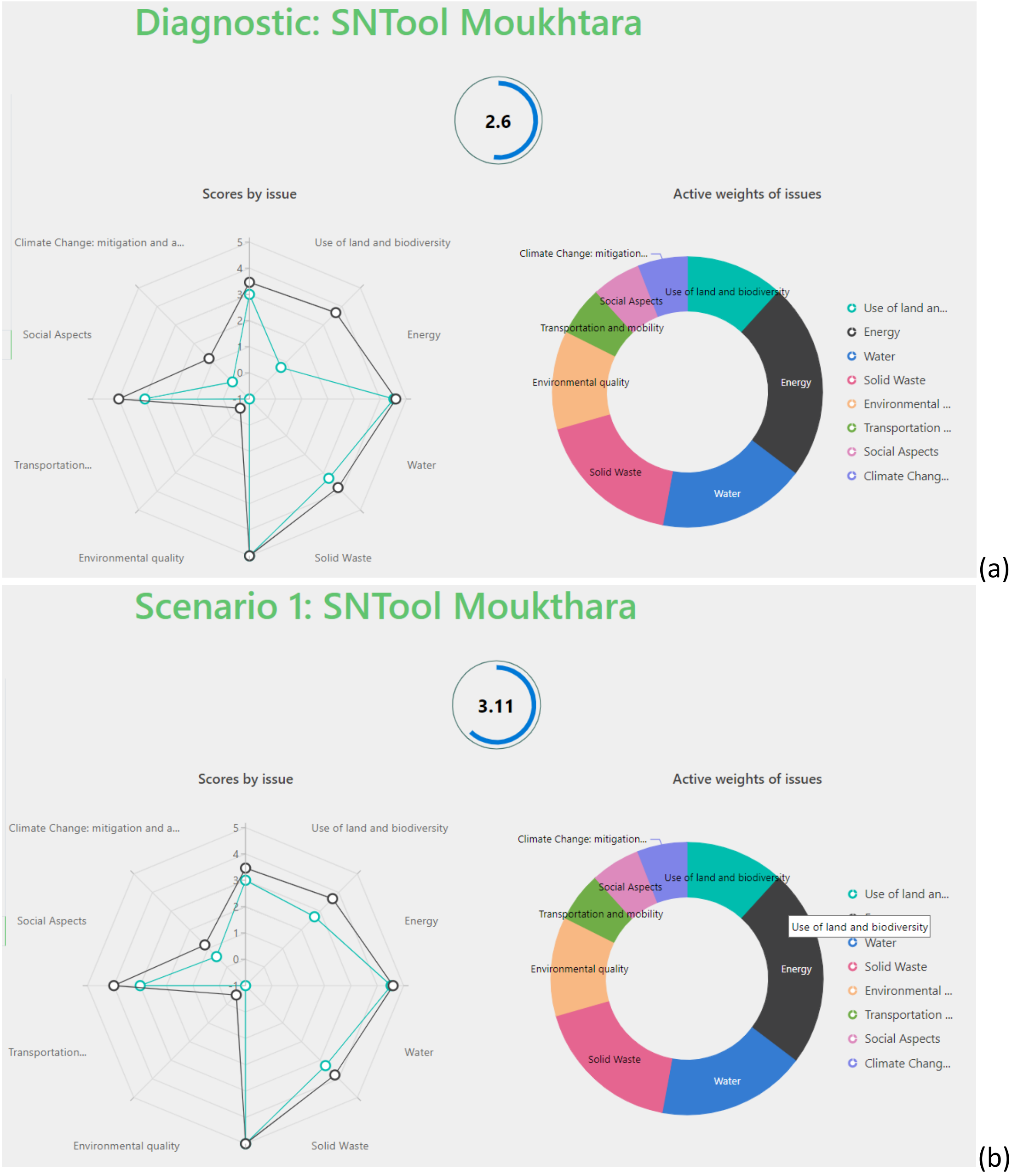

Figure 18. Sustainability score for the existing condition (a) and Scenario1 (b).

Since only one scenario was assessed, the **selected scenario was by default Scenario1**, in which **2 Issues have improved** sustainability scores, as illustrated in Figure 19.

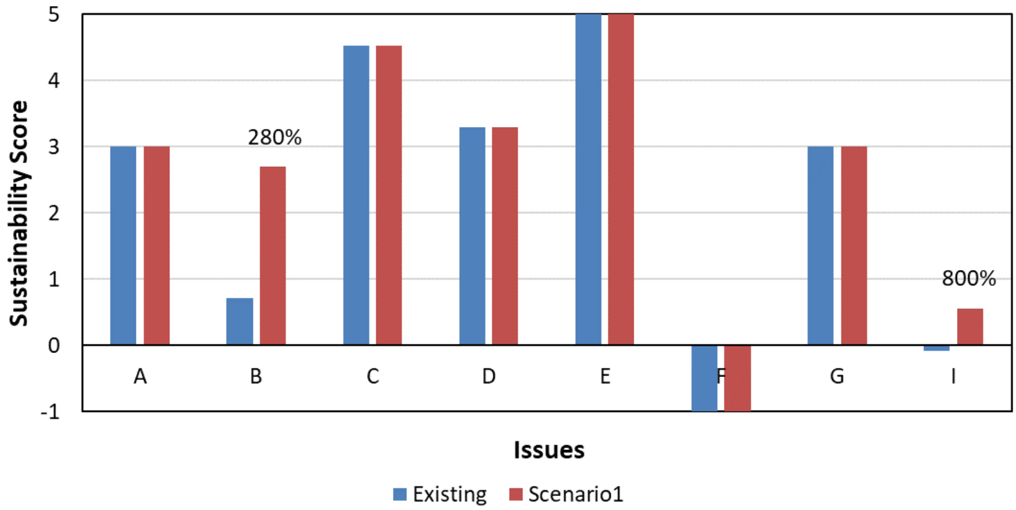

Figure 19. Issues sustainability scores of the tested area in the existing condition and in Scenario 1.

3.4. Neighborhood in Sousse

Name of the urban area	*Sahloul 3*
Brief Description	
Surface area	*0.6 km^2*
Building density	*6.2 m^3/m^2*
Total land area occupied by buildings, streets, parking and parkland in the local area	*0.42 (km^2*
Total land surface area used for residential purposes	*0.17 km^2*
Aggregate gross area of housing units	*0.34 m^2*
Aggregate gross area of office buildings	*10000 m^2*
Aggregate gross area of retail commercial buildings	*68000 m^2*
Aggregate gross area of public buildings	*700 m^2*

Data sources used to collect all the necessary information for the assessment included:

- Neighborhood tour
- Municipality of Sousse
- Local Urban Plan (PLU) of the city of Sousse

- ➢ Sousse governorate
- ➢ Regional Directorates of Public Departments and Agencies
- ➢ Online GEO Tools (Google Earth, Geoportal of the city of Sousse, Aerial photo (Ministry of Equipment), Atlas of neighborhoods (http://pduisousse.tn/documents/), Geographic Information System – Qgis)
- ➢ Tunisian Electricity and Gas Corporation (STEG)
- ➢ National Services (Société Nationale d'Exploitation et de Distribution des Eaux (SONEDE), National Institute of Statistics (INS), National Office for Sanitation (ONAS), National Waste Management Agency (ANGED), National Agency for Environmental Protection (ANPE), National Observatory for Road Safety Information, Training, Documentation and Studies).

Nine Issues are included in the SNTool-Sousse. Among them, Category B includes the highest number of active indicators, while Categories D and E have the lowest (Figure 20).

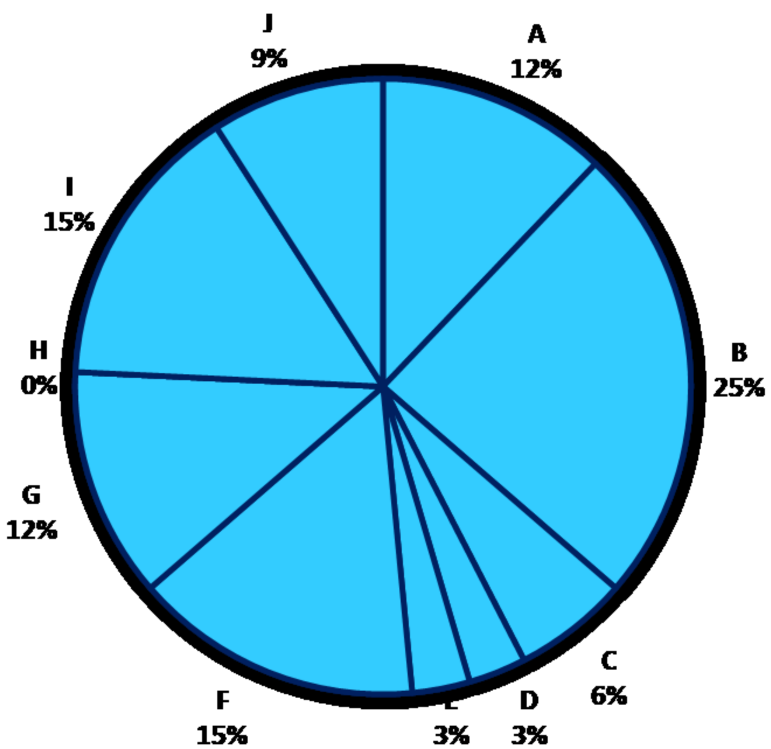

Figure 20. Distribution of active Indicators in SNTool-Sousse.

From the 43 Categories in the Generic Framework SNTool, 20 are inactive in the national SNTool. Issues of Use of land and biodiversity (A), Energy (B), Water (C), Solid Waste (D) and Climate Change: mitigation and adaptation (I) have been assigned the priority 4, while all others have priority 3. (Figure 21).

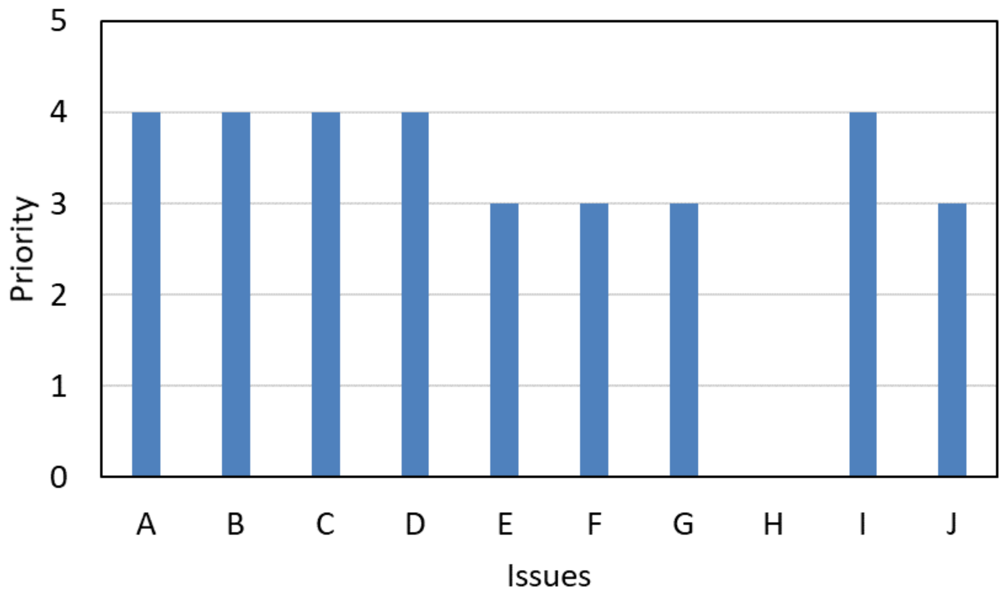

Figure 21. Priority of active Issues in SNTool-Sousse (1: minor, 5: major).

In the SNTool-Sousse the majority of Indicators (85%) have the same benchmarks with the Generic Framework SNTool. Four Indicators have lighter benchmarks, while only one Indicator has stricter limits. The majority of Indicators (49%) have assessment scores below minimum acceptable performance (0), while 27% of the Indicators have assessment scores above 4, as shown in Figure 22.

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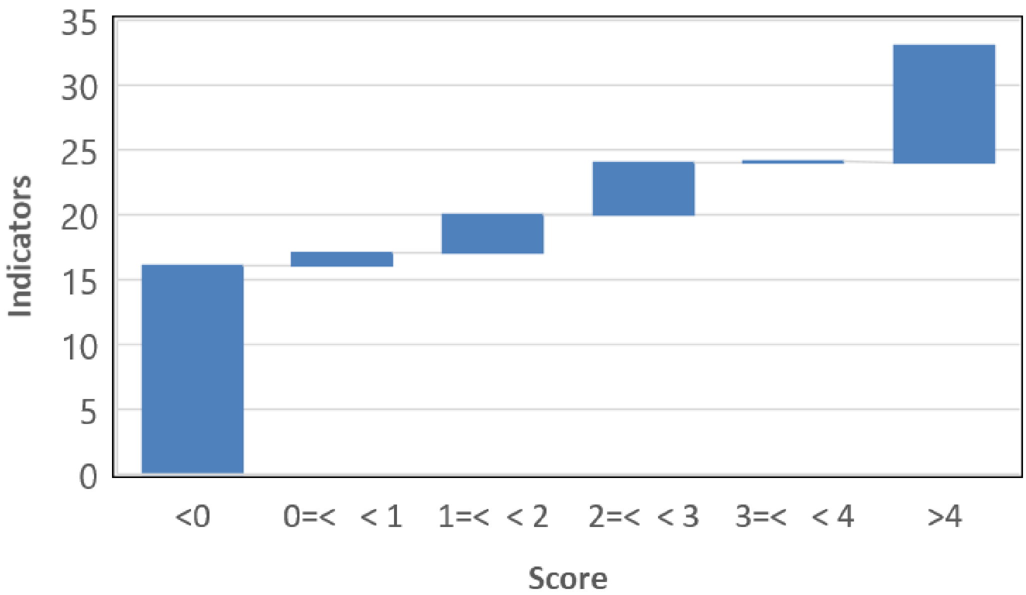

Figure 22. Distribution of Indicators in the 6 different score levels in SNTool-Sousse.

The details of the active Indicators, the benchmarks, the priorities and weighting factors, as well as the scores and actual values for the existing condition and the proposed scenario are presented in Table 8.

Table 8. Assessment of existing condition of Sahloul 3 (SNTool-Sousse), in existing condition and in the two scenarios (S-1 and S-2). For the scenario, only the modified Indicators are presented, the other remain the same with the existing condition. Underlined values indicate that the benchmark is identical to the Generic Framework SNTool.

Code	Indicator	Units	Benchmark (0)	Benchmark (5)	Priority (weight)	Score (Value)		
						Existing	Scen 1	Scen 2
					Urban Area	0.85	1.55	1.53
A	**Use of land and biodiversity**				**4 (13%)**	**0.40**	**0.27**	**0.27**
A1	**Use of land**				**4 (40%)**	**0.50**	**0.50**	**0.50**
A1.1	Population density in built-up areas (neighborhood area minus green and blue)	Inhabitants per km²	60000	200000	(100%)	1.25 (95000)		
A2	**Green urban areas**				**4 (40%)**	**-0.10**	**-0.23**	**-0.23**
A2.1	Proportion of all vegetated areas within the neighborhood boundaries in relation to the total area	%	<u>30</u>	<u>40</u>	(33.3%)	-1.00 (5.66)	-1.00 (6.91)	-1.00 (6.91)
A2.2	Total area of green in the city divided by neigborhood's total population	m^2/inhabitant	<u>5</u>	<u>50</u>	(33.3%)	0.27 (7.42)		

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A2.4	Density of green spaces within the area	%	15	25	(33.3%)	-1.00 (7.45)	-1.00 (10.7)	-1.00 (9.52)
B	**Energy**				**4 (13%)**	**1.85**	**2.90**	**2.49**
B1	**Energy infrastructure**				**3 (27%)**	**1.36**	**1.36**	**1.36**
B1.1	Percentage of households with authorized access to electricity	%	89	100	(100%)	5.00 (100)		
B2	**Energy consumptions**				**4 (36%)**	**0.85**	**0.97**	**1.20**
*B2.1	Aggregated annual total final thermal energy consumption per aggregated indoor useful floor area	kWh/m²/year	100	30	(25%)	5.00 (19.42)		
*B2.4	Aggregated annual total final electric energy consumption per aggregated internal useful floor area	kWh/m²/year	25	5	(25%)	2.79 (13.87)		
*B2.7	Aggregated annual total primary energy consumption per aggregated indoor useful floor area	kWh/m²/year	300	80	(25%)	-1.00 (53.24)	0.29 (48)	2.90 (30)
B2.10	Total electricity consumption of public street lighting divided by the total distance of streets where street lights are present	kWh/Km year	15000	8000	(25%)	2.60 (11424)		
B3	**Renewable energy**				**4 (36%)**	**-0.36**	**0.57**	**-0.07**
*B3.1	Total consumption of final thermal energy generated from renewable sources on-site divided by total final thermal energy consumption	%	30	100	(33.3%)	-1.00 (4.3)	0.71 (40)	-1.00 (20)
*B3.4	Total consumption of final electric energy generated from renewable sources on-site divided by total final electric energy consumption	%	30	100	(33.3%)	-1.00 (6.9)	5.00 (100)	1.43 (50)
*B3.7	Total consumption of primary energy generated from renewable sources on-site divided by total primary energy consumption	%	30	100	(33.3%)	-1.00 (0)	-1.00 (1)	-1.00 (1)
C	**Water**				**4 (13%)**	**2.20**	**3.20**	**2.99**
C1	**Water infrastructure**				**4 (36%)**	**1.82**	**1.82**	**1.82**
C1.2	Percentage of buildings within the neighborhood that are served by wastewater collection	%	95	100	(100%)	5.00 (100)		
C2	**Water consumption**				**4 (36%)**	**0.38**	**1.38**	**1.17**
C2.3 *	Annual potable water consumption per occupant	Liters/day/person	250	60	(100%)	2.11 (169.84)	3.79 (106)	3.21 (128)
D	**Solid Waste**				**4 (13%)**	**-0.50**	**2.15**	**2.15**
D2	**Solid waste management**				**3 (50%)**	**-0.50**	**2.15**	**2.15**

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*D2.2	Percentage of inhabitants with access to solid waste and recycling collection points within 400 meters walking distance	%	75	95	(100%)	-1.00 (0)	4.30 (92.21)	4.30 (92.21)
E	**Environmental quality**				**3 (9%)**	**-0.27**	**-0.27**	**-0.27**
E1	**Air quality**				**3 (27%)**	**-0.27**	**-0.27**	**-0.27**
*E1.2	Number of days within a year that PM_{10} concentration exceeds the daily limit	days / y	15	11	(100%)	-1.00 (42)	-1.00 (21)	-1.00 (21)
F	**Transportation and mobility**				**3 (9%)**	**2.27**	**2.45**	**2.45**
F1	**Performance of mobility service**				**2 (18%)**	**0.91**	**0.91**	**0.91**
*F1.1	Percentage of inhabitants that are within 400 meters walking distance of at least one public transportation service stop	%	30	70	(100%)	5.00 (80)		
F2	**Green mobility**				**3 (27%)**	**-0.27**	**-0.27**	**-0.27**
*F2.3	Aggregate length of bicycle paths in the city per inhabitant	m/inhabitant	5	40	(100%)	-1.00 (0.02)	-1.00 (1)	-1.00 (1)
F3	**Safety in mobility**				**4 (36%)**	**0.73**	**0.91**	**0.91**
F3.1	Percentage of the city designated as a pedestrian/car free zone	%	10	25	(50%)	-1.00 (2.9)	0.00 (10)	0.00 (10)
F3.2	Percentage of roads' length that has dedicated sidewalks	%	80	100	(50%)	5.00 (100)		
F4	**Urban morphology and transportation**				**2 (18%)**	**0.91**	**0.91**	**0.91**
F4.2	Number of intersections related to the overall surface area	number/km^2	70	200	(100%)	5.00 (206)		
G	**Social Aspects**				**3 (9%)**	**0.59**	**0.76**	**0.83**
G1	**Accessibility (disabled persons)**				**3 (13%)**	**0.07**	**0.23**	**0.31**
G1.1	Percent of key public buildings that are accessible for use by physically disabled persons	%	50	90	(50%)	2.00 (66)	4.60 (86.8)	4.60 (86.8)
G1.2	Percent of sidewalks and other pedestrian ways that are accessible for use by physically disabled persons	%	50	100	(50%)	-1.00 (0)	-1.00 (27)	0.10 (51)
G2	**Housing**				**3 (13%)**	**0.65**	**0.65**	**0.65**
G2.4	Percentage of inhabitants living in slums, informal settlements or inadequate housing	%	5	0	(100%)	5.00 (0)		
G3	**Availability of public and private facilities and services**				**3 (13%)**	**-0.13**	**-0.13**	**-0.13**
*G3.1	Percentage of inhabitants that are within 800 meters walking distance of at least 3 key services	%	50	100	(100%)	-1.00 (25)		
I	**CLIMATE CHANGE: mitigation and adaptation**				**4 (13%)**	**0.92**	**0.92**	**1.11**
I1	**Climate change mitigation**				**3 (19%)**	**0.94**	**0.94**	**0.94**
*I1.1	Total amount of greenhouse gases in tonnes (equivalent	Tons CO_2 eq. inhabitant	5	2	(50%)	5.00 (1.06)		

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	carbon dioxide units) generated over a calendar year divided by the current neighborhood population							
I1.2	Total amount of greenhouse gases in Kg (equivalent carbon dioxide units) generated over a calendar year per aggregated indoor useful floor area	$kgCO_2$ eq m^2	120	30	(50%)	5.00 (8.07)		
I2	**Adaptation to the climatic action: heatwaves and increase of temperature**				**3 (19%)**	**-0.19**	**-0.19**	**-0.19**
I2.2	Leaf Area Index: ratio of total vegetated surface area (on ground and on roofs, and including trees), divided by total site area	number	20	50	(100%)	-1.00 (9.06)	-1.00 (18)	-1.00 (18)
I3	**Adaptation to the climatic action: pluvial flood**				**3 (19%)**	**-0.19**	**-0.19**	**0.00**
*I3.3	Share of the urban area that is permeable to water	%	20	100	(100%)	-1.00 (7.86)	-1.00 (10)	0.00 (20)
I4	**Adaptation to climate action: river and coastal flooding**				**3 (19%)**	**0.36**	**0.36**	**0.36**
I4.1	Share of buildings located in vulnerable to flooding areas	%	10	5	(100%)	1.92 (8.08)		
J	**GOVERNANCE**				**3 (9%)**	**0.00**	**0.96**	**1.34**
J1	**Urban Planning**				**3 (38%)**	**0.38**	**0.75**	**1.13**
J1.1	Community Involvement in Urban Planning Activities		0	5	(100%)	1.00 (1)	3.00 (3)	3.00 (3)
J3	**Public buildings operation**				**3 (38%)**	**-0.38**	**0.21**	**0.21**
J3.1	Percentage area of public buildings with recognized sustainability certifications for ongoing operations	%	20	100	(54.5%)	-1.00 (0)	1.88 (50)	1.88 (50)
J3.3	Total end use of energy in public buildings within a city divided by total indoor useful area of these buildings	kWh/m^2	25	10	(45.5%)	-1.00 (102.34)	-1.00 (80)	-1.00 (80)

* identifies the KPIs

The **existing condition** of the **neighborhood** considered in this pilot reached a **sustainability score of 0.85** and it can be considered as above the minimum requirements that can be improved. The proposed retrofit actions in both Scenarios, were affecting all nine active Issues. Scenario 1 and Scenario2 are affecting the same 18 out of the 33 Indicators. The two scenarios differ in seven Indicators, namely A2.4, B2.7, B3.1, B3.4, C2.3, G1.2 and I3.3. The sustainability score in Scenario 1 (1.55) is slightly improved with regard to Scenario 2 (1.53). The results for the sustainability assessment of SAHLOUL 3 in the existing condition and under the two scenarios are presented in Figure 23. The sustainability score of the tested area increases by 82% in Scenario 1 and by 80% in Scenario 2.

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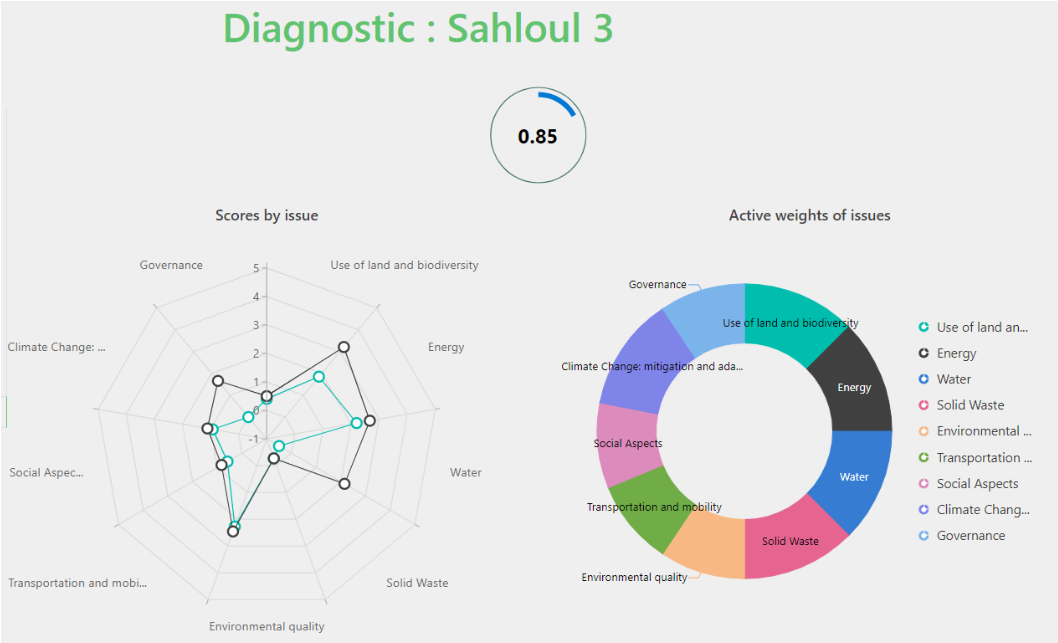
Diagnostic : Sahloul 3
0.85
Scores by issue
Governance
Use of land and biodiversity
Climate Change: ...
Energy
Social Aspec...
Water
Transportation and mobi...
Solid Waste
Environmental quality
Active weights of issues
Governance
Use of land and biodiversity
Climate Change: mitigation and ada...
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Social Aspects
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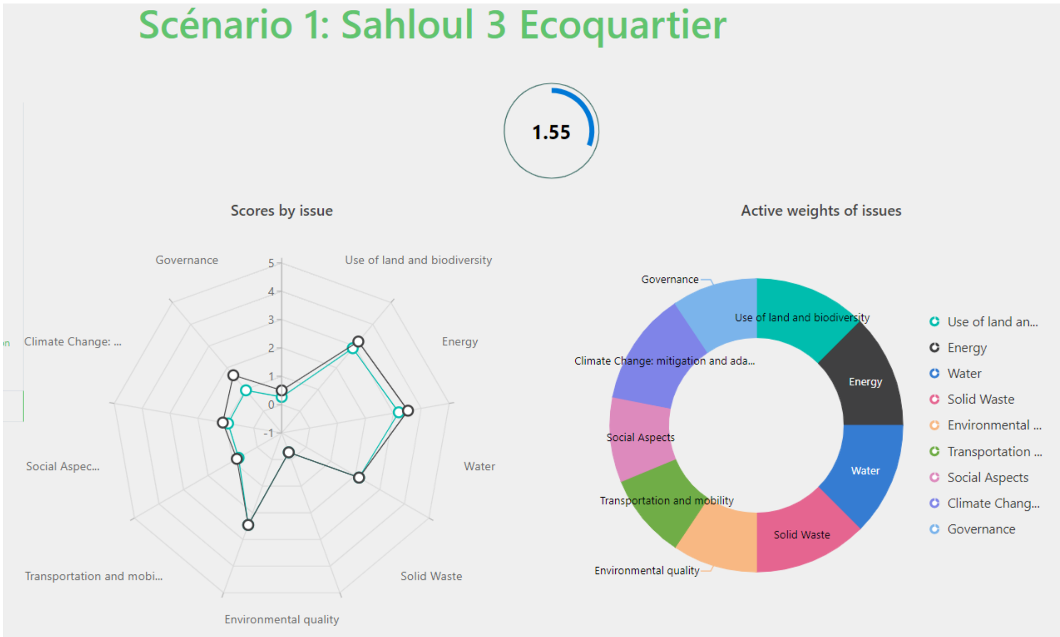
Scénario 1: Sahloul 3 Ecoquartier
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Transportation and mobi...
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Governance
Use of land and biodiversity
Climate Change: mitigation and ada...
Energy
Social Aspects
Water
Transportation and mobility
Solid Waste
Environmental quality
Use of land an...
Energy
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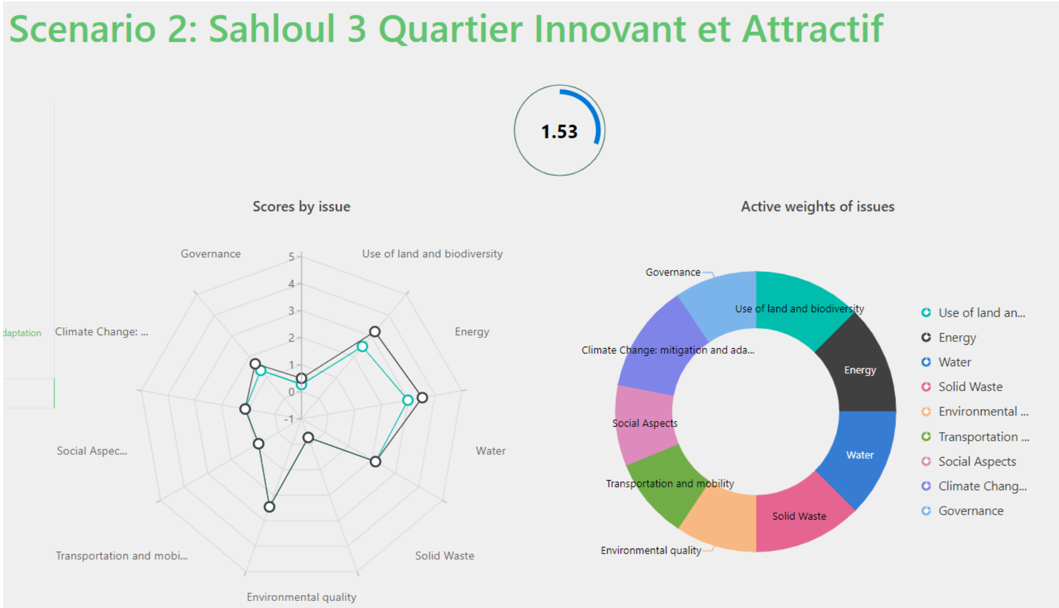
Solid Waste
Environmental ...
Transportation ...
Social Aspects
Climate Chang...
Governance
(b)



(c)

Figure 23. Sustainability score for the existing condition (a), Scenario1 (b) and Scenario2 (c).

Although the **differences are small**, the **selected scenario was Scenario 1**, in which **seven out of nine Issues have improved** sustainability scores, as illustrated in Figure 24.

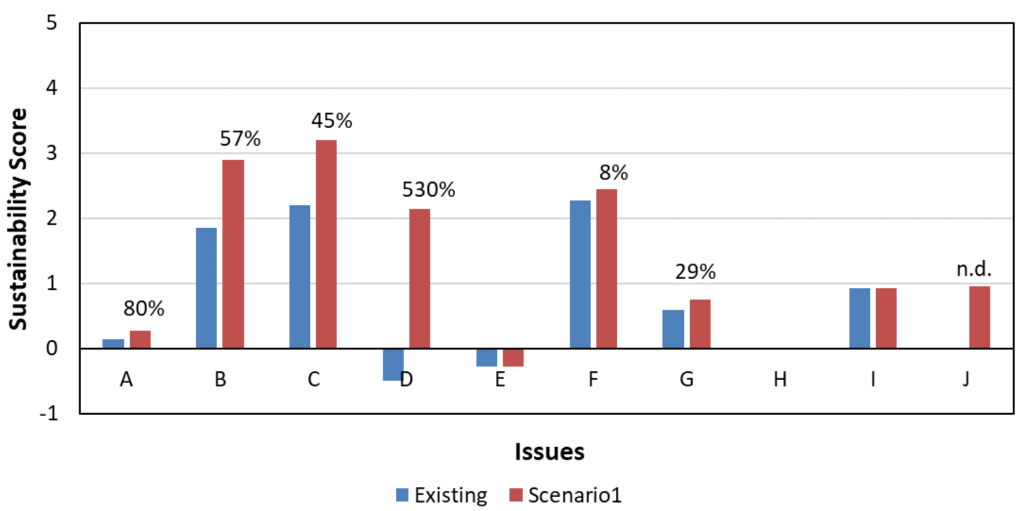


Figure 24. Issues sustainability scores of the tested area in the existing condition and in Scenario 1. The percentage of improvement in Issue J is not defined (n.d.), since the initial score was 0.

4. Pilot Studies: Buildings

The three participating municipalities should select two buildings area in order to test the SMC methodology and the national SMC-SBTool. However, the municipality of Sousse assessed only one building, deviating from the testing methodology. The main characteristics of the audited buildings are summarized in Table 9.

According to the SMC decision-making methodology at least two scenarios should be assessed for each pilot in order to be able to follow the proposed methodology rating the proposed scenarios and selecting one. However, the Municipality of Moukhtara elaborated only one scenario for the Municipality building. For the school building no scenario was assessed, since it was a recently renovated building. In addition, the Municipality of Sousse assessed only one building. As a result, there was no ranking of the scenarios and, therefore, the SMC methodology was not properly implemented in its entirety and the selection of the final retrofit scenario was biased.

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Table 9. Overview of the buildings assessed in the three pilots in Irbid, Moukhtara and Sousse.

	Irbid, Jordan		**Moukhtara, Lebanon**		**Sousse, Tunisia**
	Irbid Chamber of Commerce	*Residential Building*	*Moukhtara Municipality*	*Moukhtara Public school*	*Arrondissement Sahloul*
					
Actual building use	*Public building*	*Multi family building*	*Municipality- Public services*	*Public school*	*Public building*
Occupants	*1000 visitors + 60 Workers*	*9 households*	15	*550(students and staff)*	*20*
Construction year	1998	*2010*	1999	*1960*	*2022*
Envelope	*Concrete structure*	*Stone and Concrete structure*	A hybrid construction entity (old design- new construction). Lebanese traditional building with stone construction (Iwan Building) with concrete columns, stone cladding and brick roof.	*Old construction entity. Concrete slab-column construction with concrete blocks and mainly exterior glass skin*	Reinforced concrete structure, double hollow brick exterior walls. Interior partitions are made of plaster bricks. Single-glazed aluminium joinery.
HVAC systems	*Inverter AC heating system, Cooling with Fans, Inverter AC units, and Free air diffuser DHW with Electrical boilers and Instant electric heating water faucet and shower*		*Central Heat Pumps for heating and cooling. Electrical Boiler System for DHW. Natural ventilation (windows). Electrical Generator – Governmental electricity for lighting*	*Central Heat Pumps for heating. No cooling. Electrical Boiler System for DHW. Natural ventilation (windows).*	*Natural gas central heating Split system air conditioners No DHW. Natural ventilation Lampes LED*

	Natural ventilation LED+ Fluorescent tube+ Halogen lamp			*Electrical Generator – Governmental electricity for lighting*	
Scenario 1 (S-1)	***Active Retrofit*** *Improve energy efficiency and energy consumptions on most levels, including changing active mechanical and lighting systems and control devices and updating energy consuming appliances, in addition to introducing some renewable systems that could contribute to lowering energy consumption and increase the building's adaptation to climate change*	***Active Retrofit*** *Improve energy efficiency and energy consumptions on most levels, including changing active mechanical and lighting systems and control devices and updating energy consuming appliances, in addition to introducing some renewable systems that could contribute to lowering energy consumption and increase the building's adaptation to climate change*	***Moukhtara Municipality Greener (MMG)*** *Provide access to clean electricity and heated water to the municipality and club buildings. Install PV solar panels with storage batteries, solar water heaters, replace the electrical devices to class A.*	*N/A*	***Integration of green technologies*** *The scenario foresees interventions to replace different energy-intensive equipment, mainly air conditioning, heat generation, lighting, with others with better energy performance. The integration of renewable energy will reduce the building's carbon footprint. Other actions related to water consumption and air quality will lead to a more sustainable building*
Scenario 2 (S-2)	**Passive Retrofit** The application of passive systems to improve energy efficiency and energy consumptions on most levels, including changing glazing systems, addition of	**Passive Retrofit** The application of passive systems to improve energy efficiency and energy consumptions on most levels, including	*N/A*	*N/A*	***Eco-responsible renovation*** *Interventions on the building envelope mainly insulation of walls and roofs, adequate carpentry for exterior openings, increase of green spaces,*

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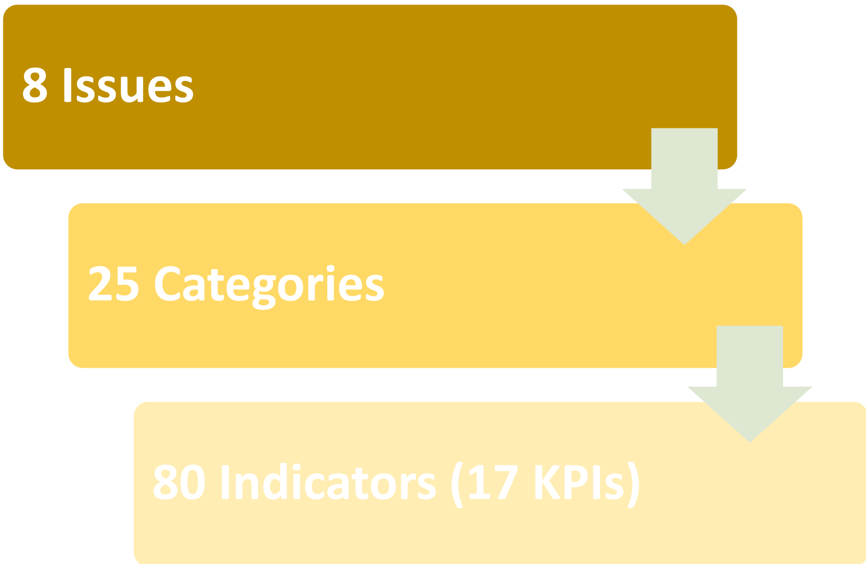
	insulation to avoid thermal bridges, and introducing shading devices. , in addition to introducing some changes in the exposed surface materials that could contribute to lowering energy consumption and increase the building's adaptation to climate change.	changing glazing systems, addition of insulation to avoid thermal bridges, and introducing shading devices. In addition to introducing some changes in the exposed surface materials that could contribute to lowering energy consumption and increase the building's adaptation to climate change.			*use of renewable energies, adoption of intelligent building management, replacement of equipment made of recyclable materials and with low incorporated energy.*
Selected Scenario	*Active Retrofit (S-1)*	*Passive Retrofit (S-2)*	*Moukhtara Municipality Greener (MMG) (S-1)*	*N/A*	*Integration of green technologies (S-1)*
Justification of Selection	*The application of active systems to improve energy efficiency and energy consumptions on most levels, and increase the building's adaptation to climate change*	*The application of passive systems to improve energy efficiency and energy consumptions on most levels, and increase the building's adaptation to climate change.*	*Only one scenario assessed*	*N/A*	*Scenario chosen at the 5th LPC meeting by unanimous vote of the partners present*

4.1. SMC SBTool (Building Scale)

The Generic Framework SBTool is organized as follows:



Issues

The **number of active Issues** in the three national SBTools were:

- Eight (8) Issues for SBTool-Irbid,
- Seven (7) Issues SBTool-Moukhtara, and
- Eight (8) Issues SBTool-Sousse.

The Issue Site Regeneration and Development (A) was not active in SBTool-Moukhtara.

The **Issue of Energy (B) is of the highest priority among the three national tools** (Figure 25). This is in line with the corresponding national SNTools, which is expected since prioritization of Issues depends on the local policies and not on the assessment scale.

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SBTOOL	IRBID	MOUKHTARA	SOUSSE
1		H	
2		D, E, F	
3	C, E, H	C, G	E
4	A, D, F, G	B	D, F
5	B		A, B, C, G, H

Figure 25. Priorities of active Issues for SBTool-Irbid, SBTool-Moukhtara and SBTool-Sousse (1: low, 5: high).

Categories

The **number of active Categories** that were assessed range between 56% - 72% with regard to the total number of Categories in the Generic Framework SBTool, with the SBTool-Moukhtara having the lowest number and the SBTool-Irbid the highest number. In total, **five (5) Categories from the Generic Framework were not selected** and not assessed in any of the three pilots, including:

- Other Atmospheric Emissions (C2)
- Electromagnetic pollution (D5)
- Climatic action: fluvial and coastal flood (H3)
- Climatic action: fire exposure (H5)
- Climatic action: wind action (H6)

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Indicators

The **three national tools include about 40% of the indicators of the Generic Framework** SBTool, with SBTool-Moukhtara having the least and SBTool-Irbid the most, while the distribution of active indicators per Issue in the three SBTools are illustrated in Figure 26.

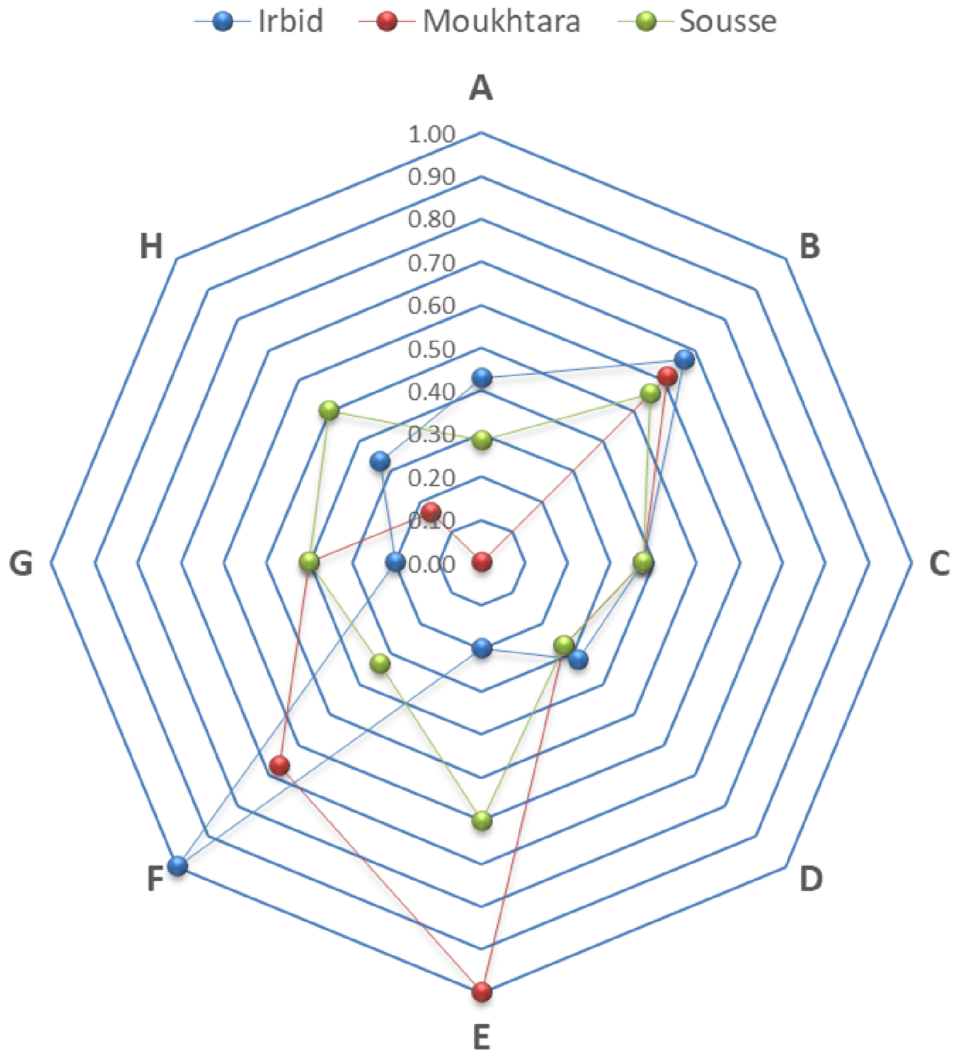

Figure 26. Ratio of active Indicators per Issue with regard to the Generic Framework SBTool in the three national SBTools.

The **total number of active Indicators** for the three national SBTools are illustrated in Figure 27. In the Generic Framework SBTool, Issue D (Indoor Environmental Quality) has the most indicators and Issue F (Social, Cultural and Perceptual Aspects) the least. However, in the three SBTools the Issue with the most active Indicators is B (Energy).

The Issues with the least active Indicators are E (Service Quality) and G (Cost and Economic Aspects) in SBTool-Irbid, F (Social, Cultural and Perceptual Aspects), G (Cost and Economic Aspects) and H (Adaptation to Climate Change) in SNTool-Moukhtara and F (Social, Cultural and Perceptual Aspects) in SBTool-Sousse. The three national SBTools are summarized in Table 10.

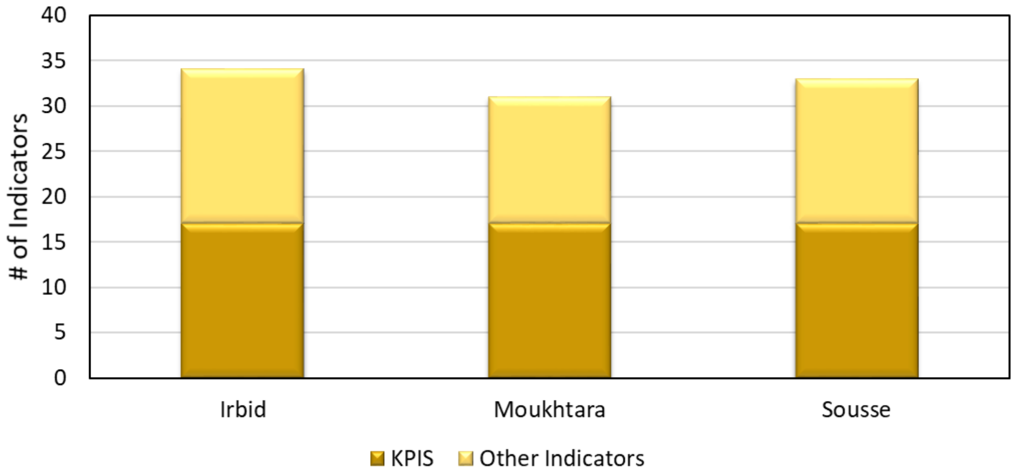

Figure 27a. Total number of active Indicators in the three national SBTools.

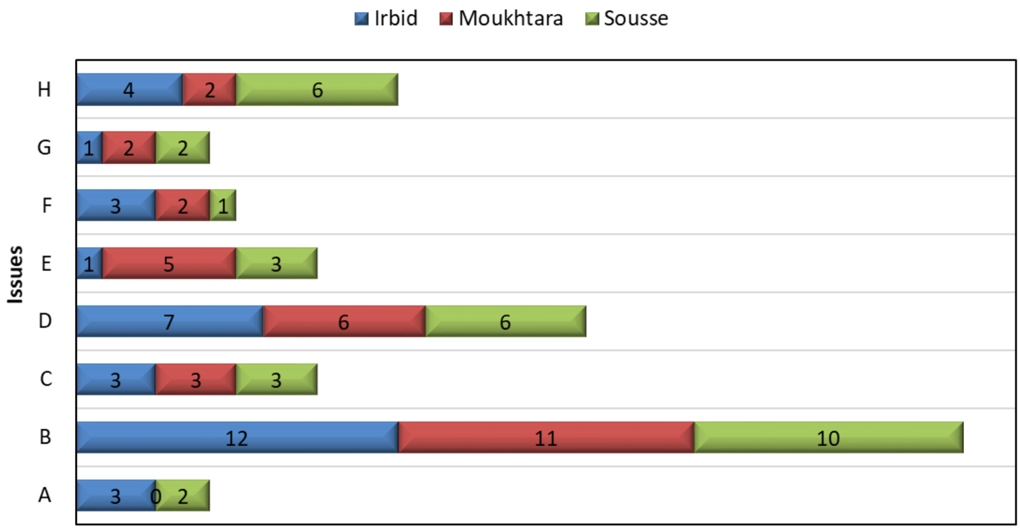

Figure 27b. Number of active Indicators per Issue in the three national SNTools.

Table 10. The three national SBTools in numbers.

	Issues	Categories	Indicators
SBTool-Irbid	8	18	34
SBTool-Moukhtara	7	14	31
SBTool-Sousse	8	17	33

A **total of nineteen Indicators are common in the three national SBTools**, including the KPIs. The common Indicators per Issue in the three national tools are illustrated in Figure 28. Beyond the seventeen KPIs, a total of **two Indicators were selected by all three pilots**, which reveals their popularity. These Indicators are assigned to two Issues, namely:

- **B4.4** Potable water consumption / standardised potable water consumption,
- **F1.1** The scope and quality of design measures planned to facilitate access and use of building facilities by persons with disabilities.

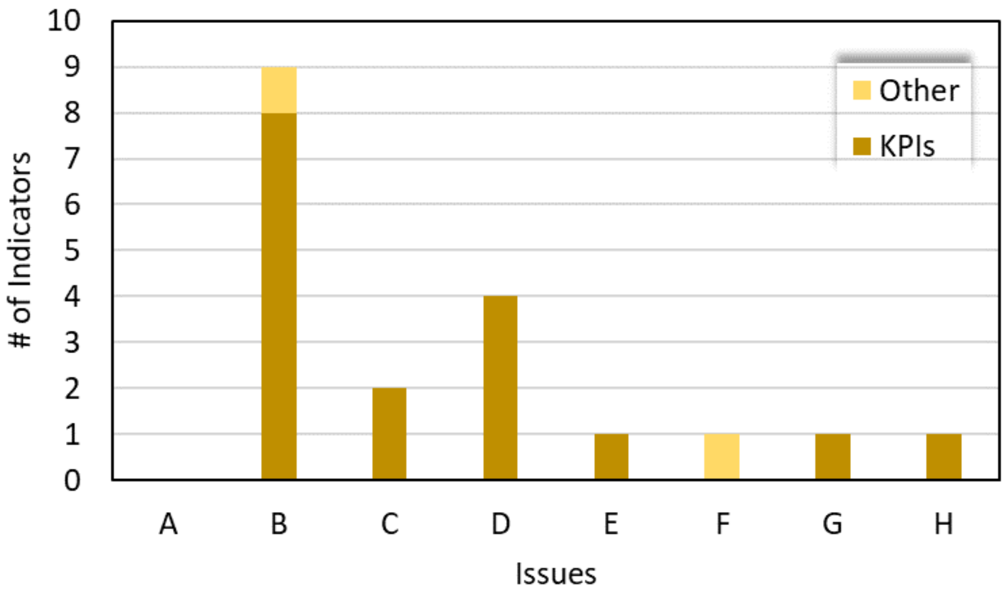

Figure 28. Common Indicators in the three national SBTools.

The Generic Framework SBTool included indicative **benchmarks** for all indicators. According to the SMC method, each national tool could either retain these benchmarks or adapt them on the basis of the local sustainability priorities and strategic policies. For the building scale, the **type of building plays a significant role in the definition of benchmarks**. For the assessed **public buildings**, the differentiation of the benchmarking of the three national tools compared to the Generic Framework SBTool is almost the same, namely the SBTool-Irbid had the most modified benchmarks (29%), followed by SBTool-Sousse (27%) and SBTool-Moukhtara (26%). For the **residential building** 27% of the active Indicators had different benchmarks (SBTool-Irbid), while for the **school building** the benchmarks are identical to the Generic Framework SBTool (SBTool-Moukhtara).

Only **two Indicators have benchmarks that differentiate significantly** from the Generic Framework SBTool:

- **B1.6**. Embodied non-renewable primary energy per useful internal floor area,
- **C1.1.** Embodied carbon.

The benchmarks for the common Indicators in the three national SBTools, are summarized in Table 11. For the SBTool-Irbid, all common Indicators have the same benchmarks compared to the Generic Framework SNTool. For the SBTool-Moukhtara, seven of the common Indicators have different benchmarks for the public building, three with more relaxed (lower) limits and four with more strict, while there is no differentiation of the benchmarks for the school building. Finally, in the SNTool-Sousse, four of the common Indicators differentiated in the benchmarks, two with lower (less strict) and two with higher (more strict) limits. As noted before, the benchmarks influence the score of each Indicator; a lower benchmark value will result to a higher score for the same value of an indicator.

Table 11. Benchmarks for the common Indicators in the three national SBTools. Underlined values indicate identical benchmark to the Generic Framework SBTool.

Indicators		Benchmarks		
		Irbid	Moukhtara	Sousse
*B.1.1. Primary energy demand per internal useful floor area per year (kWh/m²/yr)	0:	155	155	155
	5:	80	50 (municipality) 80 (school)	80
*B.1.2. Delivered thermal energy demand per internal useful floor area per year (kWh/m²/yr)	0:	30	30	312
	5:	15	15	200
*B.1.3. Delivered electric energy demand per internal useful floor area per year (kWh/m²/yr)	0:	120	60 (municipality) 120 (school)	100
	5:	90	5 (municipality) 90 (school)	65
	0:	20	20	20

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*B.1.4. Share of renewable energy in final thermal energy consumptions (%)	5:			
*B.1.5. Share of renewable energy in final electric energy consumption (%)	0: 5:	100	100	100
*B.1.6. Embodied non-renewable primary energy per useful internal floor area (MJ/m²/yr)	0:	432	2500 (municipality) 432 (school)	432
	5:	400	2000 (municipality) 400 (school)	400
*B.3.4. Weight of recycled materials on total weight of materials (%)	0:	15	15	15
	5:	50	50	50
*B.4.3. Potable water consumption per occupant (m³/occupant/year)	0:	100	50 (municipality) 100 (school)	100
	5:	30	10 (municipality) 30 (school)	30
B.4.4. Potable water consumption / standardised potable water consumption	0:	80	50 (municipality) 80 (school)	20
	5:	0	0 (municipality) 0 (school)	0
*C.1.1. kg CO2 equivalents per useful internal floor area (product stage) (Kg CO²eq/m²)	0:	3.1	500 (municipality) 3.1 (school)	3.1
	5:	2.2	700 (municipality) 2.2 (school)	2.2
*C.1.2. kg CO2 equivalents per useful internal floor area per year (Kg CO²eq/m²/ year)	0:	54	54	54
	5:	28	28	28
*D.1.2. TVOC concentration in indoor air (µg/ m³)	0:	0.5	0.5	0.5
	5:	0.1	0.1	0.1
*D.1.7. Mechanical ventilation rate per useful internal floor area (L/s/m²)	0:	0.6	0.6	0.6
	5:	1.2	1.2	1.2
*D.2.3. Predicted Percentage of Dissatisfied (%)	0:	20	20	20
		10	10	10
*D.3.1. Mean Daylight Factor (%)	5:	2	2	2
	0:	4	4	4
*E.1.2. Rate the total smart readiness of buildings in terms of three key functionalities, i.e. responding to the needs of occupants, optimizing energy performance, interacting with energy grids (%)	5:	40	40	40
	0:	100	100	100
F.1.1. Scope and quality of design measures planned to facilitate access and use of building facilities by persons with disabilities	5:	0	0	0
	0:	5	5	5
*G.1.4. Energy annual cost per useful internal floor area (€/m²/yr)	5:	20	20	70
	0:	5	5	20
*H.1.2. Mean Solar Reflectance Index of paved surfaces and roofs in the area	5:	50	20 (municipality) 50 (school)	50
	0:	100	100	100

* identifies the KPIs

The **assessment scores** for the **existing condition** of the buildings range **from 1.19** (Irbid public building pilot) **to 2.45** (Moukhtara school building).

- For the public buildings, Issues with scores below minimum acceptable are 25% in SBTool-Irbid, 0% in SBTool-Moukhtara and 38% in SBTool-Sousse, while there are no Issues with score above 3.
- For the school building there are no Issues with score below 0, while for the residential building one Issue has a negative score. It is worth mentioning that there is no Issue with score above 1.

The distribution of assessed Issues scores is presented in Figure 29.

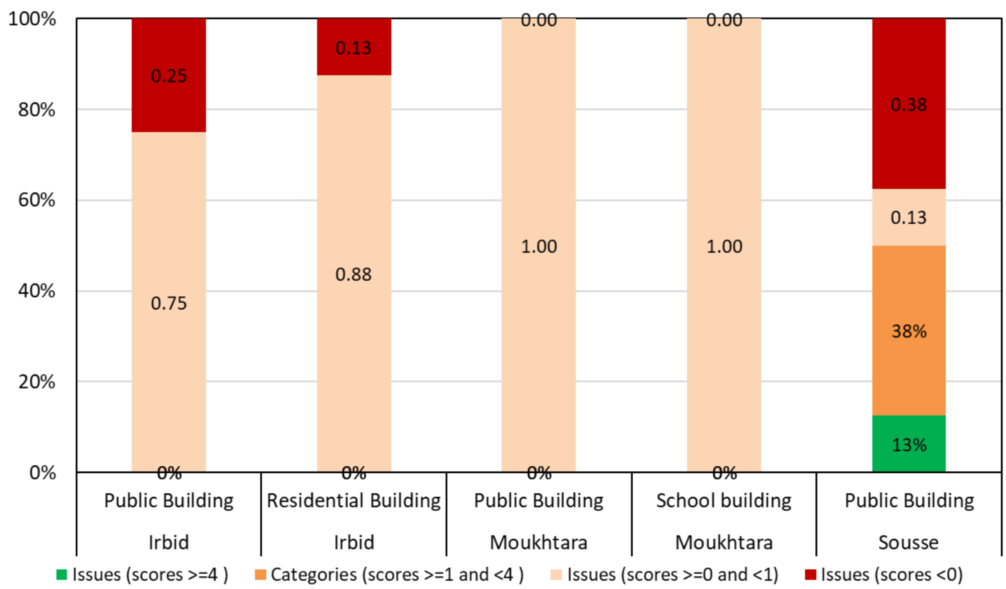

Figure 29. Distribution of Issues to various scores in the three national SBTools.

Analysing the assessment scores of the various Categories, 6-7% of them have reached high scores (above 4) in the three national SBTools. On the other hand, 7%-41% of the Categories have scores below the minimum requirements (Figure 30). Category H1 (Climatic action: increase of temperature) has negative scores in four out of five pilots.

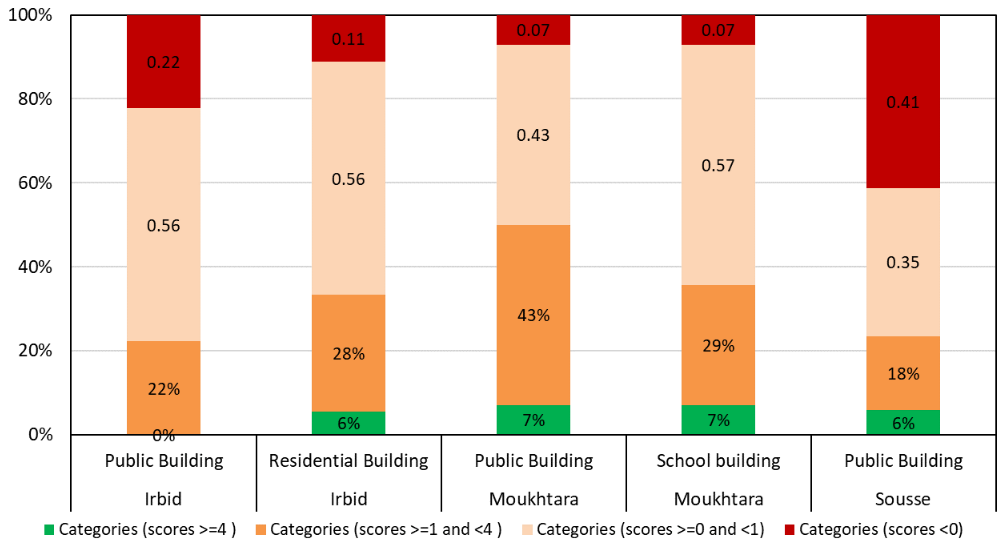

Figure 30. Distribution of Categories to various scores in the three national SBTools.

For the Sousse public building, about half of the active Indicators (55%) have scores below the minimum acceptable level. For the Moukhtara buildings the corresponding percentages are 23% (public building) and 32% (school building), while for the Irbid buildings the corresponding percentages are 32% (public building) and 18% (residential building). Indicators with scores above 4 reached 9% (public building) and 21% (school building) in Irbid, 35% for both buildings in Moukhtara and 15% for the Sousse public building, as illustrated in Figure 31.

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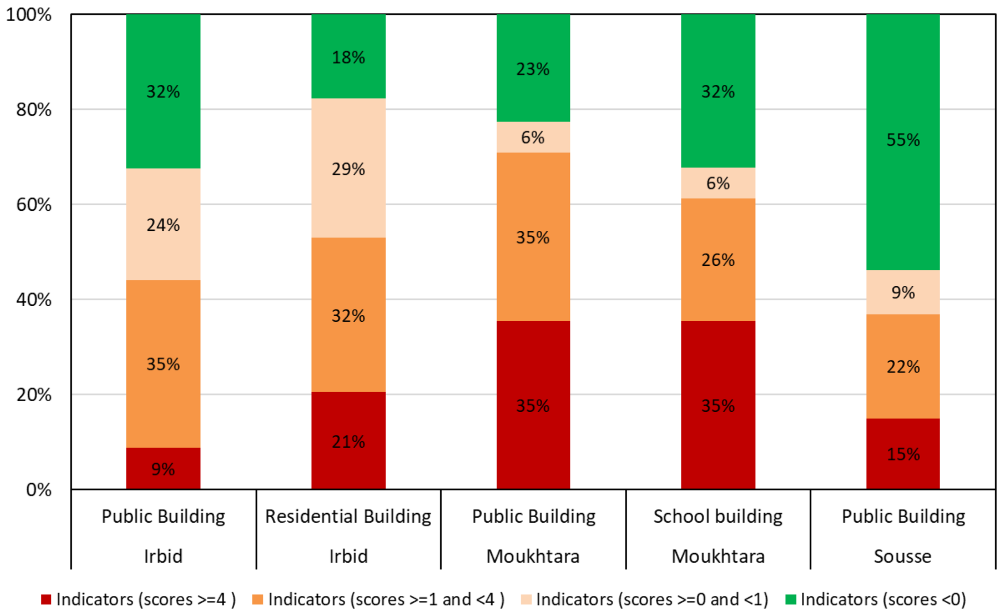

Figure 31. Distribution of Indicators to various scores in the three national SBTools.

In all assessed buildings, the **KPIs with negative scores** range between 18%-59%. The **B1.6** (Embodied non-renewable primary energy) has a score **below the minimum acceptable requirements in all five buildings**. On the other hand, the **KPIs with the highest scores** (above 4) range between 6%-29% (Figure 32). **G1.4** (Energy annual cost per useful internal floor area) has the **highest score in four out of five pilots**.

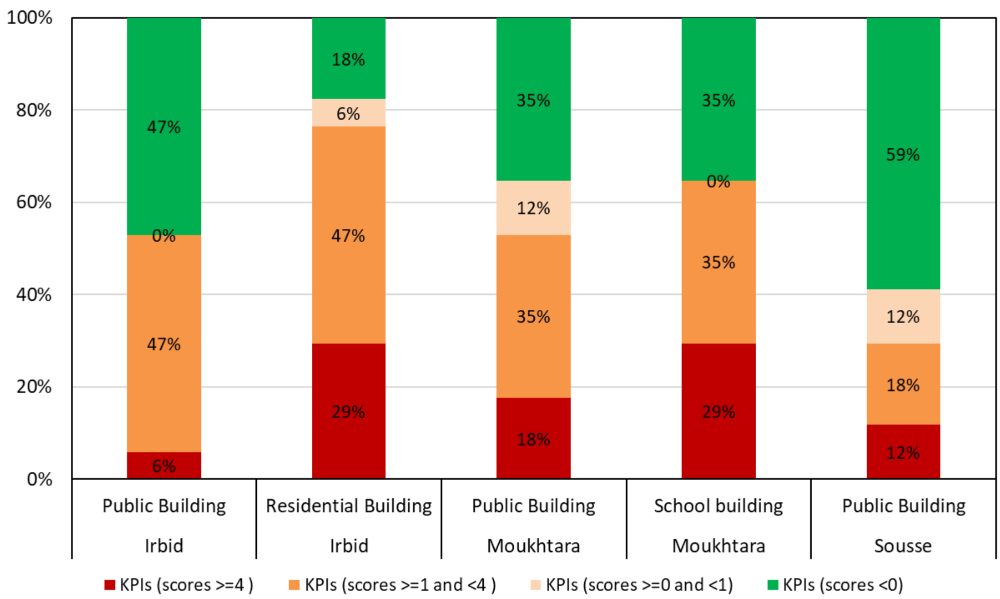

Figure 32. Distribution of KPI's to various scores in the three national SBTools.

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The assessment scores and the corresponding values of the common Indicators, for the five pilot studies are summarized in Table 12.

Table 12. The scores (and values) for the common Indicators in the five pilots.

KPI	SBTool - Irbid		SBTool - Moukhtara		SBTool - Sousse
	Public building	Residential building	Municipality building	Public building	Residential building
*B1.1	-1.00 (289)	5.00 (48)	4.86 (52.97)	5.00 (46.5)	3.83 (226.23)
*B1.2	-1.00 (70)	1.33 (26)	-1.00 (36.17)	-1.00 (35.2)	-1.00 (30.5)
*B1.3	-1.00 (201)	5.00 (33)	3.93 (16.8)	5.00 (11.3)	2.82 (80.25)
*B1.4	-1.00 (12)	0.31 (25)	-1.00 (0)	-1.00 (6)	-1.00 (0)
*B1.5	0.44 (27)	0.44 (27)	-1.00 (0)	2.38 (58)	-1.00 (0)
*B1.6	-1.00 (903)	-1.00 (903)	-1.00 (3000)	-1.00 (3000)	-1.00 (814.43)
*B3.4	-1.00 (0)	-1.00 (0)	-1.00 (10)	0.71 (20)	-1.00 (8)
*B4.3	5.00 (2)	0.14 (98)	5.00 (0.05)	5.00 (0.2)	-1.00 (175)
B4.4	-1.00 (100)	-1.00 (100)	5.00 (0)	4.70 (4.8)	-1.00 (60)
*C1.1	0.56 (3)	0.56 (3)	-1.00 (495)	-1.00 (495.79)	2.72 (2.61)
*C1.2	-1.00 (74)	5.00 (12)	3.27 (37)	4.13 (32.55)	3.53 (35.62)
*D1.2	2.50 (0.3)	2.50 (0.3)	2.5 (0.3)	2.50 (0.3)	-1.00 (0.6)
*D1.7	0.83 (0.7)	0.83 (0.7)	1.67 (0.8)	-1.00 (0)	1.25 (0.75)
*D2.3	1.50 (17)	4.00 (12)	1.70 (16.6)	1.70 (16.6)	-1.00 (35)
*D3.1	2.50 (3)	2.50 (3)	2.5 (3)	2.50 (3)	5.00 (4.7)
*E1.2	1.67 (60)	3.33 (80)	1.67 (60)	1.67 (60)	-1.00 (23.06)
F.1.1.	0.00 (0)	0.00 (0)	1.00 (1)	1.00 (1)	3.00 (3)
*G1.4	1.33 (16)	5.00 (5)	4.23 (7.3)	5.00 (3.64)	4.40 (25.97)
*H1.2	-1.00 (35)	-1.00 (35)	0.44 (27)	-1.00 (27)	-1.00 (27.8)

* identifies the KPIs

4.2. Buildings in Irbid

The SBTool-Irbid was contextualized and used for two pilot studies, namely a **public building** and a **residential building**. The national **SBTool** includes **8 Issues**, **18 Categories** and **34 Indicators**. Category B (Energy and Resources Consumption) includes the most active indicators and Categories E (Service Quality) and G (Cost and Economic Aspects) the least (Figure 33). Priorities of the Issues range between 3 and 5, while the most important Issues are A (Site Regeneration and Development) and B (Energy and Resources Consumption), as illustrated in Figure 34.

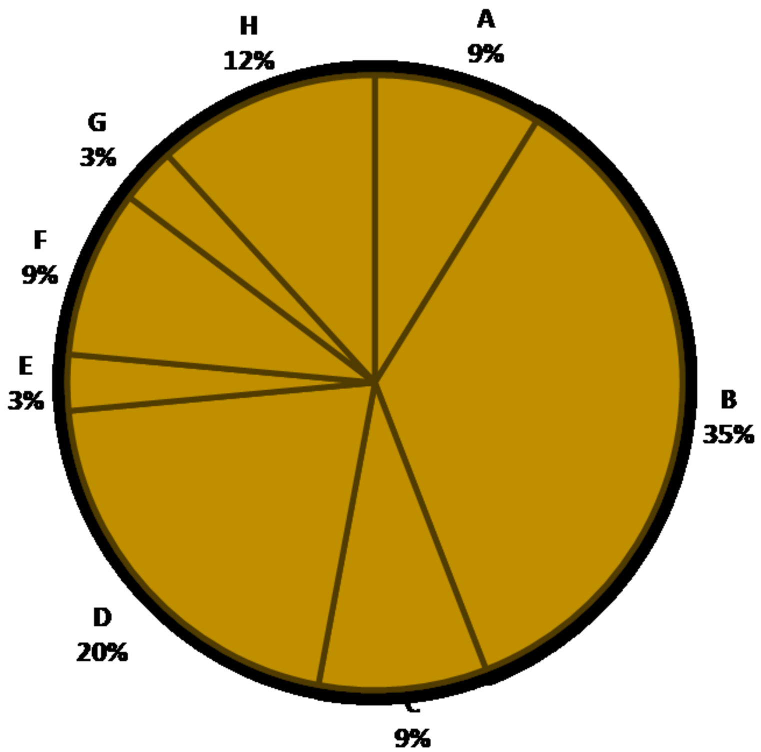

Figure 33. Active Indicators per Issue in SBTool-Irbid.

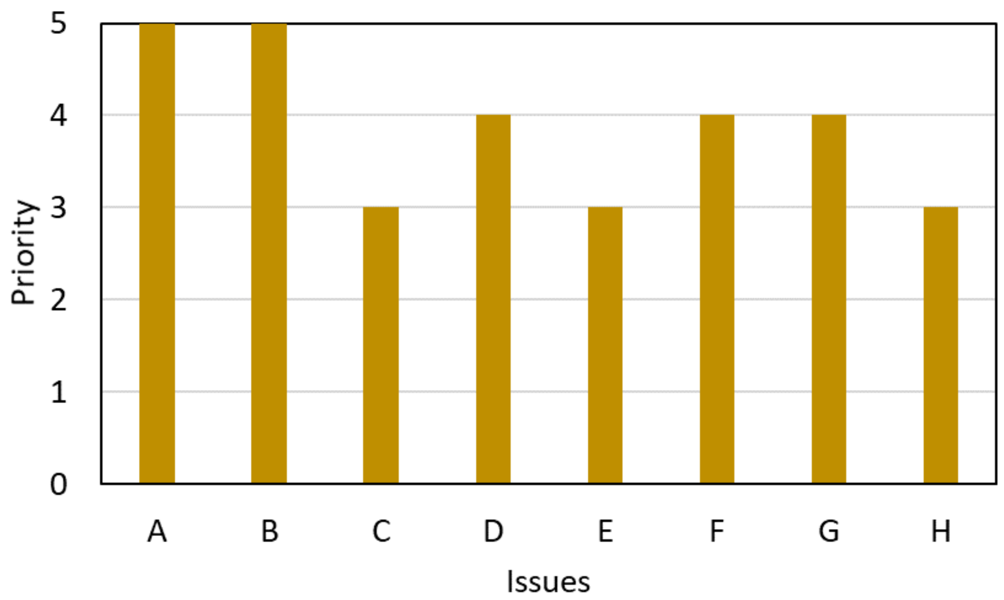

Figure 34. Priority of active Issues in SBTool-Irbid (1: minor, 5: major).

Data sources used to collect all the necessary information for the assessment include:

- *GIM Transportation Department*

- *GIS Mapping*
- *Site assessment through physical visits and observation.*
- *Onsite measurements through detectors*
- *Buildings architectural, mechanical and construction plans and drawings*
- *Building electricity and water bills samples*
- *Questionnaire Survey*
- *Irbid Electricity Company and Water Company*
- *Ministry of Environment, Ministry of Energy and Mineral Resources, Ministry of Public Works and Housing*
- *Contractors Association*

4.2.1. Public Building – Irbid

Name of the Building	*Irbid Chamber of Commerce*
Actual building use	Public building
Year of construction	*1998*
Level of degradation of the building	*Average*
Number of levels above earth	4
Number of levels underground	1
Heating system	*Inverter AC*
Cooling system	*Fans + natural cooling + Inverter AC units + Free air diffuser*
DHW system	*Electrical boilers + Instant electric heating water faucet and shower*
Ventilation system	*Natural ventilation*
Lighting system	*LED+* Fluorescent tube+ Halogen lamp
Average U value	*0.57 W/m^2 K for walls*
Number of occupants	*1000 visitors + 60 Workers*
Hours of occupation per year	*2016 hrs per year*

In the SBTool-Irbid for the public building, 27% of the Indicators have different benchmarks compared to the Generic Framework SBTool. Five Indicators have more relaxed lower limits, one has a more strict level, while 3 Indicators have more strict benchmarks at level 0 and more relaxed at level 5.

The majority of Indicators (32%) have negative assessment scores, while only 9% have assessment scores above 4, as shown in Figure 35.

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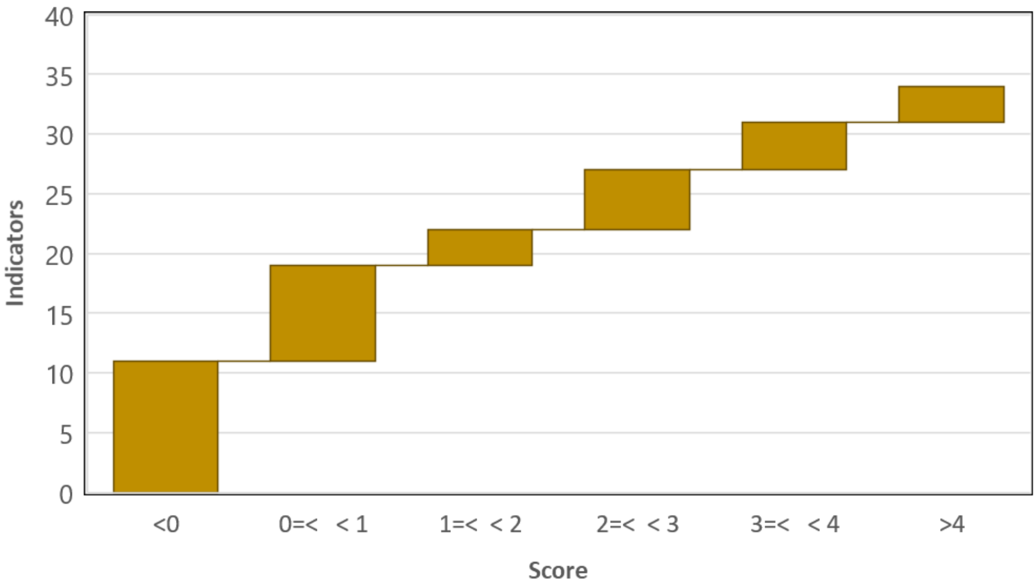

Figure 35. Distribution of Indicators in the 6 different score levels in SBTool-Irbid for the public building.

The details of the active Indicators, the benchmarks, the priorities and weighting factors, as well as the scores and actual values for the existing condition and the proposed scenarios are presented in Table 13.

Table 13. Assessment of public building (SBTool-Irbid), in existing condition and in two scenarios (S-1 and S-2). For the scenarios, only the modified Indicators are presented, the others remain the same with the existing condition. Underlined values indicate that the benchmark is identical to the Generic Framework SBTool.

Code	Indicator	Units	Benchmark (0)	Benchmark (5)	Priority	Score (Value) Existing	Score (Value) S-1	Score (Value) S-2
					Building	1.19	1.97	1.85
A	**Site Regeneration and Development**				**5 (16.1%)**	**1.75**	**1.98**	**2.20**
A1	**Site Selection**				**5 (55.6%)**	**1.75**	**1.75**	**1.75**
A1.2	Accessibility index to public transportation	-	1.5	12	(50%)	2.62 (7)		
A1.4	Average distance from key services	m	2000	50	(50%)	3.69 (560)		
A2	**Site development**				**4 (44.4%)**	**0.00**	**0.22**	**0.44**
A2.1	The extent of vegetated landscaped area that is planted with native plants	%	0	100	(100%)	0.00 (0)	0.50 (10)	1.00 (20)
B	**Energy**				**5 (16.1%)**	**0.76**	**2.61**	**2.10**
B1	**Energy infrastructure**				**5 (26.3%)**	**-0.20**	**0.41**	**0.17**
*B1.1	Primary energy demand per internal useful floor area per year	kWh/m²/yr	155	80	(16.7%)	-1.00 (289)	2.00 (125)	0.33 (150)

*B1.2	Delivered thermal energy demand per internal useful floor area per year	kWh/m²/yr	30	15	(16.7%)	-1.00 (70)	3.00 (21)	1.67 (25)
*B1.3	Delivered electric energy demand per internal useful floor area per year	kWh/m²/yr	120	90	(16.7%)	-1.00 (201)	3.33 (100)	0.83 (115)
*B1.4	Share of renewable energy in final thermal energy consumptions	%	20	100	(16.7%)	-1.00 (12)	0.31 (25)	0.31 (25)
*B1.5	Share of renewable energy in final electric energy consumption	%	20	100	(16.7%)	0.44 (27)		
*B1.6	Embodied non-renewable primary energy per useful internal floor area	MJ/m²	432	400	(16.7%)	-1.00 (903)	0.31 (430)	0.31 (430)
B2	**Electrical peak demand**				**5 (26.3%)**	**-0.26**	**0.66**	**0.33**
B2.1	Average of peak monthly electrical demand for one year	W/m²	100	20	(100%)	-1.00 (1400)	2.50 (60)	1.25 (80)
B3	**Materials**				**4 (21.1%)**	**0.43**	**0.61**	**0.61**
*B3.4	Weight of recycled materials on total weight of materials	%	15	50	(50%)	-1.00 (0)	0.71 (20)	0.71 (20)
B3.5	Weight of local materials on total weight of materials	%	30	80	(50%)	5.00 (80)		
B4	**Use of potable water, stormwater and greywater**				**5 (26.3%)**	**0.79**	**0.93**	**0.99**
B.4.2	Total consumption of water per building occupant	m³/occupant yr	12	5	(33.3%)	5.00 (2)		
*B4.3	Potable water consumption / standardised potable water consumption	%	100	30	(33.3%)	5.00 (2)		
B4.4	Potable water consumption / standardised potable water consumption	%	80	0	(33.3%)	-1.00 (100)	0.63 (70)	1.25 (60)
C	**Environmental Loadings**				**3 (9.7%)**	**-0.11**	**2.54**	**1.82**
C1	**Greenhouse Gas Emissions**				**3 (50%)**	**-0.11**	**1.29**	**0.57**
*C1.1	kg CO2 equivalents per useful internal floor area (product stage)	Kg CO2eq/m²	3.1	2.2	(50%)	0.56 (3)		
*C1.2	kg CO2 equivalents per useful internal floor area per year	Kg CO2eq/m² year	54	28	(50%)	-1.00 (74)	4.62 (30)	1.73 (45)
C3	**Solid Wastes**				**3 (50%)**	**0.00**	**1.25**	**1.25**
C3.2	Ratio of the number of collectable solid waste categories within a 100 m distance from the building's entrance to the reference solid waste categories	%	0	100	(100%)	0.00 (0)	2.50 (50)	2.50 (50)
D	**Indoor Environmental Quality**				**4 (12.9%)**	**1.69**	**2.19**	**2.19**
D1	**Indoor Air Quality and Ventilation**				**5 (33.3%)**	**0.86**	**0.86**	**0.86**
*D1.2	TVOC concentration in indoor air	μg/ m³	0.5	0.1	(25%)	2.50 (0.3)		
D1.3	CO2 concentration in indoor air	ppm	2600	400	(25%)	3.64 (1000)		

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D1.6	Relative humidity in indoor air	%	60	30	(25%)	3.33 (40)		
*D1.7	Mechanical ventilation rate per useful internal floor area	L/s/m^2	0.6	1.2	(25%)	0.83 (0.7)		
D2	**Air Temperature and Relative Humidity**				**5 (33.3%)**	**0.00**	**0.50**	**0.50**
*D2.3	Predicted Percentage of Dissatisfied	%	20	10	(100%)	1.50 (17)		
D3	**Daylighting and Illumination**				**5 (33.3%)**	**0.83**	**0.83**	**0.83**
*D3.1	Mean Daylight Factor	%	2	4	(50%)	2.50 (3)		
D3.2	Level of daylight provision		1	3	(50%)	2.50 (2)		
E	**Service Quality**				**3 (9.7%)**	**1.67**	**1.67**	**1.67**
E1	**Controllability**				**3 (100%)**	**1.67**	**1.67**	**1.67**
*E1.2	Rate the total smart readiness of buildings in terms of three key functionalities, i.e. responding to the needs of occupants, optimizing energy performance, interacting with energy grids	%	40	100	(100%)	1.67 (60)		
F	**Social, Cultural and Perceptual Aspects**				**4 (12.9%)**	**2.14**	**2.39**	**2.39**
F1	**Social Aspects**				**4 (50%)**	**0.89**	**1.14**	**1.14**
F1.1	The scope and quality of design measures planned to facilitate access and use of building facilities by persons with disabilities	Score	0	5	(50%)	0.00 (0)	1.00 (1)	1.00 (1)
F1.2	Hours of sunlight	Hours	1	8	(50%)	3.57 (6)		
F2	**Perceptual**				**4 (50%)**	**1.25**	**1.25**	**1.25**
F2.1	Quality of view out	Score	25	75	(100%)	2.50 (50)		
G	**Cost and Economic Aspects**				**4 (12.9%)**	**1.33**	**1.33**	**1.33**
G1	**Cost and Economics**				**4 (100%)**	**1.33**	**1.33**	**1.33**
*G1.4	Energy annual cost per useful internal floor area	€/m^2/yr	20	5	(100%)	1.33 (16)		
H	**ADAPTATION TO CLIMATE CHANGE**				**3 (9.7%)**	**-0.36**	**0.62**	**0.62**
H1	**Climatic action: increase of temperature**				**4 (36.4%)**	**-0.36**	**0.17**	**0.17**
*H1.2	Mean Solar Reflectance Index of paved surfaces and roofs in the area	SRI	50	100	(60%)	-1.00 (35)	0.50 (55)	0.50 (55)
H1.3	Percent of building envelope with orientation between West and South East that will be covered by vegetation during the warm season (June 12st)	%	20	80	(40%)	-1.00 (12)	0.42 (25)	0.42 (25)
H2	**Climatic action: pluvial flood**				**3 (27.3%)**	**0.00**	**0.27**	**0.27**
H2.2	Share of the site that is permeable to water	%	0	25	(100%)	0.00 (0)	1.00 (5)	1.00 (5)
H4	**Climatic action: drought**				**4 (36.4%)**	**0.00**	**0.18**	**0.18**
H4.2	Share of greywater collected and cleaned for reuse	%	0	100	(100%)	0.00 (0)	0.50 (10)	0.50 (10)

* identifies the KPIs

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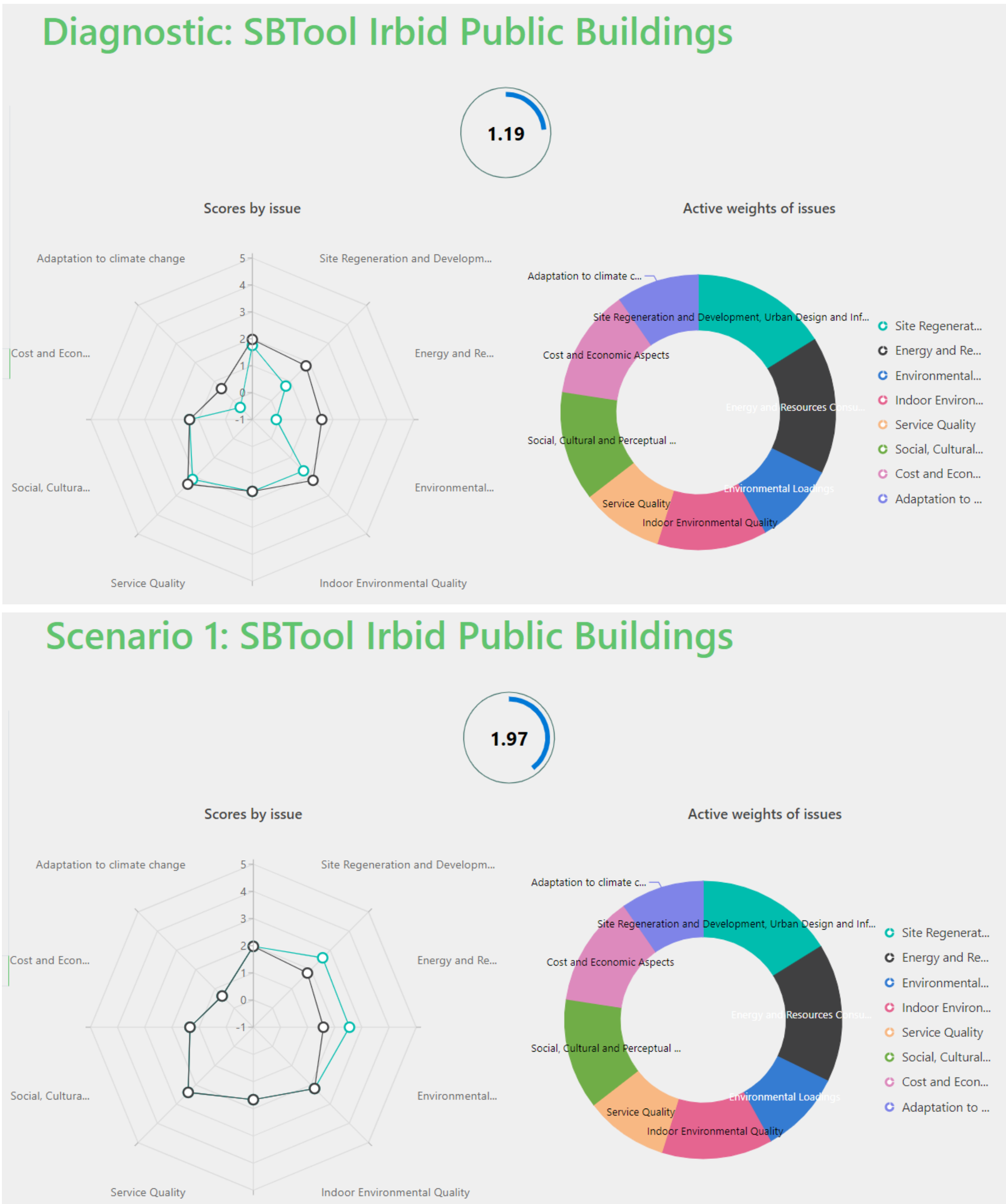
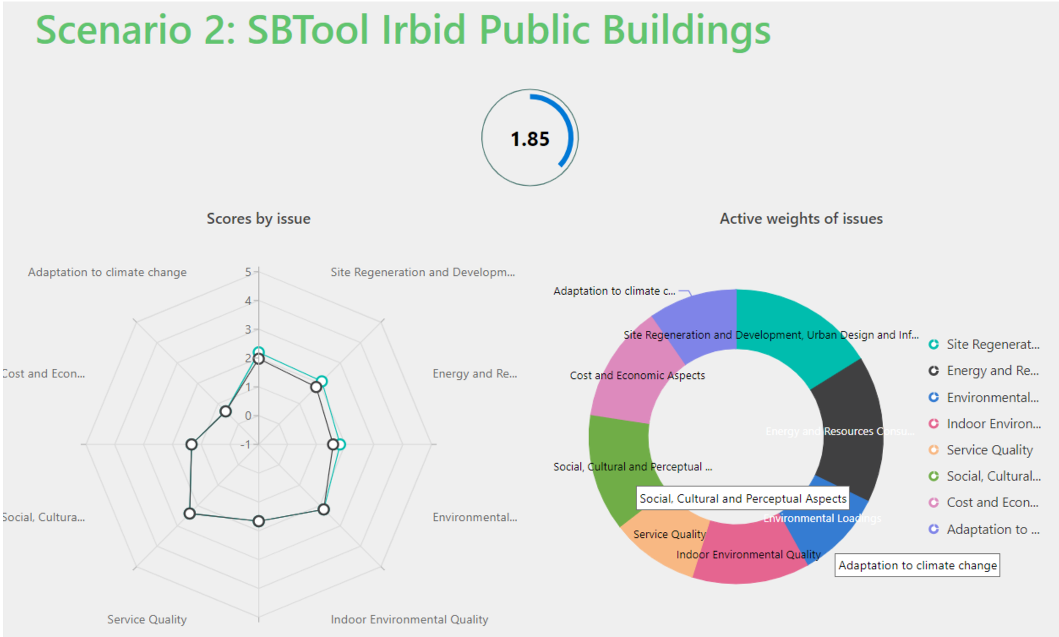
The **existing condition** of the **building** considered in this pilot reached a **sustainability score of 1.19** and it can be considered as above the minimum requirements that can be improved. The proposed retrofit actions in both Scenarios affected 5 Issues, 11 Categories and 16 Indicators. Scenario 1 has a sustainability score of 1.97, increased by 66% compared to existing condition, while Scenario 2 has a sustainability score of 1.85, increased by 55%. The results for the sustainability assessment of Irbid Chamber of Commerce building in the existing condition and under the two scenarios are presented in Figure 36.





(c)

Figure 36. Sustainability score for the existing condition (a), Scenario1 (b) and Scenario2 (c).

The **selected retrofit scenario is Scenario 1** that has the higher sustainability score and thus a higher potential for improvement. In the selected scenario, Issue C has the highest improvement of its sustainability score, as illustrated in Figure 37.

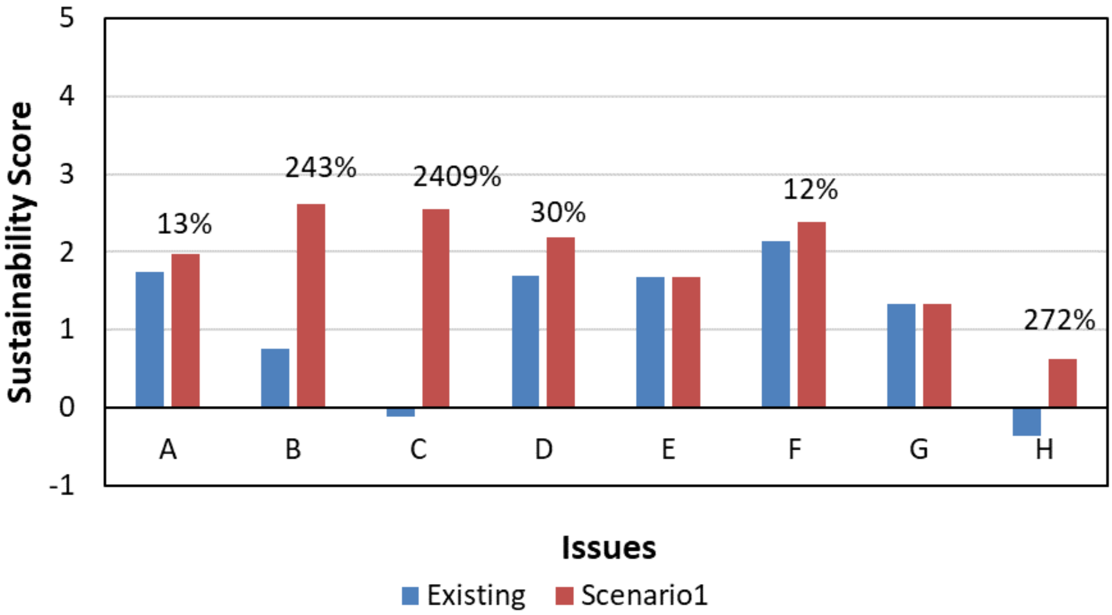


Figure 37. Issues sustainability scores of the assessed building in the existing condition and in Scenario 1.

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4.2.2. Residential Building – Irbid

Name of the Building	*Residential building*
Actual building use	*Multi family building*
Year of construction	*2010*
Level of degradation of the building	*Average*
Number of levels above earth	*4*
Number of levels underground	*1*
Heating system	*AC - Gas*
Cooling system	*Fan, AC, free air*
DHW system	*Boilers*
Ventilation system	*Natural ventilation*
Lighting system	*LED*
Average U value	*0.57W/m^2 for walls*
Number of occupants	*9 households*
Hours of occupation per year	*8760 hr per year*

In the SBTool-Irbid for the residential building, 27% of the Indicators have different benchmarks compared to the Generic Framework SBTool. Six Indicators have more relaxed lower limits, while three Indicators have more strict benchmarks for level 0 and a more relaxed for level 5.

The majority of Indicators (29%) have assessment scores between 0 and 1, 21% have assessment scores above 4, while 18% have negative scores, as shown in Figure 38.

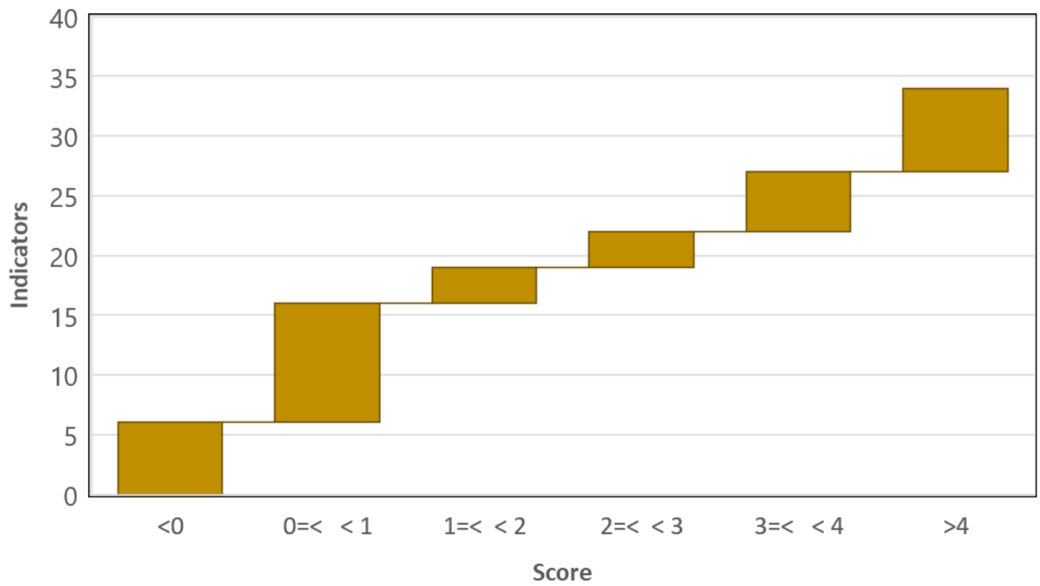

Figure 38. Distribution of Indicators in the 6 different score levels in SBTool-Irbid for the public building.

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The details of the active Indicators, the benchmarks, the priorities and weighting factors, as well as the scores and actual values for the existing condition and the proposed scenarios are presented in Table 14.

Table 14. Assessment of residential building (SBTool-Irbid), in existing condition and in two scenarios (S-1 and S-2). For the scenarios, only the modified Indicators are presented, the others remain the same with the existing condition. Underlined values indicate that the benchmark is identical to the Generic Framework SBTool.

Code	Indicator	Units	Benchmark		Priority	Score (Value)		
			(0)	(5)				
						Existing	S-1	S-2
					Building	**2.19**	**2.59**	**2.66**
A	**Site Regeneration and Development**				**5 (16.1%)**	**1.91**	**1.98**	**2.20**
A1	**Site Selection**				**5 (55.6%)**	**1.89**	**1.75**	**1.75**
A1.2	Accessibility index to public transportation	(50%)	1.5	12		3.10 (8)	2.62 (7)	2.62 (7)
A1.4	Average distance from key services	(50%)	2000	50		3.69 (560)		
A2	**Site development**				**4 (44.4%)**	**0.02**	**0.22**	**0.44**
A2.1	The extent of vegetated landscaped area that is planted with native plants	%	0	100	(100%)	0.05 (1)	0.50 (10)	1.00 (20)
B	**Energy**				**5 (16.1%)**	**0.71**	**1.99**	**1.73**
B1	**Energy infrastructure**				**5 (26.3%)**	**0.49**	**0.61**	**0.54**
*B1.1	Primary energy demand per internal useful floor area per year	kWh/m²/yr	155	80	(16.7%)	5.00 (48)		
*B1.2	Delivered thermal energy demand per internal useful floor area per year	kWh/m²/yr	30	15	(16.7%)	1.33 (26)		
*B1.3	Delivered electric energy demand per internal useful floor area per year	kWh/m²/yr	120	90	(16.7%)	5.00 (33)		
*B1.4	Share of renewable energy in final thermal energy consumptions	%	20	100	(16.7%)	0.31 (25)		
*B1.5	Share of renewable energy in final electric energy consumption	%	20	100	(16.7%)	0.44 (27)		
*B1.6	Embodied non-renewable primary energy per useful internal floor area	MJ/m²	432	400	(16.7%)	-1.00 (903)	1.88 (420)	0.31 (430)
B2	**Electrical peak demand**				**5 (26.3%)**	**-0.26**	**0.49**	**0.33**
B2.1	Average of peak monthly electrical demand for one year	W/m²	100	20	(100%)	-1.00 (1700)	1.88 (70)	1.25 (80)
B3	**Materials**				**4 (21.1%)**	**0.42**	**0.68**	**0.60**
*B3.4	Weight of recycled materials on total weight of materials	%	15	50	(50%)	-1.00 (0)	1.43 (25)	0.71 (20)

B3.5	Weight of local materials on total weight of materials	%	30	80	(50%)	5.00 (80)		
B4	**Use of potable water, stormwater and greywater**				**5 (26.3%)**	**0.06**	**0.21**	**0.26**
B.4.2	Total consumption of water per building occupant	m^3/occupant yr	12	5	(33.3%)	1.57 (98)		
*B4.3	Potable water consumption / standardised potable water consumption	%	100	30	(33.3%)	0.14 (98)		
B4.4	Potable water consumption / standardised potable water consumption	%	80	0	(33.3%)	-1.00 (100)	0.63 (70)	1.25 (60)
C	**Environmental Loadings**				**3 (9.7%)**	**1.39**	**1.89**	**2.64**
C1	**Greenhouse Gas Emissions**				**3 (50%)**	**1.39**	**1.39**	**1.39**
*C1.1	kg CO2 equivalents per useful internal floor area (product stage)	Kg CO2eq/m^2	3.1	2.2	(50%)	0.56 (3)		
*C1.2	kg CO2 equivalents per useful internal floor area per year	Kg CO2eq/m^2 year	54	28	(50%)	5.00 (12)		
C3	**Solid Wastes**				**3 (50%)**	**0.00**	**0.50**	**1.25**
C3.2	Ratio of the number of collectable solid waste categories within a 100 m distance from the building's entrance to the reference solid waste categories	%	0	100	(100%)	0.00 (0)	1.00 (20)	2.50 (50)
D	**Indoor Environmental Quality**				**4 (12.9%)**	**2.92**	**2.92**	**2.92**
D1	**Indoor Air Quality and Ventilation**				**5 (33.3%)**	**0.76**	**0.76**	**0.76**
*D1.2	TVOC concentration in indoor air	µg/ m^3	0.5	0.1		2.50 (0.3)		
D1.3	CO2 concentration in indoor air	ppm	2600	400		4.09 (800)		
D1.6	Relative humidity in indoor air	%	60	30		1.67 (50)		
*D1.7	Mechanical ventilation rate per useful internal floor area	L/s/m^2	0.6	1.2		0.83 (0.7)		
D2	**Air Temperature and Relative Humidity**				**5 (33.3%)**	**1.33**	**1.33**	**1.33**
*D2.3	Predicted Percentage of Dissatisfied	%	20	10		4.00 (12)		
D3	**Daylighting and Illumination**				**5 (33.3%)**	**0.83**	**0.83**	**0.83**
*D3.1	Mean Daylight Factor	%	2	4	(50%)	2.50 (3)		
D3.2	Level of daylight provision	Level number?	1	3	(50%)	2.50 (2)		
E	**Service Quality**				**3 (9.7%)**	**3.33**	**3.33**	**3.33**
E1	**Controllability**				**3 (100%)**	**3.33**	**3.33**	**3.33**
*E1.2	Rate the total smart readiness of buildings in terms of three key functionalities, i.e. responding to the needs of occupants, optimizing energy performance, interacting with energy grids	%	40	100	(100%)	3.33 (80)		
F	**Social, Cultural and Perceptual Aspects**				**4 (12.9%)**	**2.55**	**2.80**	**2.80**
F1	**Social Aspects**				**4 (50%)**	**0.80**	**1.05**	**1.05**

F1.1	The scope and quality of design measures planned to facilitate access and use of building facilities by persons with disabilities	Score	0	5	(50%)	0.00 (0)	1.00 (1)	1.00 (1)
F1.2	Hours of sunlight	Hours	1	8	(50%)	3.18 (8)		
F2	**Perceptual**				**4 (50%)**	**1.75**	**1.75**	**1.75**
F2.1	Quality of view out	Score	25	75	(100%)	3.50 (60)		
G	**Cost and Economic Aspects**				**4 (12.9%)**	**5.00**	**5.00**	**5.00**
G1	**Cost and Economics**				**4 (100%)**	**5.00**	**5.00**	**5.00**
*G1.4	Energy annual cost per useful internal floor area	€/m^2/yr	20	5	(100%)	5.00 (5)		
H	**ADAPTATION TO CLIMATE CHANGE**				**3 (9.7%)**	**-0.36**	**0.62**	**0.62**
H1	**Climatic action: increase of temperature**				**4 (36.4%)**	**-0.36**	**0.17**	**0.17**
*H1.2	Mean Solar Reflectance Index of paved surfaces and roofs in the area	SRI	50	100	(60%)	-1.00 (35)	0.50 (55)	0.50 (55)
H1.3	Percent of building envelope with orientation between West and South East that will be covered by vegetation during the warm season (June 12st)	%	20	80	(40%)	-1.00 (12)	0.42 (25)	0.42 (25)
H2	**Climatic action: pluvial flood**				**3 (27.3%)**	**0.00**	**0.27**	**0.27**
H2.2	Share of the site that is permeable to water	%	0	25	(100%)	0.00 (0)	1.00 (5)	1.00 (5)
H4	**Climatic action: drought**				**4 (36.4%)**	**0.00**	**0.18**	**0.18**
H4.2	Share of greywater collected and cleaned for reuse	%	0	100	0.50 (10)	0.00 (0)	0.50 (10)	0.50 (10)

* identifies the KPIs

The **existing condition** of the **building** considered in this pilot reached a **sustainability score of 2.19** and it can be considered as significantly above the minimum requirements. The proposed retrofit actions in both Scenarios affected 5 Issues, 11 Categories and 12 Indicators. Scenario 1 has a sustainability score of 2.59, increased by 18% compared to existing condition, while Scenario 2 has a sustainability score of 2.66, increased by 21%. The results for the sustainability assessment of Irbid residential building in the existing condition and under the two scenarios are presented in Figure 39.

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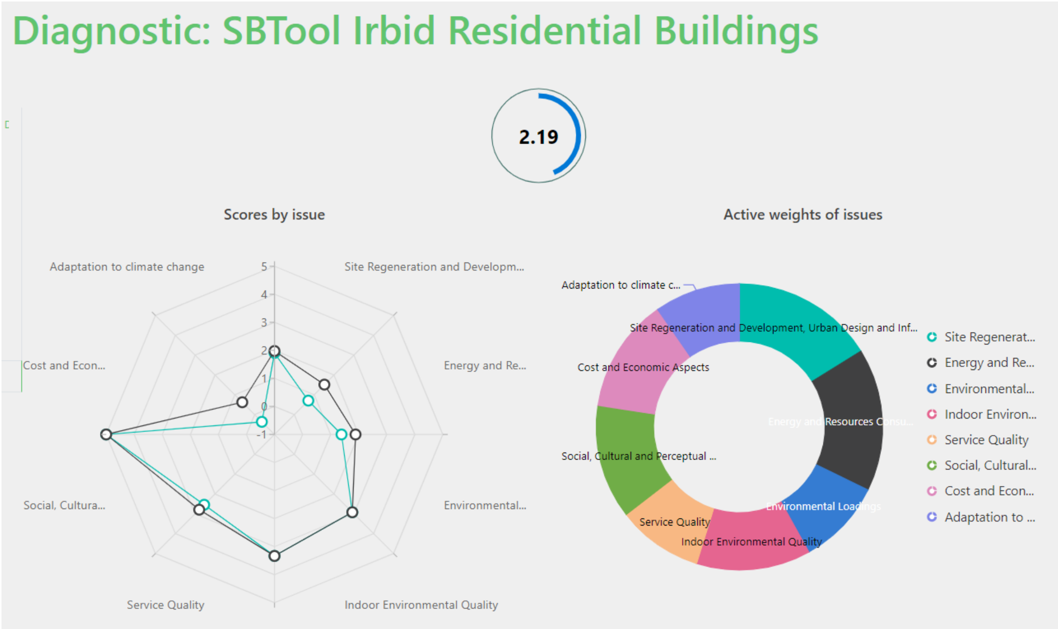
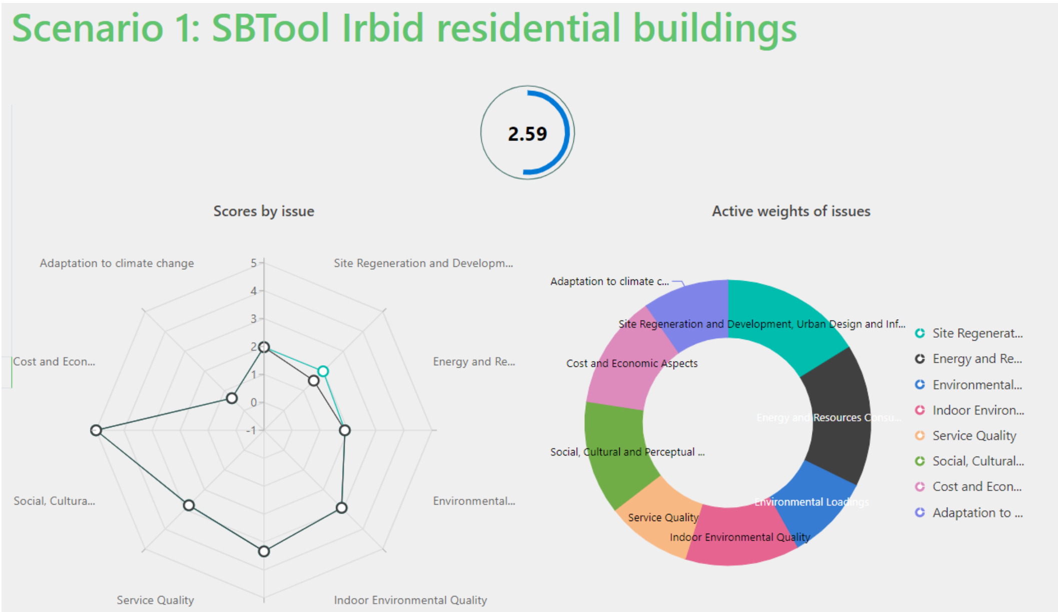

Diagnostic: SBTool Irbid Residential Buildings
2.19
Scores by issue
Adaptation to climate change
Site Regeneration and Developm...
Energy and Re...
Environmental...
Indoor Environmental Quality
Service Quality
Social, Cultura...
Cost and Econ...
Active weights of issues
Adaptation to climate c...
Site Regeneration and Development, Urban Design and Inf...
Cost and Economic Aspects
Social, Cultural and Perceptual ...
Service Quality
Indoor Environmental Quality
Site Regenerat...
Energy and Re...
Environmental...
Indoor Environ...
Service Quality
Social, Cultural...
Cost and Econ...
Adaptation to ...

(a)


Scenario 1: SBTool Irbid residential buildings
2.59
Scores by issue
Adaptation to climate change
Site Regeneration and Developm...
Energy and Re...
Environmental...
Indoor Environmental Quality
Service Quality
Social, Cultura...
Cost and Econ...
Active weights of issues
Adaptation to climate c...
Site Regeneration and Development, Urban Design and Inf...
Cost and Economic Aspects
Social, Cultural and Perceptual ...
Service Quality
Indoor Environmental Quality
Site Regenerat...
Energy and Re...
Environmental...
Indoor Environ...
Service Quality
Social, Cultural...
Cost and Econ...
Adaptation to ...

(b)

(c)

Figure 39. Sustainability score for the existing condition (a), Scenario1 (b) and Scenario2 (c).

The **selected retrofit scenario is Scenario 2** that has the higher sustainability score and thus a higher potential for improvement. In the selected scenario, Issue H has the highest improvement of its sustainability score, as illustrated in Figure 40.

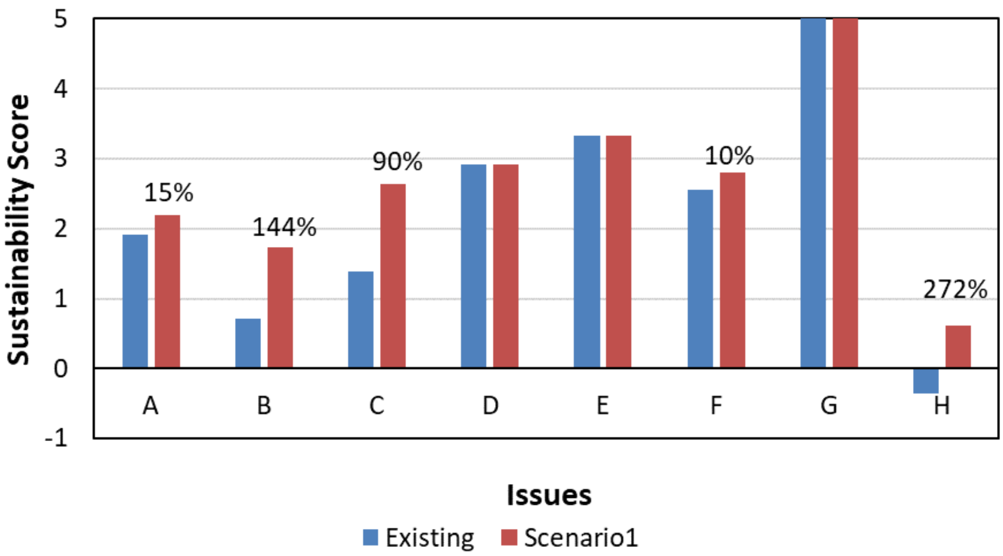


Figure 40. Issues sustainability scores of the assessed building in the existing condition and in Scenario 1.

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4.3. Buildings in Moukhtara

The **SBTool-Moukhtara** was contextualized and used for **two pilot studies**, namely a **public building** and a **school building**. Seven Issues are included in the national **SBTool**, since Site Regeneration and Development (A) is not assessed. Issue B (Energy and Resources Consumption) includes the most active indicators and Issues F (Social, Cultural and Perceptual Aspects), G (Cost and Economic Aspects) and H (Adaptation to Climate Change) the least (Figure 41). Priorities of the Issues range between 1 and 4, while the most important Issue is B (Energy and Resources Consumption) (Figure 42). From the 25 Categories in the Generic Framework SBTool, 14 are active in the national SBTool.

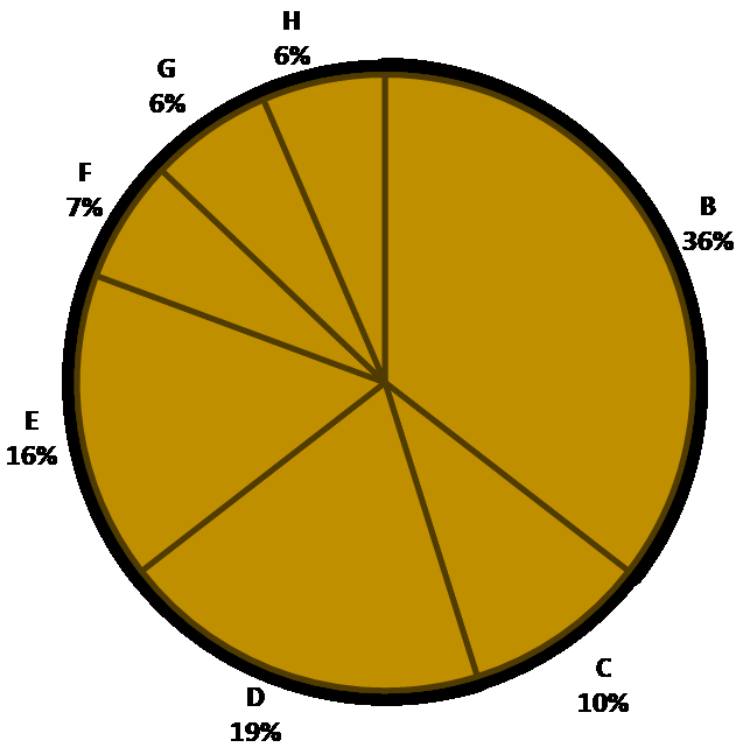

Figure 41. Active Indicators per Issue in SBTool-Moukhtara.

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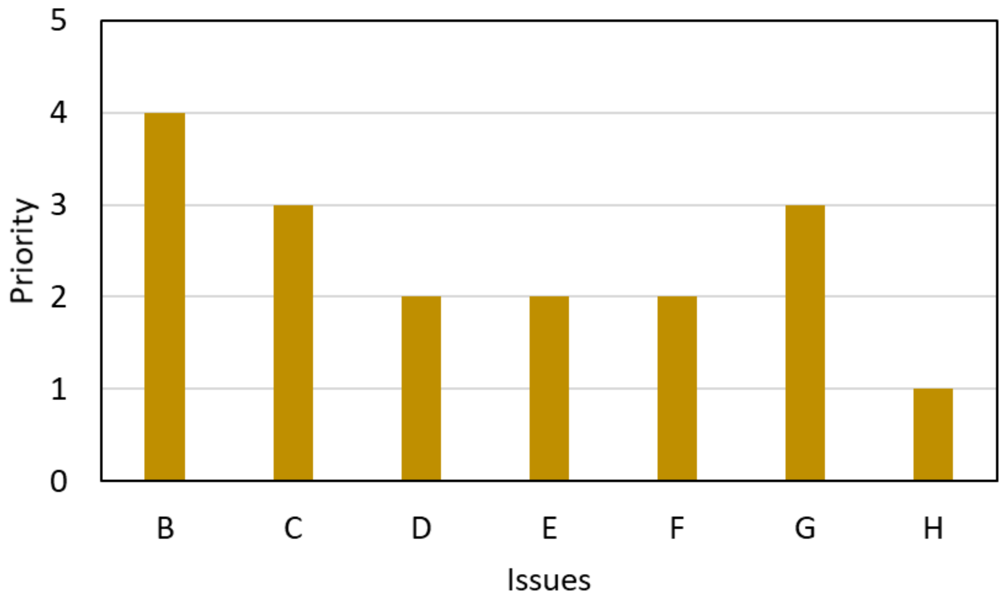

Figure 42. Priority of active Issues in SBTool-Moukhtara (1: minor, 5: major).

Data sources:

The Moukhtara Municipality Engineering team, led by the SMC team Coordinator, collected all the necessary data. Data verification and analysis was conducted by the SMC Team Lead and Quality Management consultants. The calculations of the targets and values were based on local standards and where necessary on some well-educated assumptions (Libnor). Final values were confirmed through coordination between all the members of the SMC team.

4.3.1. Municipality building – Moukhtara

Name of the Building	*Moukhtara Municipality*
Actual building use	*Municipality- Public services*
Year of construction	*1999*
Level of degradation of the building	*Low level of degradation: slightly damaged walls-medium damage in interiors such as doors and furniture*
Number of levels above earth	*3*
Number of levels underground	*0*
Heating system	*Central Heat Pumps*
Cooling system	*Central Air Conditioner*
DHW system	*Electrical Boiler System*

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Ventilation system	*Natural ventilation (windows)*
Lighting system	*Electrical Generator – Governmental electricity*
Average U value	*Total: 1.44 W/m²K (Exterior stone Walls) + 2.99W/m²K (Brick roof)*
Number of occupants	*15*
Hours of occupation per year	*1872 hrs per year*

In the SBTool-Moukhtara for the municipality building, 26% of the Indicators have different benchmarks compared to the Generic Framework SBTool. The majority of Indicators (35%) have assessment scores above 4, while 23% have negative assessment scores, as shown in Figure 43.

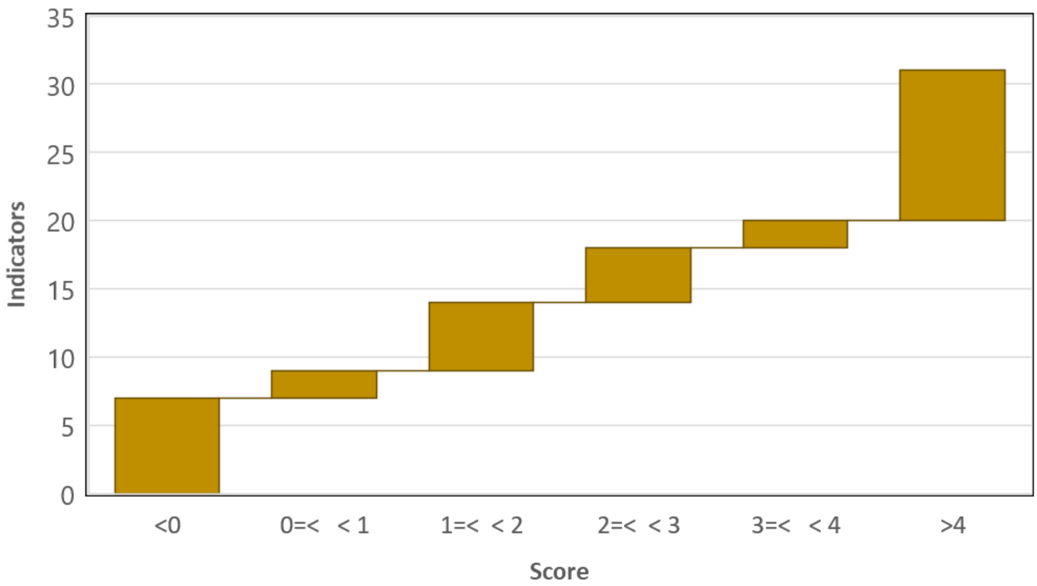

Figure 43. Distribution of Indicators in the 6 different score levels in SBTool-Moukhtara for the municipality building.

The details of the active Indicators, the benchmarks, the priorities and weighting factors, as well as the scores and actual values for the existing condition and the proposed scenarios are presented in Table 15.

Table 15. Assessment of Moukhtara municipality building (SBTool-Moukhtara), in existing condition and one scenario (S-1). For the scenarios, only the modified Indicators are presented, the others remain the same with the existing condition. Underlined values indicate that the benchmark is identical to the Generic Framework SBTool.

Code	**Indicator**	**Units**	**Benchmark**		**Priority (weight)**	**Score (Value)**	
			(0)	**(5)**			
						Existing	**S-1**

					Building	2.45	2.98
B	**Energy**				4 (23.5%)	**2.18**	**2.66**
B1	**Energy infrastructure**				3 (33.3%)	**0.26**	**0.74**
*B1.1	Primary energy demand per internal useful floor area per year	kWh/m²/yr	155	50	(16.6%)	4.86 (52.97)	
*B1.2	Delivered thermal energy demand per internal useful floor area per year	kWh/m²/yr	30	15	(16.6%)	-1 (36.17)	0.96 (27.12)
*B1.3	Delivered electric energy demand per internal useful floor area per year	kWh/m²/yr	60	5	(16.6%)	3.93 (16.8)	
*B1.4	Share of renewable energy in final thermal energy consumptions	%	20	100	(16.6%)	-1 (0)	0.31 (25)
*B1.5	Share of renewable energy in final electric energy consumption	%	20	100	(16.6%)	-1 (0)	4.38 (90)
*B1.6	Embodied non-renewable primary energy per useful internal floor area	MJ/m²	2500	2000	(16.9%)	-1 (3000)	
B3	**Materials**				2 (22.2%)	**-0.22**	**-0.22**
*B3.4	Weight of recycled materials on total weight of materials	%	15	50	(100%)	-1 (10)	
B4	**Use of potable water, stormwater and greywater**				4 (44.4%)	**2.13**	**2.13**
B4.1	Net fresh water per useful internal floor area	m3/m2	20	5	(25%)	5 (1.4)	
B4.2	Total consumption of water per building occupant	m3/occupant yr	120	50	(25%)	4.21 (61)	
*B4.3	Potable water consumption / standardised potable water consumption	%	50	10	(25%)	5 (0.05)	
B4.4	Potable water consumption / standardised potable water consumption	%	50	0	(25%)	5 (0)	
C	**Environmental Loadings**				3 (17.6%)	**1.38**	**2.13**
C1	**Greenhouse Gas Emissions**				1 (100%)	**1.38**	**2.13**
*C1.1	kg CO2 equivalents per useful internal floor area (product stage)	Kg CO2eq/m²	500	700	(33.3%)	-1 (495)	
*C1.2	kg CO2 equivalents per useful internal floor area per year	Kg CO2eq/m² year	54	28	(33.3%)	3.27 (37)	5 (17)
C1.3	kg CO2 equivalents per useful internal floor area for a period of 50 years	Kg CO2eq/m2	10	3	(33.3%)	1.86 (7.4)	2.39 (6.66)
D	**Indoor Environmental Quality**				2 (11.8%)	**2.66**	**2.66**
D1	**Indoor Air Quality and Ventilation**				1 (33.3%)	**0.69**	**0.69**
*D1.2	TVOC concentration in indoor air	µg/ m³	0.5	0.1	(50%)	2.5 (0.3)	
*D1.7	Mechanical ventilation rate per useful internal floor area	L/s/m²	0.6	1.2	(50%)	1.67 (0.8)	
D2	**Air Temperature and Relative Humidity**				1 (33.3%)	**1.13**	**1.13**
D2.1	Percentage of the time out of the range of defined interior maximum and minimum temperatures during the heating season	%	10	8	(33.3%)	4.25 (8.3)	

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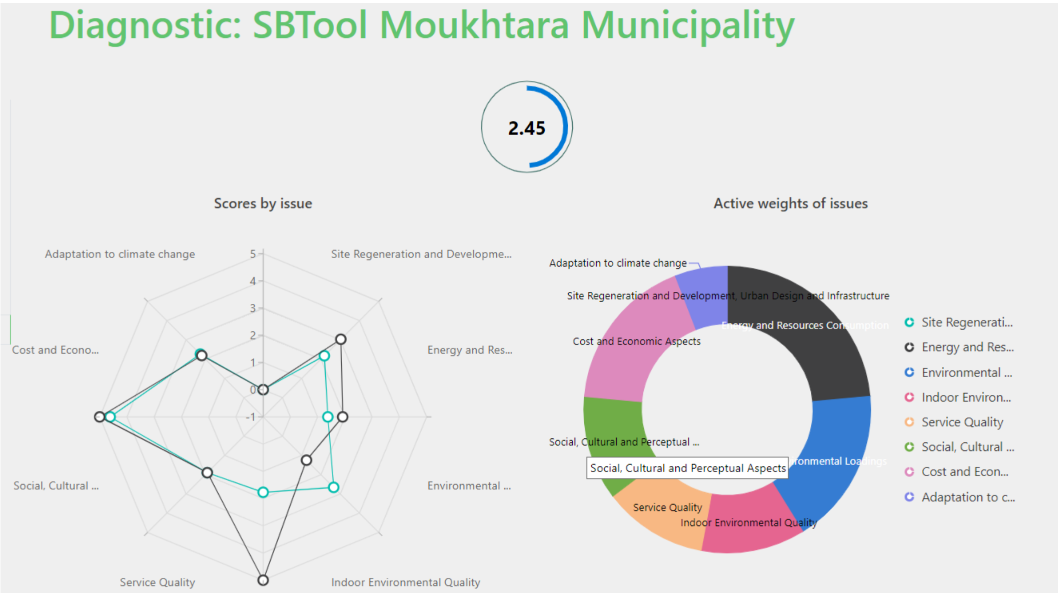
D2.2	Percentage of the time out of the range of defined interior maximum and minimum temperatures during the cooling season	%	10	8	(33.3%)	4.25 (8.3)	
*D2.3	Predicted Percentage of Dissatisfied	%	20	10	(33.3%)	1.7 (16.6)	
D3	**Daylighting and Illumination**				1 (33.3%)	**0.83**	**0.83**
*D3.1	Mean Daylight Factor	%	2	4	(100%)	2.5 (3)	
E	**Service Quality**				2 (11.8%)	**1.77**	**3.60**
E1	**Controllability**				2 (40%)	**0.13**	**1.63**
E1.1	Percentage of control functions within class A	%	50	100	(50%)	2.5 (3)	4 (90)
*E1.2	Rate the total smart readiness of buildings in terms of three key functionalities, i.e. responding to the needs of occupants, optimizing energy performance, interacting with energy grids	%	40	100	(50%)	2.5 (3)	4.17 (90)
E2	**Optimization and Maintenance of Operating Performance**				3 (60)	**1.64**	**1.96**
E2.1	The availability of a comprehensive and long-term plan at the end of Design phase, and evidence of its implementation during Operations phase	Score	0	5	(18.2%)	0 (0)	3 (3)
E2.2	The provision of energy sub-metering systems and water consumption monitoring systems, according to design documentation	Score	0	5	(54.5%)	2.5 (2.5)	
E2.3	The scope and quality of design documentation retained for use by building operators, according to design documentation	Score	0	5	(27.3%)	5 (5)	
F	**Social, Cultural and Perceptual Aspects**				2 (11.8%)	**1.90**	**1.90**
F1	**Social Aspects**				2 (40%)	**0.40**	**0.40**
F1.1	The scope and quality of design measures planned to facilitate access and use of building facilities by persons with disabilities	Score	0	5	(100%)	1 (1)	
F2	**Perceptual**				3 (60)	**1.50**	**1.50**
F2.1	Quality of view out	Score	25	75	(100%)	2.5 (50)	
G	**Cost and Economic Aspects**				3 (17.6%)	**4.62**	**5.00**
G1	**Cost and Economics**				1 (100%)	**4.62**	**5.00**
*G1.4	Energy annual cost per useful internal floor area	€/m²/yr	20	5	(50%)	4.23 (7.3)	5 (0.75)
G1.5	Water annual cost per useful internal floor area	€/m²/yr	5	1	(50%)	5 (0)	
H	**ADAPTATION TO CLIMATE CHANGE**				1 (5.9%)	**2.26**	**2.26**

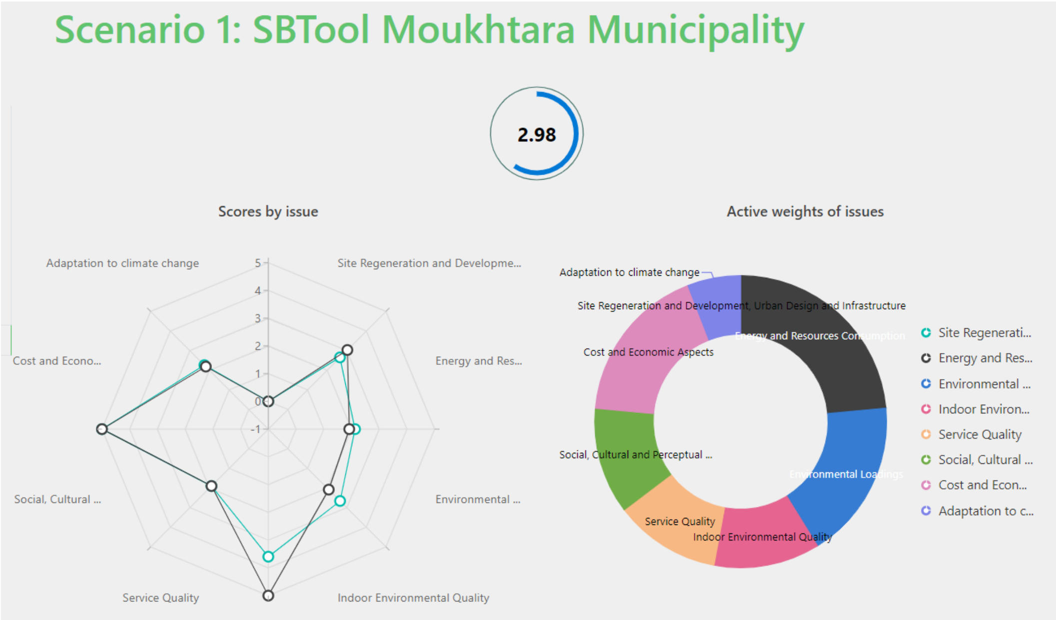
H1	**Climatic action: increase of temperature**				3 (60%)	**0.26**	**0.26**
*H1.2	Mean Solar Reflectance Index of paved surfaces and roofs in the area	SRI	20	100	(100%)	0.44 (27)	
H4	**Climatic action: drought**				2 (40%)	**2.00**	**2.00**
H4.2	Share of greywater collected and cleaned for reuse	%	80	100	(100%)	5 (100)	

* identifies the KPIs

The existing condition of the **municipality building** considered in this pilot reached a **sustainability score of 2.45** and it can be considered as significantly above the minimum requirements. Scenario 1 affected 4 Issues, 5 Categories and 9 Indicators. The sustainability score reached in Scenario 1 is 2.98, increased by 22%. The results for the sustainability assessment of the Moukhtara municipality building in the existing condition and under the scenario are presented in Figure 44.



(a)



(b)

Figure 44. Sustainability score for the existing condition (a) and Scenario1 (b).

Since only one scenario was assessed, so the **selected scenario was by default Scenario 1**. In the selected scenario **five out of eight Issues have improved sustainability scores**, as illustrated in Figure 45.

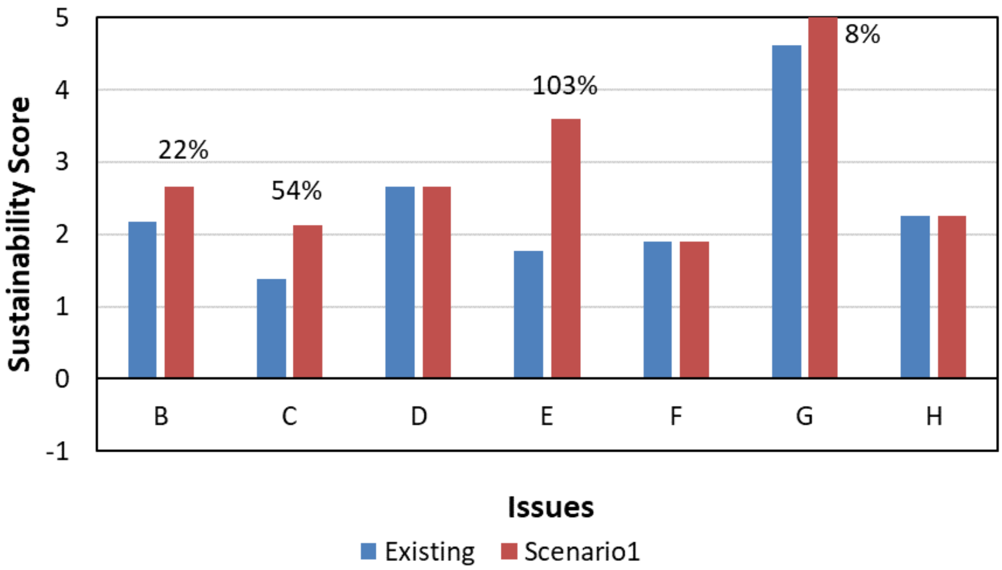


Figure 45. Issues sustainability scores of the assessed building in the existing condition and in Scenario 1.

4.3.2. Public school – Moukhtara

Name of the Building	*Moukhtara Public school*
Actual building use	*Public school- education*
Year of construction	*1960*
Level of degradation of the building	*Low level of degradation: The school was renovated in 2018, and it underwent a wide repair in walls, exterior finishes, doors, aluminium windows and paintings.*
Number of levels above earth	*4*
Number of levels underground	*0*
Heating system	*Central Heat Pumps*
Cooling system	
DHW system	*Electrical Boiler System*
Ventilation system	*Natural ventilation (Windows)*
Lighting system	*Electrical Generator – Governmental electricity.*
Average U value	*Total: 2.15 W/m²K (Exterior Walls concrete +glass*
Number of occupants	*550(students and staff)*
Hours of occupation per year	*1350 hrs per year*

In the SBTool-Moukhtara for the school building, all Indicators have the same benchmarks compared to the Generic Framework SBTool. The majority of Indicators (35%) have assessment scores above 4, while 32% have negative assessment scores, as shown in Figure 46.

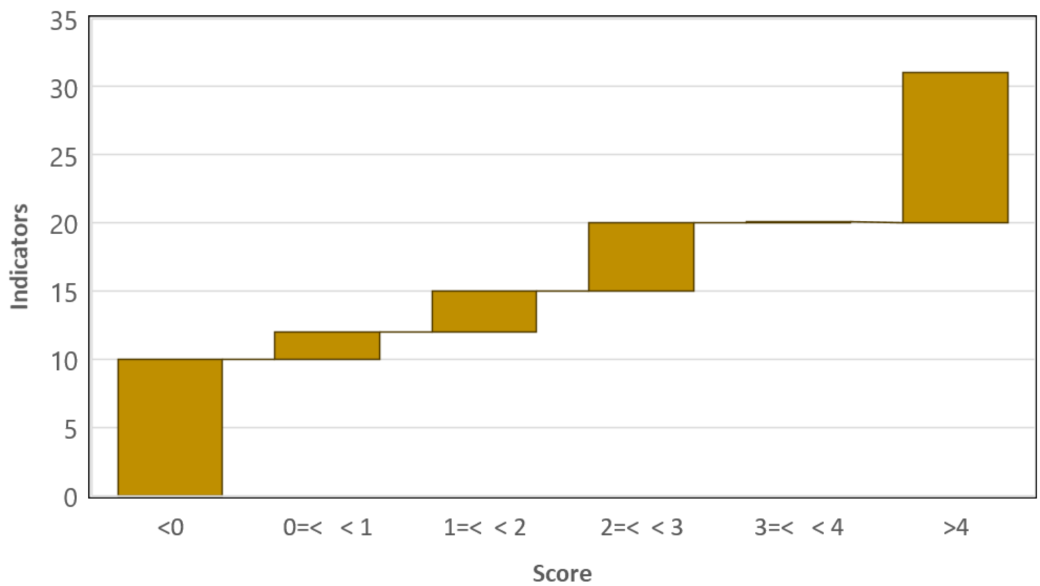


Figure 46. Distribution of Indicators in the 6 different score levels in SBTool-Moukhtara for the school building.

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The details of the active Indicators, the benchmarks, the priorities and weighting factors, as well as the scores and actual values for the existing condition are presented in Table 16.

Table 16. Assessment of Moukhtara Public school (SBTool- Moukhtara), in existing condition. Underlined values indicate that the benchmark is identical to the Generic Framework SBTool.

Code	Indicator	Units	Benchmark		Priority	Score (Value)
			(0)	(5)		
						Existing
					Building	2.39
B	**Energy**				4 (23.5%)	**2.87**
B1	**Energy infrastructure**				3 (33.3%)	**0.52**
*B1.1	Primary energy demand per internal useful floor area per year	kWh/m²/yr	155	80		5 (46.5)
*B1.2	Delivered thermal energy demand per internal useful floor area per year	kWh/m²/yr	30	15		-1 (35.2)
*B1.3	Delivered electric energy demand per internal useful floor area per year	kWh/m²/yr	120	90		5 (11.3)
*B1.4	Share of renewable energy in final thermal energy consumptions	%	20	100		-1 (6)
*B1.5	Share of renewable energy in final electric energy consumption	%	20	100		2.38 (58)
*B1.6	Embodied non-renewable primary energy per useful internal floor area	MJ/m²	432	400		-1 (3000)
B3	**Materials**				2 (22.2%)	**0.16**
*B3.4	Weight of recycled materials on total weight of materials	%	15	50		0.71 (20)
B4	**Use of potable water, stormwater and greywater**				4 (44.4%)	**2.19**
B4.1	Net fresh water per useful internal floor area	m3/m2	20	5		5 (0.84)
B4.2	Total consumption of water per building occupant	m3/occupant yr	120	50		5 (2.35)
*B4.3	Potable water consumption / standardised potable water consumption	%	100	30		5 (0.2)
B4.4	Potable water consumption / standardised potable water consumption	%	50	0		4.7 (4.8)
C	**Environmental Loadings**				3 (17.6%)	**0.71**
C1	**Greenhouse Gas Emissions**				1 (100%)	**0.71**
*C1.1	kg CO2 equivalents per useful internal floor area (product stage)	Kg CO2eq/m²	500	700		-1 (495.79)
*C1.2	kg CO2 equivalents per useful internal floor area per year	Kg CO2eq/m² year	54	28		4.13 (32.55)
C1.3	kg CO2 equivalents per useful internal floor area for a period of 50 years	Kg CO2eq/m2	10	3		-1 (26)
D	**Indoor Environmental Quality**				2 (11.8%)	**1.63**
D1	**Indoor Air Quality and Ventilation**				1 (33.3%)	**0.25**
*D1.2	TVOC concentration in indoor air	μg/ m³	0.5	0.1		2.5 (0.3)

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*D1.7	Mechanical ventilation rate per useful internal floor area	L/s/m²	0.6	1.2		-1 (0)
D2	**Air Temperature and Relative Humidity**				1 (33.3%)	**0.55**
D2.1	Percentage of the time out of the range of defined interior maximum and minimum temperatures during the heating season	%	10	8		-1 (8.3)
D2.2	Percentage of the time out of the range of defined interior maximum and minimum temperatures during the cooling season	%	10	8		-1 (8.3)
*D2.3	Predicted Percentage of Dissatisfied	%	20	10		1.7 (16.6)
D3	**Daylighting and Illumination**				1 (33.3%)	**0.83**
*D3.1	Mean Daylight Factor	%	2	4		2.5 (3)
E	**Service Quality**				2 (11.8%)	**1.77**
E1	**Controllability**				2 (40%)	**0.13**
E1.1	Percentage of control functions within class A	%	50	100		-1 (14.2)
*E1.2	Rate the total smart readiness of buildings in terms of three key functionalities, i.e. responding to the needs of occupants, optimizing energy performance, interacting with energy grids	%	40	100		1.67 (60)
E2	**Optimization and Maintenance of Operating Performance**				3 (60)	**1.64**
E2.1	The availability of a comprehensive and long-term plan at the end of Design phase, and evidence of its implementation during Operations phase	Score	0	5		0 (0)
E2.2	The provision of energy sub-metering systems and water consumption monitoring systems, according to design documentation	Score	0	5		2.5 (2.5)
E2.3	The scope and quality of design documentation retained for use by building operators, according to design documentation	Score	0	5		5 (5)
F	**Social, Cultural and Perceptual Aspects**				2 (11.8%)	**1.90**
F1	**Social Aspects**				2 (40%)	**0.40**
F1.1	The scope and quality of design measures planned to facilitate access and use of building facilities by persons with disabilities	Score	0	5		1 (1)
F2	**Perceptual**				3 (60)	**1.50**
F2.1	Quality of view out	Score	25	75		2.5 (50)
G	**Cost and Economic Aspects**				3 (17.6%)	**5.00**
G1	**Cost and Economics**				1 (100%)	**5.00**
*G1.4	Energy annual cost per useful internal floor area	€/m²/yr	20	5		5 (3.64)
G1.5	Water annual cost per useful internal floor area	€/m²/yr	5	1		5 (0)
H	**ADAPTATION TO CLIMATE CHANGE**				1 (5.9%)	**1.40**
H1	**Climatic action: increase of temperature**				3 (60%)	**-0.60**
*H1.2	Mean Solar Reflectance Index of paved surfaces and roofs in the area	SRI	50	100		-1 (27)
H4	**Climatic action: drought**				2 (40%)	**2.00**

H4.2	Share of greywater collected and cleaned for reuse	%	<u>50</u>	<u>70</u>		5 (100)

* identifies the KPIs

The **existing condition** of the **school** considered in this pilot reached a **sustainability score of 2.39** and it can be considered as significantly above the minimum requirements. The proposed retrofit actions in both Scenarios, were affecting five active Issues. Scenario 1 affected 8 Categories and 14 Indicators, while Scenario 2 affected 10 Categories and 13 Indicators. The sustainability score in Scenario 2 (1.79) is improved with regard to Scenario 1 (1.50). The results for the sustainability assessment of Arrondissement Sahloul in the existing condition and under the two scenarios are presented in Figure 47. The sustainability score of the assessed building increases by 25% in Scenario 1 and by 49% in Scenario 2.

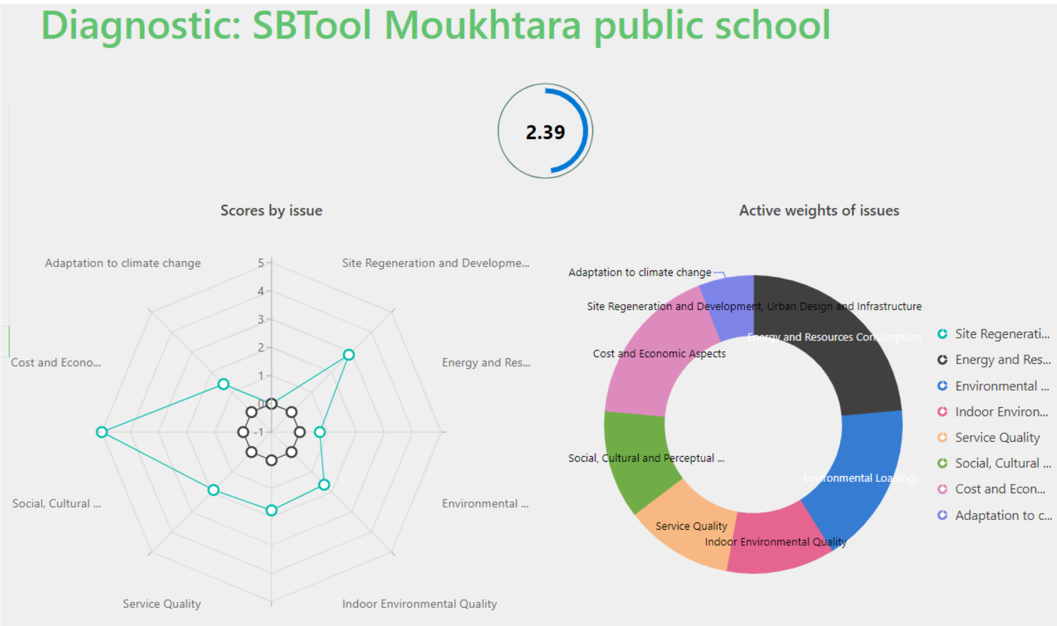

Figure 47. Sustainability score for the existing condition.

4.4. Buildings in Sousse

4.4.1. Public building - Sousse

Name of the Building	*Arrondissement Sahloul*
Actual building use	*Public building - Office*
Year of construction	*2022*
Number of levels above earth	*1*
Number of levels underground	*0*

Heating system	*Natural gas central heating*
Cooling system	*Split system air conditioners*
DHW system	
Ventilation system	*Natural*
Lighting system	*Lampes LED*
Average U value	*1.11 W/m²K*
Number of occupants	*20*
Hours of occupation per year	*3000* hrs per year

Data sources used to collect all the necessary information for the assessment included:

- Building visit, Building Permit Plan
- Atlas of neighborhoods (http://pduisousse.tn/documents/)
- Google map, Google earth
- Open Street Map
- PLU of the municipality of Sousse
- Municipality: departments
- SONEDE Invoice
- Environmental Service
- Waste collection undertaking
- National Waste Management Agency ANGED

Eight Issues are included in the SBTool-Sousse. Among them, Issue B includes the most active indicators, while Issue F the least (Figure 48).

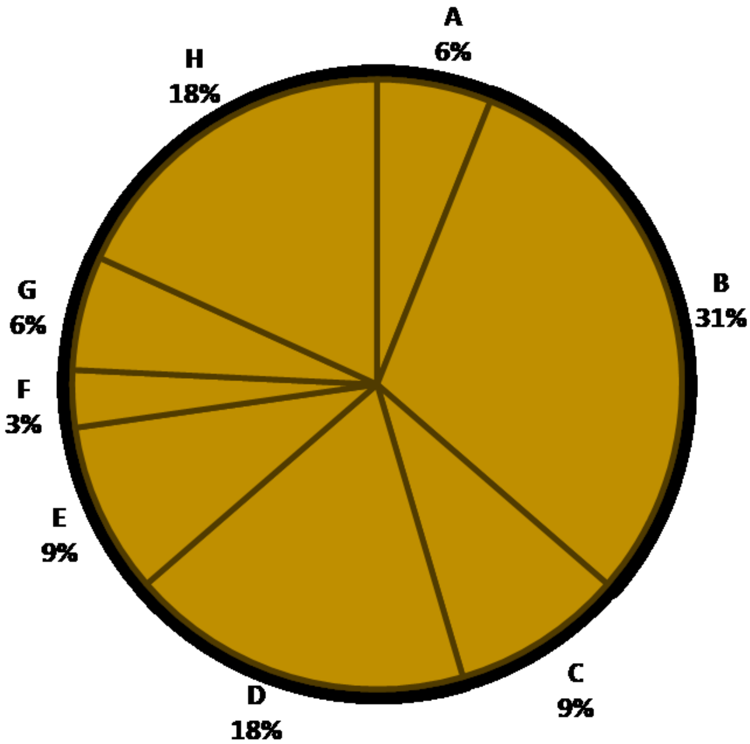

Figure 48. Distribution of active Indicators in SBTool-Sousse.

From the 25 Categories in the Generic Framework SBTool, 17 are active in the national SBTool. Five Issues have been assigned the maximum priority (5), while all others have priorities between 3 and 4 (Figure 49).

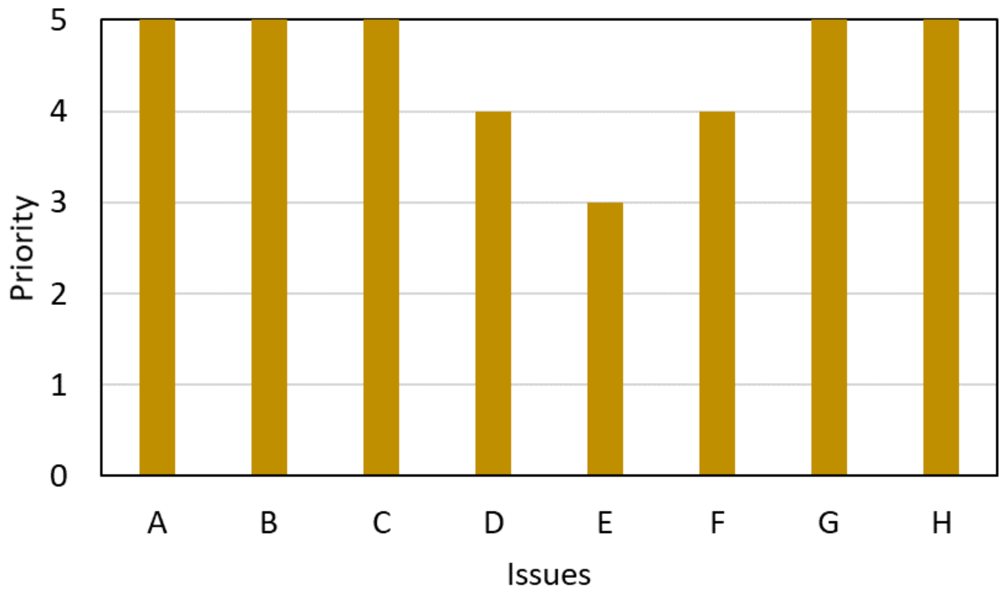

Figure 49. Priority of active Issues in SBTool-Sousse (1: minor, 5: major).

In SBTool-Sousse the majority of Indicators (73%) have the same benchmarks with the Generic Framework SBTool. Four Indicators have lighter benchmarks, while five Indicators have stricter limits. The majority of Indicators (55%) have assessment scores below minimum acceptable performance (0), while 15% have assessment scores above 4, as shown in Figure 50.

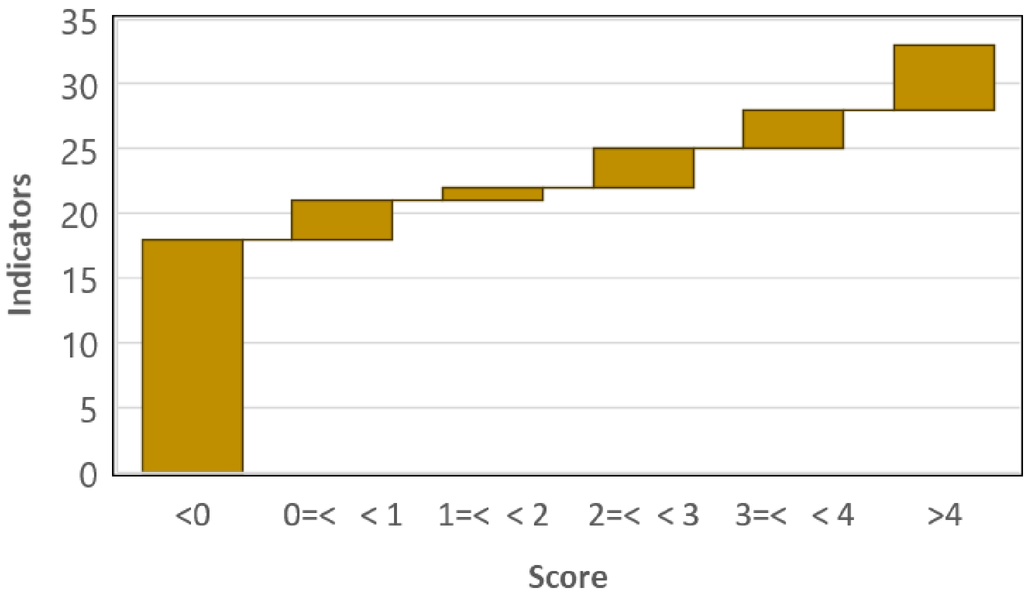

Figure 50. Distribution of Indicators in the 6 different score levels in SBTool-Sousse.

The details of the active Indicators, the benchmarks, the priorities and weighting factors, as well as the scores and actual values for the existing condition and the proposed scenario are presented in Table 17.

Table 17. Assessment of Arrondissement Sahloul (SBTool-Sousse), in existing condition and in two scenarios (S-1 and S-2). For the scenarios, only the modified Indicators are presented, the others remain the same with the existing condition. Underlined values indicate that the benchmark is identical to the Generic Framework SBTool.

Code	Indicator	Units	Benchmark (0)	Benchmark (5)	Priority (weight)	Score (Value) Existing	Score (Value) S-1	Score (Value) S-2
					Building	1.20	1.5	1.79
A	**Site Regeneration and Development**				**5 (14%)**	**0.06**	**0.31**	**0.99**
A2	**Site development**				**3 (38%)**	**0.06**	**0.31**	**0.99**
A2.2	Number of recreation services offered in outdoor areas of the building	-	3	5	(33.3%)	2.50 (4)		
A2.3	Number of bicycle parking spaces/Number of occupants	%	4	20	(66.7%)	-1.00 (0)	4.57 (18.63)	2.70 (12.63)
B	**Energy**				**4 (14%)**	**-0.36**	**0.44**	**0.49**
B1	**Energy infrastructure**				**5 (31%)**	**0.14**	**0.31**	**0.21**
*B1.1	Primary energy demand per internal useful floor area per year	kWh/m²/yr	312	200	(16.7%)	3.83 (226.23)		
*B1.2	Delivered thermal energy demand per internal useful floor area per year	kWh/m²/yr	15	5	(16.7%)	-1.00 (30.5)	0.00 (15)	0.4 (14.20)
*B1.3	Delivered electric energy demand per internal useful floor area per year	kWh/m²/yr	100	65	(16.7%)	2.82 (80.25)		
*B1.4	Share of renewable energy in final thermal energy consumptions	%	20	100	(16.7%)	-1.00 (0)	0.31 (25)	
*B1.5	Share of renewable energy in final electric energy consumption	%	20	100	(16.7%)	-1.00 (0)	0.63 (30)	
*B1.6	Embodied non-renewable primary energy per useful internal floor area	MJ/m²	432	400	(16.7%)	-1.00 (814.43)		
B3	**Materials**				**3 (19%)**	**-0.19**	**-0.19**	**-0.19**
*B3.4	Weight of recycled materials on total weight of materials	%	15	50	(50%)	-1.00 (8)		
B3.5	Weight of local materials on total weight of materials	%	80	30	(50%)	-1.00 (100)		
B4	**Use of potable water, stormwater and greywater**				**5 (31%)**	**-0.31**	**0.31**	**0.47**
*B4.3	Potable water consumption / standardised potable water consumption	%	100	30	(50%)	-1.00 (175)	0.00 (100)	1.00 (86)

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B4.4	Potable water consumption / standardised potable water consumption	%	20	0	(50%)	-1.00 (60)	2.00 (12)	
C	**Environmental Loadings**				**5 (14%)**	**2.97**	**2.97**	**2.97**
C1	**Greenhouse Gas Emissions**				**5 (42%)**	**1.30**	**1.30**	**1.30**
*C1.1	kg CO2 equivalents per useful internal floor area (product stage)	Kg CO2eq/m^2	3.1	2.2		2.72 (2.61)		
*C1.2	kg CO2 equivalents per useful internal floor area per year	Kg CO2eq/m^2 year	54	28		3.53 (35.62)		
C3	**Solid Wastes**				**4 (33%)**	**1.67**	**1.67**	**1.67**
C3.1	Weight of waste and materials generated per m2 of internal useful floor area	Kg/m^2	54	28	(100%)	5.00 (0.01)		
D	**Indoor Environmental Quality**				**4 (11%)**	**1.19**	**1.31**	**1.64**
D1	**Indoor Air Quality and Ventilation**				**4 (22%)**	**0.03**	**0.14**	**0.21**
*D1.2	TVOC concentration in indoor air	μg/ m^3	0.5	0.1	(50%)	-1.00 (0.6)	0.00 (0.50)	0.63 (0.45)
*D1.7	Mechanical ventilation rate per useful internal floor area	L/s/m^2	0.6	1.2	(50%)	1.25 (0.75)		
D2	**Air Temperature and Relative Humidity**				**4 (22%)**	**-0.22**	**-0.22**	**0.04**
*D2.3	Predicted Percentage of Dissatisfied	%	20	10	(100%)	-1.00 (35)	-1.00 (25)	0.2 (19.60)
D3	**Daylighting and Illumination**				**4 (22%)**	**0.56**	**0.56**	**0.56**
*D3.1	Mean Daylight Factor	%	2	4		5.00 (4.7)		
D3.2	Level of daylight provision		1	3		0.00 (1)		
D4	**Noise and Acoustics**				**3 (17%)**	**0.83**	**0.83**	**0.83**
D4.1	$D_{2m,nT,w}$ - Weighted standardized level difference for traffic noise (sound insulation)	dB	27.5	38.5	(100%)	5.00 (54)		
E	**Service Quality**				**3 (8%)**	**-0.50**	**0.88**	**1.25**
E1	**Controllability**				**4 (50%)**	**-0.50**	**0.00**	**0.33**
*E1.2	Rate the total smart readiness of buildings in terms of three key functionalities, i.e. responding to the needs of occupants, optimizing energy performance, interacting with energy grids	%	40	100	(100%)	-1.00 (23.06)	0.00 (40)	0.67 (48)
E2	**Optimization and Maintenance of Operating Performance**				**4 (50%)**	**0.00**	**0.88**	**0.91**
E2.1	The availability of a comprehensive and long-term plan at the end of Design phase, and evidence of its implementation during Operations phase	Score	0	5	(25%)	0.00 (0)	1.00 (1)	1.30 (1.3)
E2.2	The provision of energy sub-metering systems and water consumption monitoring systems, according to design documentation	Score	0	5	(75%)	0.00 (0)	2.00 (2)	2.00 (2)
F	**Social, Cultural and Perceptual Aspects**				**4 (11%)**	**1.50**	**1.50**	**1.50**

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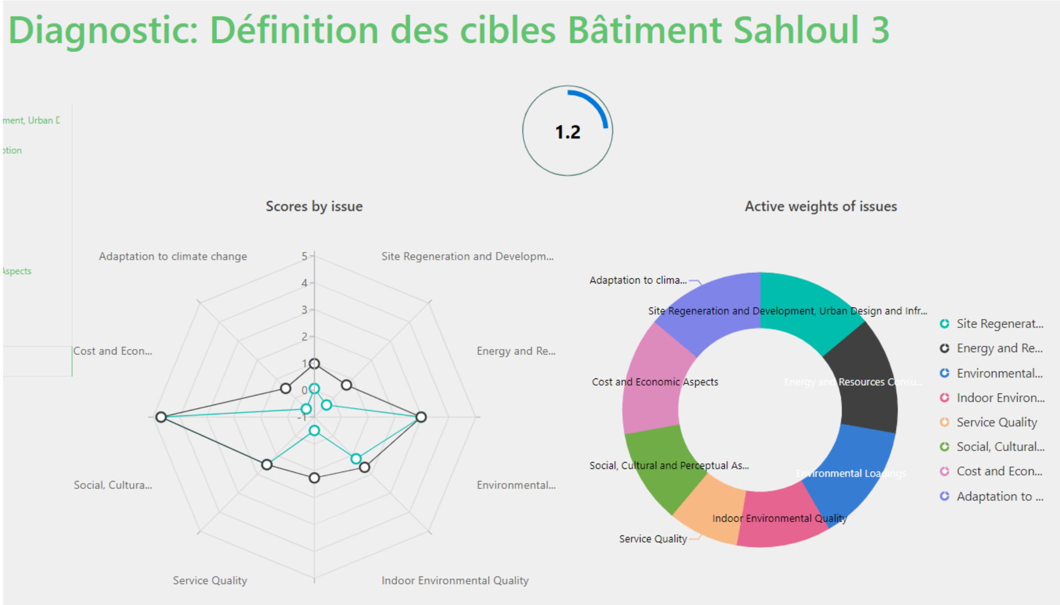
F1	**Social Aspects**				**3 (50%)**	**1.50**	**1.50**	**1.50**
F1.1	The scope and quality of design measures planned to facilitate access and use of building facilities by persons with disabilities	Score	0	5		3.00 (3)		
G	**Cost and Economic Aspects**				**5 (14%)**	**4.70**	**4.70**	**4.70**
G1	**Cost and Economics**				**4 (100%)**	**4.70**	**4.70**	**4.70**
*G1.4	Energy annual cost per useful internal floor area	€/m^2/yr	70	20	(50%)	4.40 (25.97)		
G1.5	Water annual cost per useful internal floor area	€/m^2/yr	7	2	(50%)	5.00 (1.29)		
H	**ADAPTATION TO CLIMATE CHANGE**				**5 (14%)**	**-0.57**	**-0.38**	**0.51**
H1	**Climatic action: increase of temperature**				**4 (19%)**	**-0.19**	**0.00**	**0.26**
*H1.2	Mean Solar Reflectance Index of paved surfaces and roofs in the area	SRI	50	100	(42.9%)	-1.00 (27.8)	0.00 (50)	2.00 (70)
H1.3	Percent of building envelope with orientation between West and South East that will be covered by vegetation during the warm season (June 12st)	%	30	70	(28.6%)	-1.00 (5)	0.00 (30)	0.70 (35.60)
H1.4	Leaf Area Index: ratio of total vegetated surface area (on ground and on roofs, and including trees), divided by total site area	%	30	70	(28.6%)	-1.00 (8)	0.00 (30)	1.00 (38)
H2	**Climatic action: pluvial flood**				**4 (19%)**	**-0.19**	**-0.19**	**0.06**
H2.1	Share of the on-site stormwater retention capacity in relation to the optimal retention capacity	%	20	50	(50%)	-1.00 (15.38)		1.67 (30)
H2.2	Share of the site that is permeable to water	%	50	100	(50%)	-1.00 (8)		
H4	**Climatic action: drought**				**4 (19%)**	**-0.19**	**-0.19**	**0.19**
H4.1	Share of rainwater collected and stored for reuse from roofs and plot's paved area	%	50	100	(100%)	-1.00 (0)		1.00 (60)

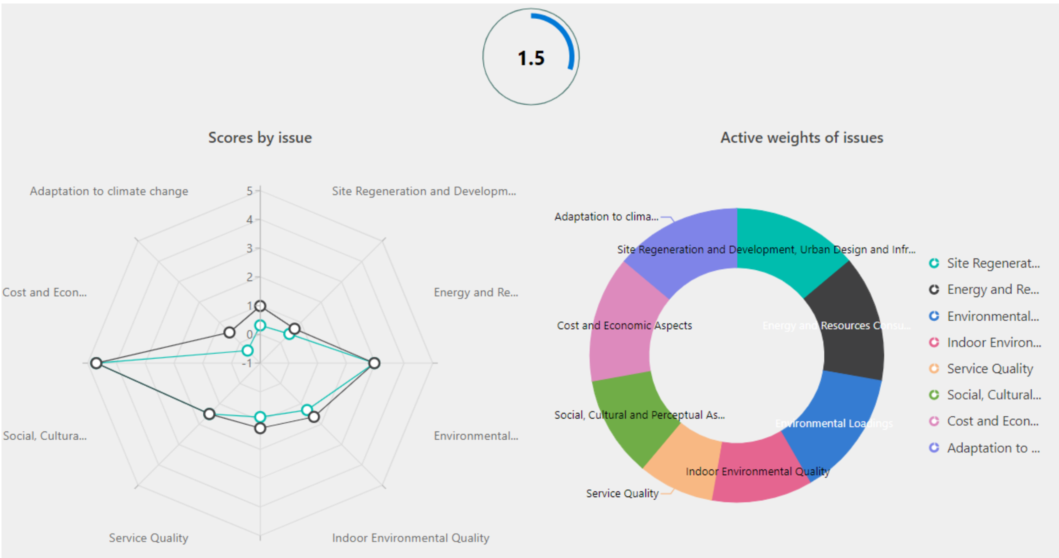
* identifies the KPIs

The existing condition of the **building** considered in this pilot reached a **sustainability score of 1.20** and it can be considered as above the minimum requirements that can be improved. The proposed retrofit actions in both Scenarios, were affecting five active Issues. Scenario 1 affected 8 Categories and 14 Indicators, while Scenario 2 affected 10 Categories and 13 Indicators. The **sustainability score in Scenario 2 (1.79)** is improved with regard to Scenario 1 (1.50). The results for the sustainability assessment of Arrondissement Sahloul in the existing condition and under the two scenarios are presented in Figure 51. The sustainability score of the assessed building increases by 25% in Scenario 1 and by 49% in Scenario 2.

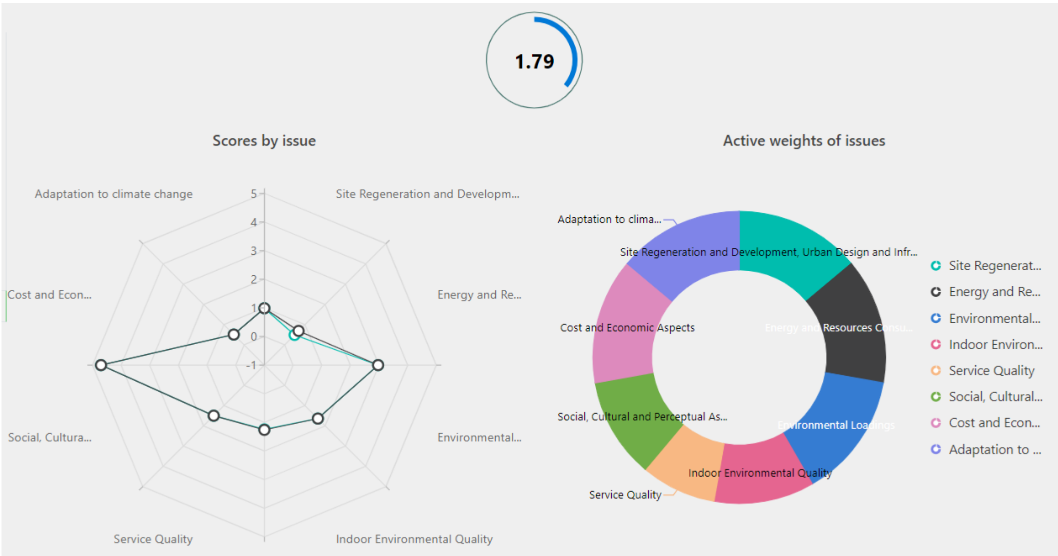
Diagnostic: Définition des cibles Bâtiment Sahloul 3



(a)



(b)



(c)

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Figure 51. Sustainability score for the existing condition (a), Scenario1 (b) and Scenario2 (c).

Although Scenario 2 has the greater improvement of the building sustainability score, the **selected scenario was Scenario 1, through the participatory approach**. In the selected scenario **five out of eight Issues have improved sustainability scores**, as illustrated in Figure 52.

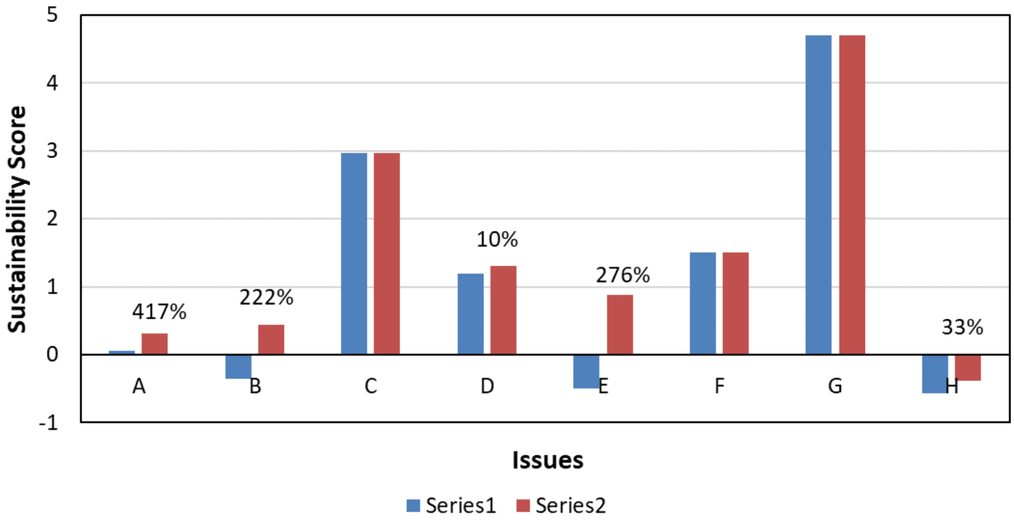

Figure 52. Issues sustainability scores of the assessed building in the existing condition and in Scenario 1.

5. Conclusions

The SMC system was used in the field during **eight pilot studies** in the three South-East Mediterranean cities to demonstrate its applicability in diverse applications at different building uses and urban areas.

The main purpose of the pilots was, **to develop the national versions of the tools**, by

- working together with local experts and municipalities,
- selecting a suitable number of Indicators and
- incorporating representative national weights for the different sustainability issues and benchmarks for normalizing the indicator values.

The national pilots also **revealed** some interesting information on the **most popular sustainability Indicators** that were selected by each national team, illustrating the emphasis and the priorities given by the participating municipalities.

The national tools **include the same KPIs**, but **use** a **different number of Issues, Categories and Indicators** that best fit in the national and local context and their sustainability priorities. Each team selected from the pool of Indicators included in the Generic Framework the ones that are most relevant according to their national sustainability priorities and are commonly encountered at regional-local issues.

According to the pilot test results, the selected number of sustainability Indicators **averaged 33 for both building and neighborhood scale**, with the exception of **SNTool-Irbid which had 73 active Indicators**. The sustainability Issue that has **attracted more emphasis** based on the number of selected indicators was **B-Energy** with 25% to 32% of the total number Indicators used.

Following the SMC decision-making methodology, each municipality had to assess one urban area and two buildings at the existing condition and evaluate at least two renovation scenarios, so as to be able to rate the proposed scenarios and select the most suitable one (Table 18).

However, there were some deviations from the initial plan. The Municipality of Moukhtara elaborated only one scenario for their pilot study of the urban area and the first building, while for the second building no scenarios were elaborated beyond the existing condition. Similarly, the Municipality of Sousse assessed only one building. As a result, the Municipalities of Mouhkhata and Sousse did not follow all the steps of the

SMC methodology. Only the Municipality of Irbid completed all the steps of the SMC methodology for both the neighborhood and the building scale.

Table 18. Pilot studies performed in the three Municipalities.

	Irbid	Moukhtara	Sousse
Urban area			
Existing condition	✓	✓	✓
Scenario 1	✓	✓	✓
Scenario 2	✓		✓
Building 1			
Existing condition	✓	✓	✓
Scenario 1	✓	✓	✓
Scenario 2	✓		✓
Building 2			
Existing condition	✓	✓	
Scenario 1	✓		
Scenario 2	✓		

Lessons Learned

- *The selection of the indicators to be assessed is a very crucial element of the assessment procedure. They reflect the emphasis and the priorities on the various sustainability issues that is placed by the participating municipalities.*
- *The number of selected indicators is of vital importance. There isn't a fixed number of indicators that should be selected, beyond the Key Performance Indicators (KPI), which are mandatory, since they represent a minimum amount of information for addressing sustainability. However, the selection of a large number of indicators is not recommended, since that will increase the amount of necessary data, the time for collecting the necessary information and as a result increase the overall complexity of the method. This may then have a negative*

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impact on the assessment procedure and the final result. Based on the field case studies and previous experience, the average number of selected indicators is about 35-45.

- *Like in every audit process it is essential to collect good quality data, since this will have a direct impact on the overall quality of the assessment results.*
- *In general, data acquisition may be time-consuming. Information may be scattered among different administrative bodies of the municipalities and other organizations (e.g., building authorities, cadastral office, land surveying office) and other resources like census data, municipality and regional reports (e.g., operational programs), existing energy performance certificates, energy supply companies, along with publicly accessible resources (e.g., Google Earth, Open Street Map), etc. Even provisionally available data may prove difficult or even impossible to retrieve, underlying the fact that data availability is as important as data accessibility.*
- *In case of non-available data, educated assumptions or use of default values may be needed for quantifying some indicators. In this case, one needs to be aware of the resulting uncertainties or inaccuracies involved in a given approach and the ways to interpret and use the results.*
- *In all cases, a site visit is necessary in order to perform field inspections of the buildings and the neighborhood and to collect missing data or verify and extend available information.*
- *Finally, among the direct benefits resulting from the pilot studies, is the motivation and support it provides to get organized and initiate a housekeeping process within the municipality.*

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