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DOI
10.1007/s10669-022-09869-9

Publication date
2022

Document Version
Final published version

Published in
Environment Systems and Decisions

Citation (APA)
Ghennaï, A., Madani, S., & Hein, C. M. (2022). Evaluating the sustainability of scenarios for port city development with Boussole21 method. *Environment Systems and Decisions*, *43*(1), 87-106. https://doi.org/10.1007/s10669-022-09869-9

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https://doi.org/10.1007/s10669-022-09869-9

Evaluating the sustainability of scenarios for port city development with Boussole21 method

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Accepted: 30 June 2022

Abstract
This research aims to evaluate the sustainability of urban strategies in Skikda, a prehistoric, ancient, and Mediterranean port city of northeastern Algeria, known as by the Punic name Russicade. The port city of Skikda shows a diverse landscape of heritage sites and the industrial reality of a city, rich by its under-exploited cultural and tourist capacities. Nevertheless, the industrial port activities of the petrochemical refinery impose a state of urban vulnerability for the inhabitants and built, landscape, and natural heritage. The use of the open software Boussole21 of the "Smart" trend as a qualitative method allows assessment of decisions by the actors. The sustainability assessment (findings) shows that smart thinking contributes to the development of port performance and competitiveness in the international context.

Keywords Smart port cities · Assessment · Sustainability · Boussole21 · Skikda · Algeria

1 What are the particularities of port cities in the transition?

Port cities are a particular type of cities; port and city exist on a sea land continuum and intersect within an urban context. Port and city activities intersect in an area often labeled interface (Da and Xu 2016; Davenport 1980; Teschner 2018). Yet the impact of ports extends beyond the edge of the water into the hinterland, creating an extended network of port city spaces: a port cityscape (Hein 2019). Traditionally, port and city actors have collaborated to create resilience, (Hein and Schubert 2020) with benefices for both port and city in a shared space. They have effectively created a commons (Avni and Teschner 2019), manifested in spatial locations and temporalities (Teschner 2018), following a dual evolution process between spatial, and functional changes, (Aouissi and Madani 2017; Murphey 1989). For a long time, port leaders and citizens shared the benefits of trade and shipping. As a result, citizens would accommodate environmental and security challenges or infrastructural needs, meanwhile port leaders would use their knowledge for the advantage of both. In the second half of the twentieth century, containerization and industrialization led to the separation of port and city and the revitalization of former historic ports.

Containerization may be the most visible factor in port city separation, but other industrial activities have long required a certain separation of port and city. Petroleum storage, refining and transportation has become a key element in the development of global ports over the last hundred fifty years. The global increase of petroleum consumption since the 1950s has further promoted the creation of large industrial areas. New oil or gas installation emerged in port areas and creating a new energetic and geographic interface that affected the urban landscape (Couling Hein 2018, 2010). Ports all over the world facilitated global flows of oil, and built extensive infrastructures for the transport, storage, and transformation of petroleum, including refineries, storage tanks, and pipelines.

Over the contemporary challenges of climate change, the need to reduce CO2 emissions and to adopt sustainable practices have an impact on port city regions (Sparrevik et al. 2021). Petroleum ports have long been a key actor of environmental pollution of air, land and water. They need to engage the energy transition to preserve their competitiveness, economic standing (Laxe et al. 2016), but also the attractiveness and cultural values of the cities

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Published online: 05 August 2022

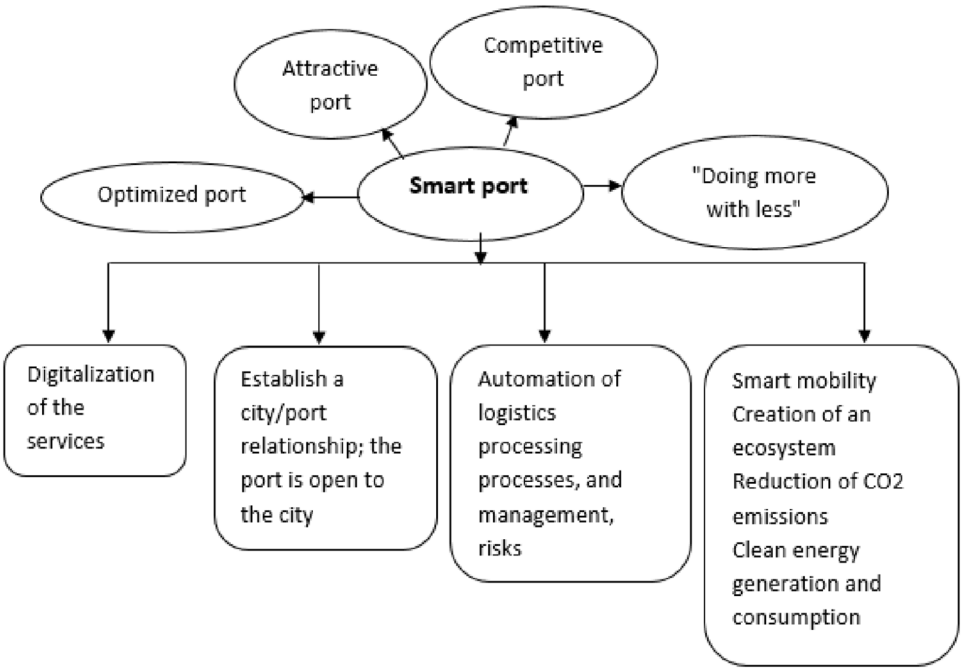

Fig. 1 Explanatory diagram of the "smart port" concept (Source: Authors, 2019)

nearby—for example for cruise ship purposes. Ports such as Rotterdam are developing sustainable strategies in order to become a smart and greener port as part of their license to operate. This new generation of high-performance and sustainable ports (Bichou et al. 2014; Lytras and Visvizi 2019) considers green growth investment an economic and a crucial driver for its maritime and operational activities (Froholdt 2018; Fenton 2020). They focus on reducing CO_2 emissions (Geller 2003), and producing energy for their functioning (Harilaos & All 2019).

The Port of Rotterdam is recognized as one of the smart port in the world, evidenced through its high smart port index SPIs (Dalaklis et al. 2022) and thanks to its optimized operation, safety, security, Smart Environmental, Energy Sub-Indices (Molavi et al. 2020; Antão et al. 2016), and its sustainability initiatives at port city interference (Alamoush et al. 2021). The Port of Rotterdam has succeeded to achieve the smartness and the effectiveness, using automation of key processes and activities (Gurzhiy et al. 2021), and innovative technologies, such as IoT sensors that allows bringing together and harmonizing all port stakeholders and port operations through a digital database, for instance of the common platform PortXchange shared via API links. This port also adopts the technology of "digital twin", which enable the increase of the intelligence of the port services, through the technology of simulation of the physical characteristics of the port, which enable it to test rapidly, change variables, and optimize the time of services and port operations (Dalaklis et al. 2022; Gurzhiy et al. 2021; Kellett et al. 2007) (Fig. 1).

In the last decade, former oil and industrial ports are emerging as abandoned brownfield sites (Rey & Lufkin 2015). These sites need special attention as underused land resources, and require cleaning up of historic environmental pollution. (De Valck et al. 2019). In contrast to earlier waterfront redevelopment projects that incorporated historic harbors (Porfyriou and Sepe 2017), these areas are much bigger and require different revitalization approaches for the next generation of waterfront regeneration. Soil clean-up and reuse of the sites, will require more sophisticated interventions that consider natural ecosystems at a landscape scale. Such interventions are needed, particularly in former petroleum areas, where the costs of clean-up are high, where transition processes have to be initiated, and where new approaches and concepts are needed to rethink these spaces and their heritage. These interventions also need to reconsider the role of the port as a commons for the city and develop tools that can bring diverse stakeholders together to develop the shared functions and spaces of port, city and the region (Lévesque 2010).

2 Skikda: a case study for sustainable port transformation

Using the case of Skikda, a seaside city located in the North East of Algeria and an important commercial and petroleum terminal, this paper assesses the process of scenario development and discussion for finding shared perspectives for ports and cities as they are faced with redevelopment and energy transition questions. Skikda's port and city development

faces a complex network of stakeholders, including the local community, port and petroleum actors, as well as public entities. Port city stakeholders have different interest, missions and goals in exploiting port city spaces (Ng et al. 2015). Nonetheless, given the environmental impact of port activities on the surrounding environment, users and the public need to have a voice in the management and proper operation of the port. Tools are needed to facilitate the interconnection and collaboration dialogue between the different key actors and stakeholders (Humphreys et al. 2019). The Algerian port city of Skikda serves an example or the potential use of value deliberation tools taking into account stakeholders' objectives and values, in line with sustainable development (Kumar 2017; Humphreys et al. 2019). Using numeric tools, this research aims to bring diverse stakeholders together in the planning process to assess future scenarios, to overcome petroleum dependency and to engage with sustainability (Villeneuve et al. 2009).

The article specifically asks: How can a sustainability assessment tool, like Boussole21 help improve transparency, and facilitate discussion around the transformation of the mixed port of Skikda that engages/challenges the natural environment (beaches, ecosystems), and historic landscapes? Assessing the current challenges of port extension in Skikda requires knowledge about the history's long past, its particular heritage and the city's emergence as a petroleum port. Skikda has a long history and is home to particular heritage and culture. Skikda has Phoenician, Roman, Ottoman, and French port traces. (Dumont and Rougé 1975; Meirat 1964; Vars 1896). Acknowledging and preserving these places is a key aspect of sustainability, for a smart port city, that understand heritage as an important value.

Skikda has been known since ancient times as an agricultural town. The richness of its lands reached the other side of the Mediterranean through its ancient ports of Ras lahdid, Kef Fatima, Guerbez, Wadi Tanji, Wadi Bibi, Collo and Stora, which are only marginalized remains today. Historically, the port of Stora has undergone many changes; Phoenicians created the port, and then the Romans exploited it. During the French colonization, the port of Stora, was renewed and enlarged to the current location of the actual mixed port, with its new characteristics, the port had become a contemporary port in its time. After independence, Algeria had transformed the port of Stora into a fishing and pleasure port; and the new French port became the actual mixed port. Once the Skikda refinery was established, the mixed port was developed to be able to export oil, but this port will be known as the old port, after the construction of the new port named "Port El-Djadid" specialized as a terminal for oil, gas, and hydrocarbons.

The oil port of Skikda is the second port in Algeria. Its port infrastructure and petrochemical specialization connect the Algerian economy to the Mediterranean and international markets. The export of hydrocarbons gives a strategic and political dimension and requires a new technical standard for a more sophisticated and sustainable conditions. The local authorities in Skikda, had developed their ports and diversify these areas between hydrocarbons, miscellaneous trade, tourism and leisure. After independence in 1962 and with the industrial revolution of the seventies, the port infrastructures have undergone operations of rehabilitation and extension, in order to meet the technical and economic needs of the new petrochemical complex, above the coast of Skikda.

The changing fate of the petroleum industry, notably the two oil crises of the 1970s and 1980s, have had a strong impact on the country's port cities and their citizens. Industrial risks such as the violent and the deadly explosion at the Liquefied Natural Gas (LNG) complex of Skikda in 2004, revealed the risks associated with gas-connected terminals (United Nations 2004). After this dramatic accident, the Algerian government classified the industrial area of Skikda, including the port area of hydrocarbons, as an area of major risk. (According to articles 32 to 37, of the Official Journal of the Democratic and Popular Algerian Republic No. 84, corresponding to 29 December 2004,[1] and the Article 2 of the Official Journal of the Democratic and Popular Algerian Republic No. 33, on 21 May 2006 (Fig. 2) [2]).

Algeria, a North African oil giant (Bardot et al. 2010), exports hydrocarbons mainly by sea. In 1979, the government decided to create three sites for the export of hydrocarbons by sea; in the east, they choose Skikda, in the center Algiers and in the west, they choose Oran. Each one of these port cities has assumed a major importance in the Algerian petroleumscape (Hein 2018), which connects the maritime terminals for the export of gas and petroleum products in the Algerian North with the extraction sites in the Algerian South. Oil and gas reservoirs were discovered in Algeria in 1956 at the heart of the Algerian desert in Ejelah and Hassi Messaoud, after the independence, Skikda, developed as the Northeast oil port. Over the next decade, the government placed the city in the center of its oil industry and infrastructure. Today, Algeria has six refineries for processing crude oil. The Northern refineries are located in Skikda, Algiers, Arzew and Oran; Whereas, the Southern refineries are distributed in the Algerian desert on Hassi Messaoud and Adrar. Currently, Algeria has two more refineries under construction, the first is located in the Algerian North at Tiaret, and the second is placed in the South, at Hassi Messaoud. This includes two units for hydrocracking fuel oil,

[1] Pdf link: https://www.joradp.dz/FTP/JO-ARABE/2004/A2004084.pdf?znjo=84.

[2] Pdf link: https://www.joradp.dz/FTP/JO-ARABE/2006/A2006033.pdf?znjo=33..

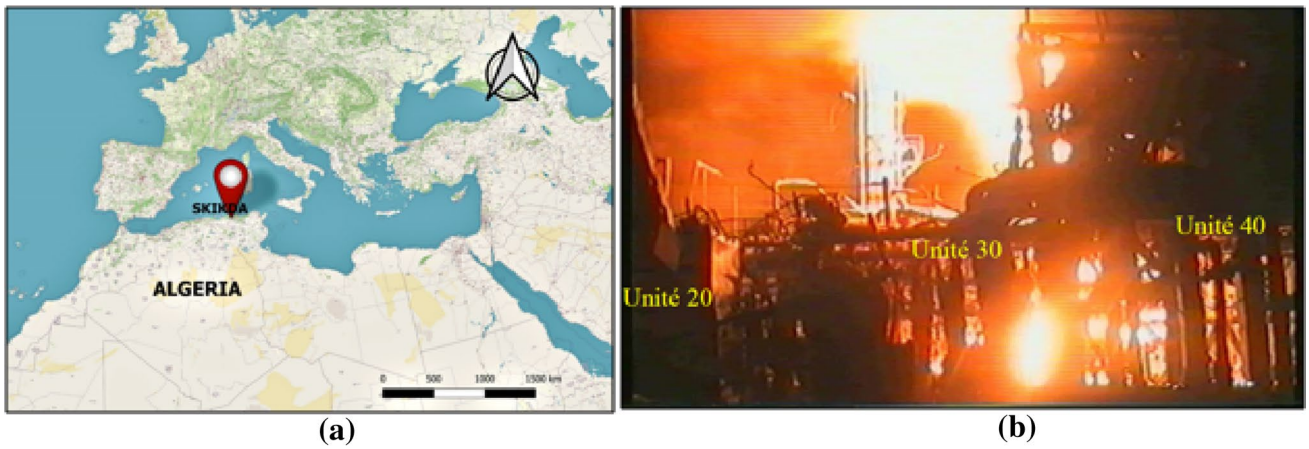

Fig. 2 **a** Location of Skikda **b** the explosion of LNG Unit at Skikda in 2004 (Source: **a** Authors, by Qgis, 2021; **b** Civil Protection of Skikda, 2004)

and processing naphtha surplus at Skikda, and four natural gas liquefaction complexes and separation by abbreviation LNG and LPG, at Skikda and Arzew. Overall, there are eight Algerian oil infrastructures in progress.[3]

Today, Skikda has five ports: the mixed port, the hydrocarbon port (port El-Djadid), and the three fishing and pleasure ports, Stora, El Marssa and Collo. Both the mixed port and the port El-Djadid, have a focus on petroleum; the mixed port is characterized by trade, shipping and oil, includes a hydrocarbon station. Meanwhile, the El-Djadid port is only specialized on petroleum; it is connected directly at the natural gas liquefaction complex named GL1K. Indeed, Skikda, it has been one of the pillars of the Algerian economy and one of the most industrialized cities in the country, for its industrial port activities and petrochemical refinery. The industrial petroleumscape of Skikda consists of two refineries, named RA1.K, and the Topping Condensate refinery, RA2.K. It includes two units of fuel oil hydrocracking and treatment of excess naphtha, two complexes of natural gas liquefaction and separation named GL1K and GL2Z, the petrochemical complex CP2K, two petrochemical complexes in partnership, Complex Helison, and Complex Helios (Fig. 3).[4]

3 Future port planning in Skikda

Due to environmental pollution, various fires within the refinery, the operations of extensions for the port and oil infrastructures in historic areas and the degradation of the heritage, Skikda has become a vulnerable city. Industrial port activities threaten the lives of the citizens, the city's identity, and maritime heritage, natural and urban landscape. The existing port is a major risk zone next to a millennial port city like Skikda. Future extension plans will have an effect on the evolution of the urban tissue, the safety of the inhabitants, the quality of life, heritage, tourism, and the socioeconomic opportunities allied to Skikda's sustainable development.

The port of Skikda needs expansion to allow for modernization and shortening of turn-around times, and to be able to keep pace with the development of the increasing size of container ships, introducing the need for larger ports, which require more intense dredging and deeper drafts (Rodrigue 2022). Therefore, it is necessary to increase its reception and loading capacities of the port of Skikda, in order to optimize the time of containers loading and unloading. Currently, the main logistical and technical problems of the ports of Skikda, are due to the dredging depth, where drafts are not so deep in order to meet the requirements of the advancing naval architecture and the ship size development. In addition, the lack of space for the export of petroleum products, and the inability of the ports to attract tankers or large ships, due to the old characteristics of both the mixed port and the hydrocarbon port.

In order to solve these logistical problems at the ports of Skikda, the port authorities turn to major Mediterranean ports, such as the port of Marseille, to receive large ships bound for Algeria, but which are not compatible with its ports. Then, the port company of Skikda sends smaller ships to distribute the load of large ships on the smaller size consistent with the Algerian modest ports. This process is expensive, and reduces the performance of the port as a strategic and economic infrastructure of the country. Therefore, the authorities aim to improve the port performance (Asgari

[3] Official WebSite of Sonatrach, (2020). URL:https: //sonatrach.com/, Accessed 10 January 2020.

[4] Idem.

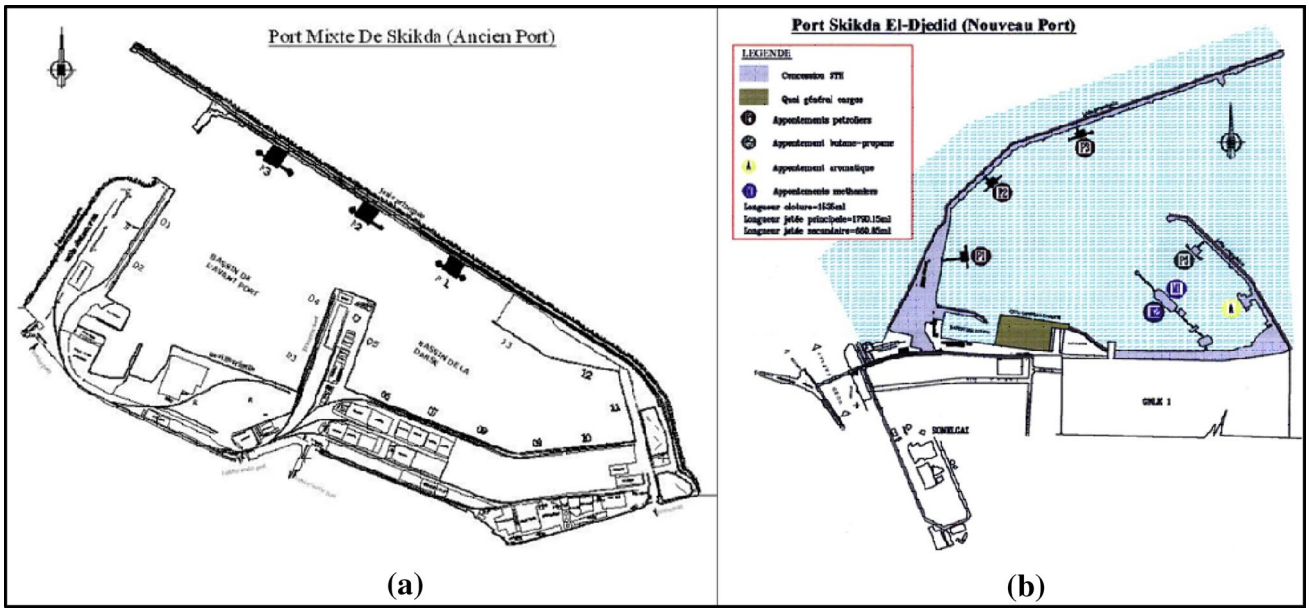

Fig. 3 **a** The plan of the mixed port of Skikda **b** the plan of the hydrocarbon port of Skikda (Source**:** EPS, Skikda)

et al. 2015) of Skikda ports, making them more accessible and attractive for tankers at the international scale.

For this purpose, the main task of the different actors is the rehabilitation of the hydrocarbon stations of the mixed port and the extension of the whole port, by the creation on the east side, a third deep water basin with drafts ranging from 15 to 17 m. The proposed extension of the port comprises a container terminal and larges docks with length from 300 to 500 m and full land dedicated to the storage of goods and containers with a total area of 90 hectares, in order to accommodate large vessels, tankers and large container ships. Also, the project consists of the construction of a ferry terminal at international standards and a Marina for pleasure and relaxation.

Since 1982, the ports of Skikda have been managed and operated by the EPS (Enterprise Port of Skikda), (according to Decree No. 82–284 of 14 August 1982. And amendment of the articles of association by share dated 21 March 1989).[5] According to the Direction of the Works Port of Skikda authorities, The EPS is also involved in the development, in conjunction with the other authorities concerned, of programs for the maintenance and development of port infrastructure. At present, the ports of Skikda are being developed and adapted to the new standards of international ships and ports. Our study focuses on the latest port extension operations to the benefit of Skikda mixed port, planned since 2012.

In 2012, the port company of Skikda (EPS) together with local authorities, launched a study for the rehabilitation and extension of both the mixed port of Skikda and the port El-Djdid of hydrocarbon. For the port El-Djadid, specialized in hydrocarbons, its operation of extension consisted on the rehabilitation of the existing oil docks and the creation of a new jetty in the oil port connected to the petrochemical refinery and natural gas liquefaction complex, and the creation of a new general terminal. The project is co-financed by the Port Company of Skikda and the National Company Sonatrach, known as the first hydrocarbon group in Africa. Sonatrach serves the entire hydrocarbon value chain, and is therefore concerned with the development and exploitation of the mixed port of Skikda.

The constructions in port El-Djadid started in 2019 after the selection of companies assigned to the realization of these maritime projects in Skikda, and will be soon achieved. Sonatrach has to pay taxes for sole occupation and pollution to Skikda state, which makes it one of the richest states in Algeria. Sonatrach, also contributes to the public funds, and participates in the financing of cultural and sports manifestations, the economic projects of infrastructure and spatial development of Skikda. This extensive funding from the oil company raises many questions about the effectiveness of the local policy in the city development, which suffers from a clear delay compared to its important economic incomes of oil.

[5] Official Website of the port of Skikda, (2020). URL: https://www.skikda-port.com/.Accessed in 10 January 2020.

The multiplicity of functions of the mixed port of Skikda leads to involvement of multiple stakeholders in its redevelopment, including the EPS and Sonatrach as operators of this maritime infrastructure; also, they are mainly invited to contribute to financing the expansion projects. In addition, the Direction of Public Works (DTP), a directorate attached to the Algerian Ministry of Public Works and Transport, is a key actor in this project. As it is the sector in charge of the realization, maintenance and development of basic infrastructures, the respect of standards, the application of technical regulations, the quality of studies, materials and works and the compliance with the specifications for public service concessions.

Furthermore, the maritime sub-sector is the greatest challenge and a major concern of the Ministry of Public Works, as 95% of the country's foreign trade transits by sea and mainly 98% of hydrocarbons. The DTP, is responsible for the design, realization and maintenance of marine and port infrastructures and marine signaling establishments (port lights, staking lights, lighthouses…). Also the conservation and police of the natural marine domain.[6]The DTP can also obtain a financial envelope from the Algerian state in order to fund the port expansion and rehabilitation project. It is also delegated to organize the tenders for technical studies, where the DTP had selected for this mission, the Algerian laboratory of Maritime Studies (LEM).

The mixed port and the oil port of Skikda, attracts the attention of the Algerian state as one of the economic gateways of the country. The port authorities envisage the extension of Skikda mixed port, for improvement and development of the port performances. This paper explores the sustainability of the scenarios currently under discussion, taking into consideration the historical, natural and sociocultural values of Skikda using Boussole21.

Boussole21, is a numerical tool for decision support, it is designed on the basis of Agenda 21, for various planning projects or urban strategies. It brings together all stakeholders in a round table to discuss the project from their different views. This planning tool can help stakeholders to take a decision (Brassard et al. 2007), but definitely, it cannot impose it. In addition, the use of smart planning tools, the reorientation of the planning to the sustainable development way and the energy transition, aims to contribute to the emergence of the new generation of smart ports. Thus, it will facilitate the needed paradigm change in the approach towards port policy, and it will assess value deliberation tools, this paper examines three scenarios proposed by the Algerian laboratory of Maritime Studies (LEM 2020; Denoual, 2010).

The ports of Skikda need to assess current urban development strategies in terms of sustainability and assess new scenarios in light of the performance of the port, the benefits for the city, its maritime identity, its history and its sociocultural aspects. The focus on this integration of space, society and culture is a new step in port planning. As Table 1 shows, questions of environmental, spatial and social sustainability have ranked low on the priority list of ports in the past century, whereas technological innovation, extended global networks or digitization were leading concerns. Recently, questions of environmental sustainability and energy transition have come to rank higher (Srinivasan et al. 2011).

Skikda ports are facing several challenges: the evolution of maritime trade, the industrial risks, heritage protection, and the need to respond the demands of the pressing development of the technology of the port industry and ships. Deciding on the key orientation of the port is difficult as the multiple actors has diverse goals. The port authority aims to improve the performance of the port by making it more accessible and competitive in its national and regional context. The DTP executives want to create a port that depends mainly on the functions of loading and unloading, equipped with an industrial installation area, the improvement of the port aims at the competitive absorption of new maritime flows expected by the Chinese Silk Road project. In the other hand, Sonatrach as an oil company is interested in the rehabilitation of the oil posts of the mixed port. The LEM, seeks to exploit the coast of Skikda for the benefit of improving the technical characteristics of the port, while citizens and the associations of Skikda want to keep the picturesque character and natural landscape of the tourist and historical area of Stora.

According to DTP and EPS authorities, the project for Modernizing the port of Skikda is needed to increase reception capacities of large vessels with capacities ranging from 50,000 to 250,000 tons and to facilitate the loading and unloading capacities of grain and petroleum products. However, port development does not mean only developing its technical capabilities, but also engaging with the perspectives of the sustainable development of the port city interface (Annual report of Skikda port 2018).[7] Therefore, this extension will not only improve the old port infrastructure, first, it will also host the pleasure port, introducing the possibility of opening the port on the city. Second, improvement involves the creation of a new gas terminal, also for liquid and solid products, two new marine stations P4 and M3, with capacity ranging from 50,000 to 250,000 tones, with the redevelopment of existing stations, where M3 will be adapted to GNL unit, and M2, will be converted for gas loading (GPL).[8]

[6] Official Website of the Algerian Ministry of Public Works and Transport, (2020), http://aaca.mtpt.gov.dz/mtpt2019/.Accessed 19 December 2019.

[7] Pdf link: Link: http://www.skikda-port.com/wp-content/uploads/2019/06/Annuaire-2006.pdf.

[8] Official Website of the port of Skikda, (2020). URL: https://www.skikda-port.com/.Accessed in 10 January 2020.

Table 1 Port classification by generation including the generation of smart ports based on The UNCTAD and WORKPORT models of port development (Source: Authors, 2020)

The port's generations	1st generation of ports	2nd generation of ports	3rd generation of ports	4th generation of ports	5th generation of ports
Time period	–	1960–1980	1980–2000	2000–2020	2020 >
Sustainability and safety	Weak sustainability prospects	Hazardous impact on employees because of the manual nature of work tasks	Reduction of manual talks and expansion of automation	Development of safety and environmental standards	ports have become more sustainable thanks to the character of energy autonomy, this new generation of port is able to cover its energy needs by its own energy production, as a kind of energy self-sufficiency
Mobility	Marine transport/ground transport interface	Industrial and economic freight	Logistics platform for international transport	International transport	Port ITS (Intelligent transport system)
Port operation and activities	Freight transportation	Transportation of passengers, or goods Industrial and commercial activities	Integration of logistics for distribution	Diversification of activities-Logistics and transport chain between ports	Build a large connected Logistics community Multimodal Services
Port/City Dialogue	spatial and functional dissociation between the port and the city	Close and occasional relationship between port and city	Integration of the port into the transport chain	Dry port connected to the seaport	The port is open to the city in a sustainable way
Information System	Telegraph Like an information system	Manual or paper information	Fiber optic telecommunications system (telephone, fax, mail)	Telematics network ports (EDI) electronic data interchange networks	Smart Networks Big data technologies
Scale	Local/regional	Relation with hinterlands	World containerization	Internationalization by connecting seaports and collaboration between other ports	Internationalization

The Algerian laboratory of Maritime Studies LEM presented two main proposals, which together contain three scenarios, for developing Skikda mixed port. After a long cursus of draft presentation, discussion, study days and the amendment, between LEM, DTP, EPS, the state authorities and SONATRACH, the works were delayed due to a lack of funding. The Port Company (EPS) funded only 30 percent of the financing, while the state retreated from financing the project due to the current economic conditions of the country. Sonatrach has also withdrawn support for this project, because it focuses just on the funding of the port hydrocarbon extension. Currently, the authorities studied other opportunities that may finance this important project. (DTP, EPS Skikda 2020).

The three scenarios proposed by LEM, all aimed at attracting larger tankers and ships by providing more docking spaces for ships with a deeper draft than those already existing at the port of Skikda. Scenario 1 proposes the widening of the embankments of the mole named The Green Castle, located in the west of the mixed port in front of the historical area, which dates back to the French colonial period with some traces of Roman installations. The second proposal, includes scenario 2 and scenario 3. Scenario 2 concerns the creation of new docks to the west side of the port, by occupying along the maritime cornice towards Stora's pleasure port. Located in the ancient Gulf, and dating back the Phoenician period. Scenario3 proposes the creation of a new dock to the east of the port on a site called the Goat Island. The east side of the port occupies an industrial site, where the industrial zone extends from Wedi Zranma and beyond Wadi Safsaf, which is a stream named after the willow trees in the region, where the Phoenicians settled on this riverside in the antiquity. The long-term histories of these sites are largely lost due to urbanization and the industrialization (LEM, DTP 2012).

The laboratory LEM, in charge of developing the scenarios, used the numerical tool Mike 21, to assess the impact of the new extension of the mixed port to the east side of the existing port, the port extension linking the mixed port and the port of Stora, and the effects of the front protection structures (LEM, DTP 2012). Mike 21 allows for modeling ecology, oil spills, water quality, and other environmental aspects[9] such as the risk of silting. Sustainable development was not really a major preoccupation in the goal of LEM, EPS or DTP, who focused on the improvement of the port performance to the benefit of the fast economic gains. One of the authors therefore used the Boussole21 tool to assess the sustainability dimension of the different scenarios. This software is based on a qualitative questionnaire under the criteria of the Agenda 21, following the principle of «Think globally and act locally». The analysis and evaluation of this project are made according to the recommendations of the experts of the port of Skikda and the DTP, based on the smart city concept, a dimension not included in the conception of the mixed port extension (Fig. 4).

3.1 The first variant: SCENARIO 1

The current scenario 1, gives the possibility of expanding the port to the west side of the mixed port in the zone named Green Castle beach, by creating a new jetty and another pool besides the two existing pools.

Description: Variant 1 proposes the development of the current waterfront, including the Beach named the Green Castle, and Paradise Beach, with a new rectangular roadstead, connected to the existing pier by a new infrastructure in the West. The new concrete platform will mark the new port's boundary, and a polluted industrial sprawl that affects the historical heritage of Stora, and the rare biodiversity of the small island Serigina (Fig. 5).

3.2 The Second variant

The second variant, presents both the scenario 2 and the scenario 3. Scenario 2 concerning the operations of redevelopment of the west side of the mixed port. Scenario 3 proposes the extension of its east side. Each of these two scenarios creates an industrial landscape with extensive impact on the historical and natural sites of Skikda.

3.2.1 SCENARIO 2

Description: Scenario 2 proposes the construction of new docks and maritime protection to the west of the existing port. It suggests the implementation of the project in a linear way on the maritime coast, and the destruction of the seafront beaches. This project involves the transformation of the Stora Cornice through the creation of a new road. The existing shoreline will be redeveloped in four zones that have three "T" protective ears. This project will create a link between the mixed port and the port of Stora, as a single port entity, and open a part of the mixed port to the public. It provides the opportunity to connect a project and new marina to the mixed port with the port of Stora, intended for fishing and pleasure. This scenario will create an artificial concrete area that consumes the beautiful beaches of Skikda (Fig. 6).

[9] Website of Mike 21: https://www.mikepoweredbydhi.com/.

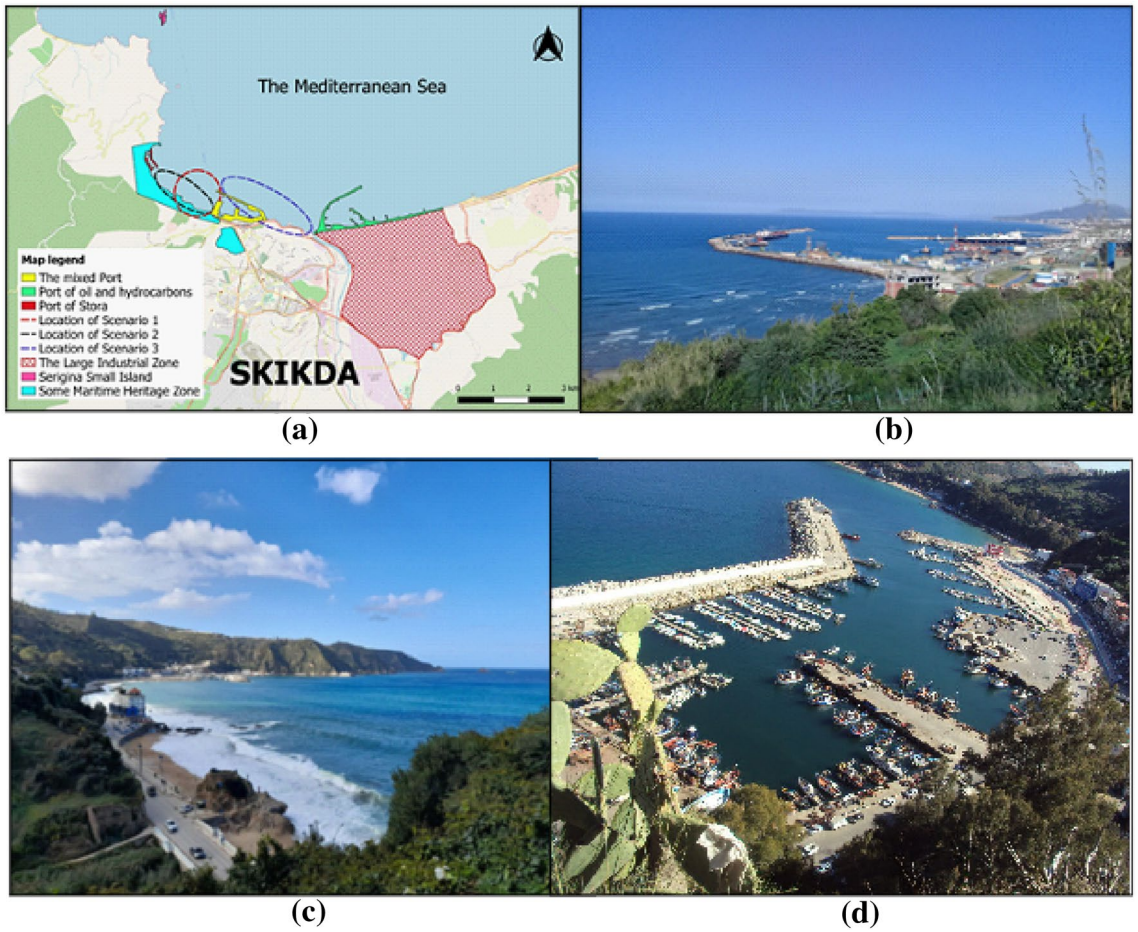

Fig. 4 **a** Location of mixed port, oil port, and port of Stora, with the location of the three scenarios, **b** Port El-Djadid for oil and hydrocarbons, **c** a view on the cornice of Stora, **d** fishing and pleasure port of Stora (Source: **a** Authors, by Qgis, 2021; **b**, **c**, **d** Authors, 2021)

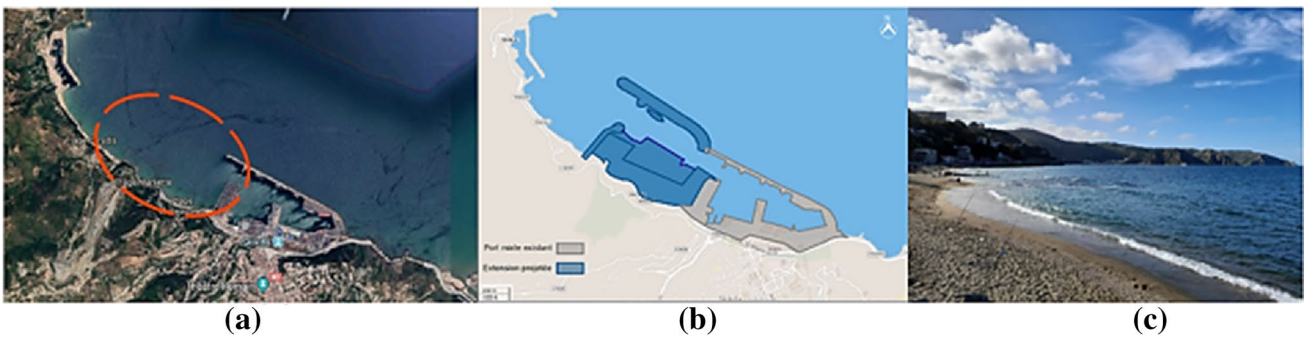

Fig. 5 **a** Delimitation of the extension zone for scenario 1, **b** Scheme of scenario 1 extension, **c** View on the location of beaches where LEM suggest the site of scenario 1, the Beach of Green Castle (Source: **a** Authors, 2019, **b** Authors, DTP Skikda, LEM Laboratory, 2022; **c** View by Authors, 2021)

3.2.2 SCENARIO 3

Description: Scenario 3 proposes the creation of a third deep water basin on the east side with draughts ranging from 15 to 17 m. The plan includes a plan for docks ranging in length from 300 to 500 m and full land dedicated to the storage of goods and containers with a total surface of about 90 hectares to accommodate large grain vessels and large

Fig. 6 **a** Delimitation of the extension zone for scenario 2, **b** Scheme of scenario 2 extension, **c** View on the location of beaches where LEM suggest the site of scenario 2 (Source: **a** Authors, 2019, **b** Authors, DTP Skikda, LEM Laboratory, 2022; **c** View by Authors, 2021)

Fig. 7 **a** Delimitation of the extension zone for scenario 3, **b** Scheme of scenario 3 extension, **c** View on the future location of Scenario 3, linked to the front of the mixed port 3 (Source: **a** Authors, 2019, **b** Authors, DTP Skikda, LEM Laboratory, 2022; **c** View by Authors, 2021)

container vessels. The site dedicated to the realization of scenario 3 will form a link between the hydrocarbon port and the mixed port. Only Wadi Zarmana, a water stream that has become a dump, will separate them. The new extension will form a continuous industrial port landscape, oriented to the opposite side of the historical Gulf of Stora. However, this will not prevent water pollution due to the oil and industrial port activities, threating the city, the natural and the historical seascape, the archeological heritage, and the rare marine biodiversity of Serigina Island located in the Gulf of Stora (Fig. 7).

4 Assess of Scenarios with Boussole21

4.1 Material and method

To better understand the logic of urban planning and urban actions at the port city interface and improve the port and city collaboration, we collected relevant data on urban and port activities and development concerning the upcoming transformation of the port and city of Skikda. This work took more than three months; it was sustained by an internship in the port's enterprise of Skikda, with regular visits to the department of the environment, the department of public works (DTP), and collaboration with some civil associations. The collected data has been processed by a numerical method that includes the dimension of sustainable development. We used the open software Boussole21, a tool for project evaluation, in order to evaluate the three different scenarios proposed by the national laboratory of maritime studies by abbreviation LEM, for the extension of the mixed port of Skikda. Boussole21 is a tool for decision support shared by key actors in urban or architectural development project (Vastveit et al. 2014).

There is No specific indicators exist for evaluating the risk management that are universally or widely accepted. Therefore, indicators are selected from various tools used to measure sustainability in various fields. These tools are Sustainability Reporting Guidelines G4 provided by the Global Reporting Initiative, RST02 grid (France), Boussole21 grid (Belgium), International Urban Sustainability Indicators List (IUSIL). The reference framework for European sustainable cities, Sustainable Transportation Performance Indicators (STPI), and risk management performance criteria proposed through the action framework led by the International Strategy for Disaster Reduction (ISDR) (Edjossan-Sossou et al. 2014). Boussole21 is an adaptation of the Bernese boussole, one of the oldest Swiss evaluation tools; it was selected for analysis (Villeneuve 2007), in order to find suggestions for criteria, objectives and indicators, and ideas for implementation. It was chosen because it allows for qualitative sustainability analysis of projects at the regional level, requires little

Table 2 Summary's Criteria of Boussole21 tool (Source: http://www.boussole21.ch/)

Economy	Environment	Society
1.1. Creation and wealth distribution	2.1. Biological diversity and natural space	3.1. Health Prevention and safety
1.2. Framework Conditions for the Economy	2.2. Energy	3.2. Training, education, sports and cultural activities
1.3. Competitiveness of the economy and innovation	2.3. Mobility and territory	3.3. Social cohesion
1.4. Public finances	2.4. Material consumption and recycling	3.4. Living environment and public space
1.5. Feasibility and viability of the project	2.5. Soil and water management and quality	3.5. Rights and safety
1.6. Compliance and suitability for needs	2.6. Indoor and outdoor air quality	3.6. Governance, political and associative life
	2.7. Climate change and risks	

time and resources, and provides an interesting graphical presentation of the results (Bergsma 2012).

There are many different scenario analysis methods (Zhe & Hayder 2020), but they all share the same core principles and the same key steps.[10] Among a wide range of sustainability assessment tools from different geographical contexts (Kaur & Garg 2019), Boussole21 gives an easier online access than other assessment tools, with respect to the Naviko tool, and the Checkliste Interessen-abwägung Nachhaltigkeit tool. The latter tool shares with Boussole21 a great similarity in form and content, although they mark a dissimilarity in the orientation of some questions, and the type of access to the assessment tool's support. Boussole21 is accessible directly online, and it is sufficient to create an account with an e-mail address, this tool gives a simple and fast method, it allows comparing variants of the same project, but not a various project in the same time. Thus, Boussole21 gives a good overview of the effects of the project. Whereas, the tool Checkliste Interessen-abwägung Nachhaltigkeit, is accessible through the download of an Excel file from the official website of the developer, this tool allows for the comparison of alternatives, although it poses shortcomings in differentiating long and short term impacts can lead to ambiguous formulations, and the process can take a significant amount of time. (Comparaison d'outils d'évaluation, d'analyse et de questionnement du développement durable, 2017[11]; Guide des outils d'évaluation de projets selon le développement durable, 2004.[12]

Boussole21 aims to define the strengths and weaknesses of a project in relation to three dimensions of sustainable development: economy, environment and society. The evaluation of each criterion is presented on a circular plan, in 19 portions with symmetrical poles, where each pole presents a criterion or a sub-criterion, weighted equally, and uniformly distributed over the diameters of the radar. These criteria—and further sub-criteria— are examined through a questionnaire that requires in-depth knowledge of the project under evaluation. Table 2 below summarizes all the criteria of Boussole21. The latest version of the tool is used in this project to evaluate the scenarios for the future extension of Skikda ports proposed by the national laboratory of maritime studies (LEM) in 2012. This laboratory was entrusted by national procurement method, to the study of the project, because of its state character and its technical and logistical capacities, which allow it to adapt to the size and the requirements of the project study (Staudt 2011).

The result of the evaluation is presented in the form of a radar diagram or radar chart to provide a full report of assessment for each scenario. The radars that translate the results of each scenario help clarify the adaptability of each proposed scenario in relation to the three pillars of sustainable development and the exigencies of Agenda 21.Therewith they help stakeholders make a decision based on scientific analysis and choose the best presented scenario.

Through an internship at the EPS Skikda, in 2018, we had the opportunity to be close to the different experts of LEM, EPS, and DTP. Together with these experts, we explored the scenarios for the development of Skikda's port by answering the questions of the "Boussole21" tool. The analysis focused on sustainable development dimension, taking into consideration the protection of the port heritage in Skikda, the natural landscape, and the ecosystem of the Gulf of Stora, that are threatened by the risks of pollution and irreversible damage. We answered the entire questionnaire, giving an evaluation that varies on a scale from A to X, with the possibility to extend the discussion about the evaluation scale under three fields mentioned in the software Boussole21,

[10] Link:https://www.are.admin.ch/dam/are/fr/dokumente/nachhaltige_entwicklung/dokumente/instrumente_nhb.pdf.download.pdf/2_Plateforme-ED_Instruments_existants.pdf.

[11] Link:https://developpementdurable.wallonie.be/sites/dd/files/2018-11/2017%2003%2008_Comparaison%20d%27outils%20EAQDD_SPW_CAADD.pdf.

[12] Link:https://www.vd.ch/fileadmin/user_upload/themes/environnement/developpement_durable/fichiers_pdf/ARE_outils_evaluation.pdf.

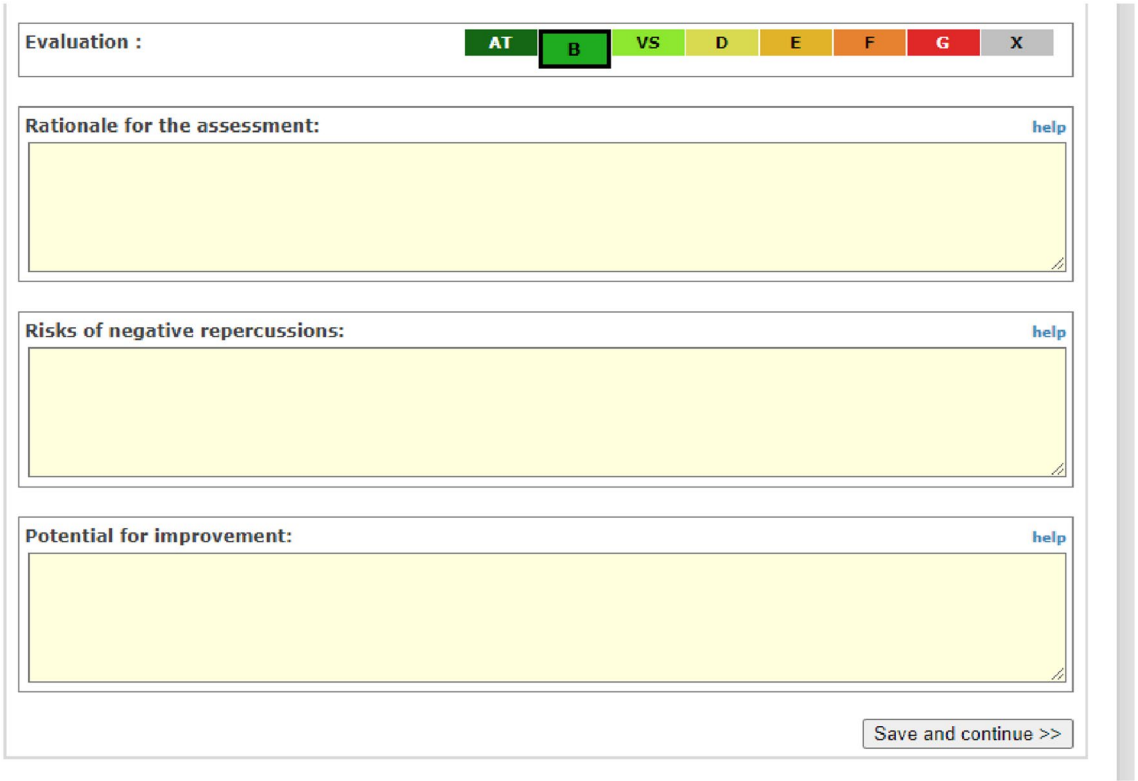

Fig. 8 The evaluation colorful scale of Boussole21, and three fields for more information about the evaluation (Source:http://www.boussole21.ch)

which are Rationale for the assessment, risks of negative repercussions, and the potential for improvement.

The three fields dedicated to more detailed information or additional data help with the assessment. According to Boussole21 guide, the first field is dedicated to the Rationale for the assessment, it helps to explain the score given to the criterion. The second field concerns the risks of negative impacts; it highlights the points where the project presents risks of deviating from the objectives of sustainable development, in the immediate future or during likely future developments. The third field addresses the potential for improvement, highlighting where the project has untapped potential for improvement, either immediately or in the case of likely future developments. These fields will accompany the Boussole21 users through the multi-criteria evaluation process (St Flour & Bokhoree 2021) (Fig. 8).

4.2 Evaluation of the three scenarios by Boussole21

The complexity of the Skikda ports between cultural heritage and the oil industry requires careful assessment of the different scenarios. Using this tool (Boussole21) allows to identify the positive and negative impacts of the project, and to take a step back by diagnosing all of its impacts on the economy, society and the environment. It allows to build a global vision of the compatibility of a project with sustainability objectives and provides a real support to move from a sectorial and often reductive vision to a global vision of a project. As a decision-making tool, Boussole21 offers the various stakeholders a solid and concrete basis for an objective and constructive discussion.[13] Most of the instruments to evaluate sustainability in municipal governments of Switzerland, developed by the Federal Office of Spatial Development and by different cantons, are sectorial. The only comprehensive evaluation instrument is Boussole21 developed by the Canton of Vaud (Schneider et al. 2018).

Boussole21 seems the adequate tool to assess the current scenarios, given the principles of the software that consider heritage and culture protection as one of the important criteria of evaluation. The inclusion of these aspects is important to predict and prevent the negative impact of industrial development or transformation on the historical heritage and the shared memory of Skikda, which date back to antiquity. In the case of Skikda mixed port scenarios, the filling in of the information fields of Boussole21: Rationale for the assessment, Risks of negative repercussions, Potential for improvement, is based on the data provided by the main

[13] http://www.boussole21.ch/pdf/jalons8_boussole21_150dpi.pdf

Table 3 Table of analysis of the three scenarios (Source: Authors, 2020)

Scenarios	Rationale for the assessment	Risks of negative repercussions	Potential for improvement
Scenario 1	The extension of the port to the West in front of and anchored into the natural landscape of the beaches, impacts economic activities related to tourism	The implantation of the project on the west side of the existing port means the spread of the industry to the coast of Skikda Despite anti-pollution measures, the project remains located in the heart of the city, creating a source of nuisance, of risks and pollution, especially with its oil specialization, which affects also the rare biodiversity of the small Island Serigina	The ambitions of the authority in order to open part of the mixed port to the public imply the cleaning and redevelopment of the mixed port. The space dedicated to port reconversion will be blocked between two industrial and vulnerable spaces
Scenario 2	The citizens refuse the development of the natural landscape to an industrial carpet	Disfiguration of the landscape character Disappearance of all the natural beaches on the coast of the Municipality of Skikda. The city will have no natural beach!	This scenario of redevelopment and artificialization of the beaches between the seafront of Skikda and Stora, is not enough to welcome the tourists, nor for the protection of the coastline, which will be well disfigured What remains as natural beaches in Skikda must preserve the aspect of the natural landscape in the face of industrial sprawl; it also requires the support of the State and citizens in order to exploit its naturel, historical and touristic diverse capacities, for an alternative source of income
Scenario 3	The exploitation of the offshore areas densifies to the project. It avoids the consumption of the coast and the beaches of Skikda	Port activities affect the rare biodiversity of the small island of Sergina, and the maritime heritage of Stora	The location of the project between the mixed port and the oil port creates a single mass of a port for petrochemical activities and an oil landscape in an area already designated as an industrial zone. In this case, the development of the port is dense and does not consume other natural areas

Table 4 Table of evaluation for the three scenarios using the scale evaluation of by Boussole21 (Source: Authors, 2020)

The economic pillar				The environmental pillar				The pillar of society			
Evaluation : A B C D E F G X											
Criteria	Evaluation of scenarios			Criteria	Evaluation of scenarios			Criteria	Evaluation of scenarios		
	1st S	2ndS	3rd S		1st S	2ndS	3rd S		1st S	2ndS	3rd S
Creation and wealth distribution	D	D	D	Biological diversity and natural space	G	G	G	Health Prevention and safety	D	E	D
	C	X	A	Energy	G	F	G	Training, education,	D	G	D
Framework Conditions for the Economy 1.3. Competitiveness of the economy and innovation				Mobility and territory	B	B	A	sports and cultural activities Social cohesion			
Public finances	E	X	B	Material consumption and recycling	F	G	E	Living environment and public space	A	D	A
Feasibility and viability of the project	B	B	B	Soil and water management and quality	G	F	F	Rights and safety	C	G	B
Compliance and suitability for needs	G	G	A	Indoor and outdoor air quality	G	E	F	Governance, political and associative life	A	A	A
Creation and wealth distribution	C	G	B	Climate change and risks	E	X	F	Health Prevention and safety	D	G	D

key actors to Skikda mixed port extension project and the authors of this paper. In addition, these additional data have been synthesized in Table 3, which summarizes for each scenario all the notes for each field in one single overall statement:

Based on the data in Table 3, a summary of the evaluation of the three scenarios is presented in Table 4

5 Results

5.1 Scenario 1

The result of the numerical analysis provided by Boussole21 software, in the first scenario, gives a radar graph that includes positive indicators for the economic and social side of the project, but a great weakness for the cultural and identity development and especially the protection of the environment. The EPS Company has important economic revenues, which enable the port of Skikda to cover all its financial expenses, including the development of the port infrastructure, this policy is known as the auto-financing. However, the port energy policy fails to satisfy its own energy needs known as the port's energy autonomy, the development of the port, must rethink the requirements of technological innovation and sustainable development in order to be converted to a smart port (Fig. 9).

5.2 Scenario 2

The result of the analysis provided by Boussole21 software to scenario 2 of the redevelopment of the west side of the mixed port. This scenario is not efficient in economic and environmental terms. The creation of a road instead of popular beaches in Skikda, is strongly rejected by the population and the community of civil associations. These redevelopments will contribute to the disappearance of all the beaches of Skikda capital, and the deterioration of areas of historical interest (Fig. 10).

5.3 Scenario 3

The radar of the current scenario 3 shows better results than the other scenarios. The choice of the project's site, named Goat Island, respects the cultural and touristic character of the Gulf of Stora. This site between the existing

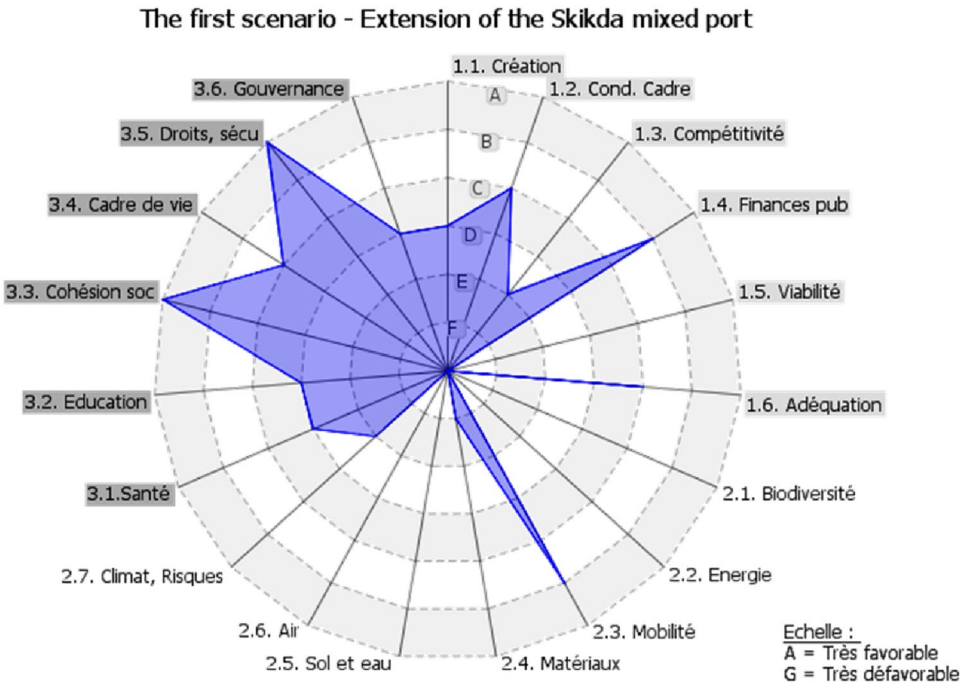

Fig. 9 Outcome of the first scenario assessment (Source: authors by Boussole21, 2020)

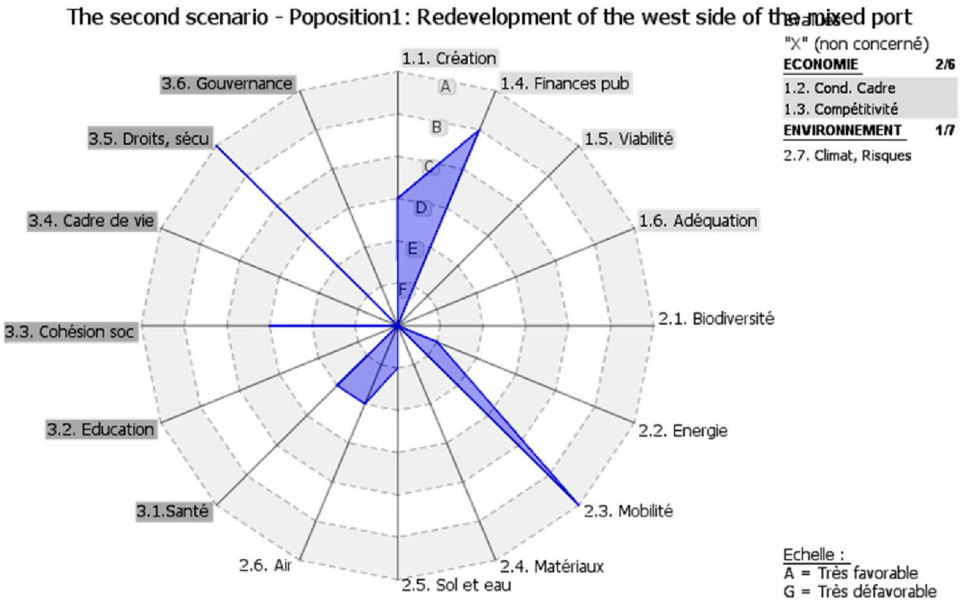

Fig. 10 Outcome of the second scenario assessment (Source: authors by Boussole21, 2020)

port and the petrochemical complex will create a logical link between the two industrial ports by forming a single port entity; the graph shows favorable economic and social character. Through this proposal, the port authorities will contribute with 50 percent to the financing of another road-drilling project in order to facilitate the connection of the port with the hinterland. The municipalities of Skikda will also benefit from the development of the road network in the face of traffic congestion. Even though the graph also shows the inadequacy of the port's strategies for sustainable development, clean energy production, waste and material recycling, pollution and protection of the rare biodiversity that characterizes the course of the Gulf of Stora, so as to restore a smart city-port interface at Skikda (Fig. 11).

6 Discussion

The development of Skikda ports is an asset for the local and national economy, but the maritime trade and the oil landscape of the city requires a reflection on the future of these oil sites and their impact on the environment and the

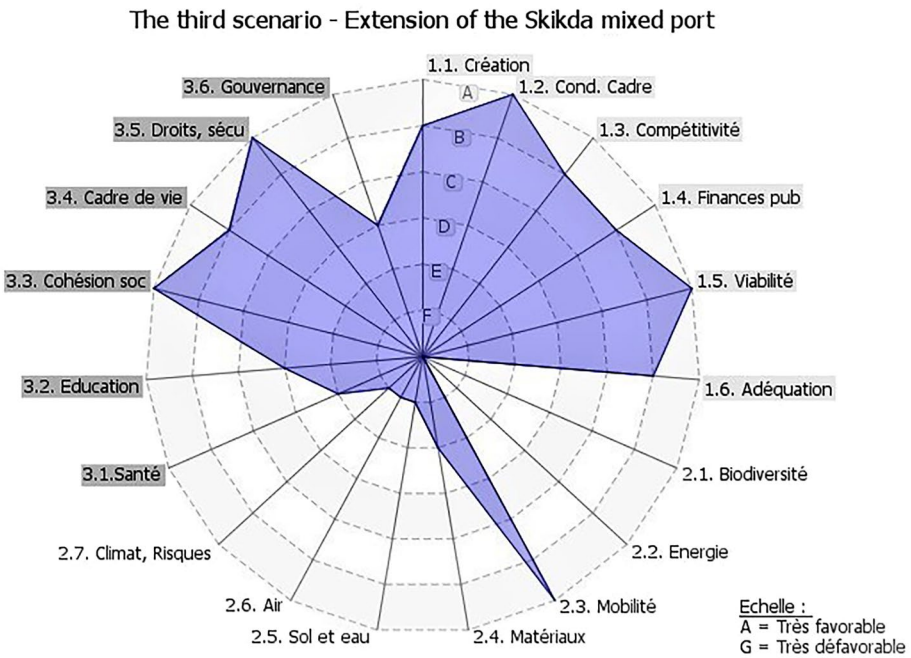

Fig. 11 Outcome of the third scenario assessment (Source: authors by Boussole21, 2020)

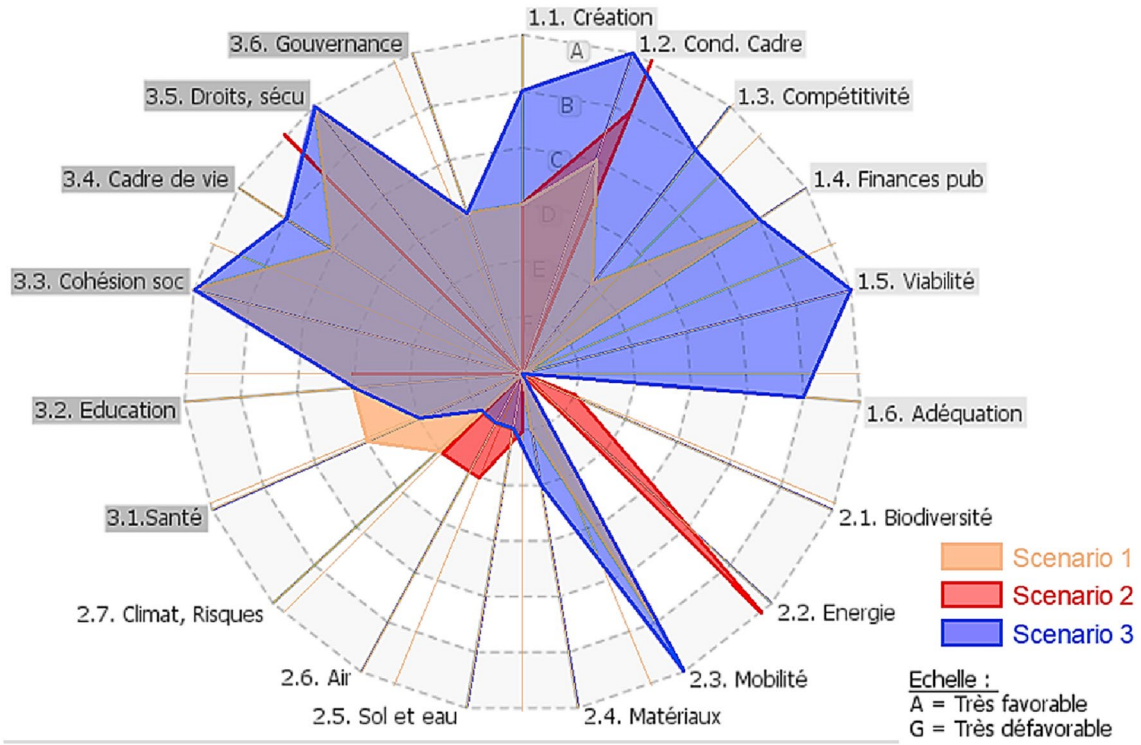

Fig. 12 Superposition of the three diagrams on a single radar (Source: Authors, 2022)

marginalized maritime heritage of Skikda. The numeric evaluation by Boussole21 of the three scenarios of the Skikda mixed port extension project, produced a unique radar diagram for each scenario. These radar diagrams give us a general view on the efficiency of the project, its interaction with the city, and its impact on the environment and heritage protection (Fig. 12).

The first proposal of LEM contains a single scenario, identified as scenario 1; the second proposal combines two scenarios, identified as scenario 2 and scenario 3. Scenario

1 will extend along the west side of the mixed port, which will consume a part of the natural beaches of Skikda, and it will contribute to the pollution of the unique biodiversity of the small island of Sergina, and damaging the archaeological and natural wealth of the Gulf of Stora. The site of implantation of the current scenario situates in the heart of the city and the center of the touristic area. Consequently, the mechanical movement will create a congestion that will suffocate the city.

Meanwhile, the authorities aim to transform an ancient part of the mixed port into a pleasure port; but it will be situated between the petrochemical port in the East, the oil docks in the North, and the new extension of the mixed port in the West. This location will be confined at an industrial zone, giving a feeling of vulnerability, for both citizens of Skikda and tourists especially after several fires and explosions that the industrial area has witnessed during the last twenty years. However, the opening of the port to the city in a thoughtful and safe way can promote a real diversification of the country's economic income by exploiting the sea fronts isolated from urban and social life, creating a solid/liquid entity, more homogeneous and more attractive to the public.

Scenario 2 will be extended along the coast until Stora, by a road that connects the mixed port with the pleasure/fishing port of Stora, with the staking of breakers and spikes that reflects a shift from the industrial port to the fishing and leisure port of the Stora historical Gulf. What will consume entirely the small coast that remains for the municipality of Skikda as an administrative capital. In this scenario, the mixed port includes the length of the coast from Filfila municipality to Skikda capital to the pleasure port of Stora, forming a single linear entity that consume all the natural beaches heavily frequented by citizens in all seasons of the year especially in summer.

This space is very frequented by citizens. If the beaches will have removed, people will be obligated to look for the other beaches of neighboring municipalities. Consequently, the city will lose all its natural landscape, and its seacoast will have transformed into a concrete carpet. The development of the Gulf of Stora did not take into consideration the landscape, cultural and maritime character of the old Gulf, for these reasons, citizens and civil associations opposed the disfiguration of one of the most favorite places for people, and the most famous of the city. The governor of the state of Skikda refused this project.

On the other hand, Scenario 3, addresses horizontal development, between the mixed port and the petroleum port near to the petrochemical complex, connecting this port mass to the industrial zone of Skikda. Subsequently, the location of this extension can avoid the consumption of the tourist beaches of Stora, protecting this historical heritage in favor of the landscape and cultural aspect of the city. The risks of pollution remain upstream of all the prospects of preserving the environment against the industrial and petrochemical reality in Skikda. Furthermore, scenario 3 includes the creation of a new route in order to improve the road network, which enters the industrial zone of Skikda. The project aims to connect the port with its hinterland and facilitates the movement of logistics between the wet port, the dry port and the petrochemical refinery. The port authorities and Skikda municipalities will provide the co-financing of this project that will reflect the common financial support to develop the city's infrastructure, which help to mitigate the impact of the port activities on the city.

The analysis carried by Boussole21 for the three scenarios proposed by LEM, demonstrates that, the third scenario is the most adequate, because it will be implanted into an industrial area, between the existing port in the West and the petrochemical complex in the east. This proposal will create a unique industrial mass, where it will be a little far from the historical and touristic area. Meanwhile, the first and the second scenarios mark a great weakness as far as it concerns the protection of the natural landscape, because of the new extension of the mixed port on the Gulf of Stora. In choosing these two scenarios, they will lead to the loss of Skikda's beaches which risks consuming all the maritime coast of the municipality of Skikda. These proposals will cause irreversible damage to either the historic seabed or the rare maritime biodiversity of the region.

6.1 Boussole21 as a planning tool

The process of evaluating scenarios using Boussole21 provides deeper understanding of the project, based on the three pillars of sustainability. This method gives the opportunity to interact with various key actors of the project, in order to answer the evaluation questionnaire of Boussole21. The software gives then the results presented in easy to read graphs. The analysis of these graphs provides transparency, as it allows to identify sustainable dimensions of each scenario and positioning them in relation to the project's objectives and the aspirations of the stakeholders, who can proceed to an overall comparison of different scenarios of the same project, according to the principles of sustainable development.

Therefore, Boussole21 can highlight the points which was not adequately addressed by the key actors, and bringing together the different stakeholders of the project, to connect the different points of view and provide a basis for value deliberations. In the case of the Skikda port extension project, these values were not taken into consideration. Thus, Boussole21 as a planning tool can be an opportunity to provide a different evaluation method, extracting unseen issues and shortcomings, and engaging several stakeholders who have been marginalized in the planning process of the

project of development of Skikda ports, such as people and the civil society.

According to its features, Boussole21 appears to be a meaningful tool for solving urban planning challenges. It has the capacity to give a global vision of the problems to be solved, and an idea of the probable's impact, by visualizing the strength and weaknesses of each scenario, in order to help the key actors to make sound decisions on the criteria of Agenda 21. Nevertheless, The tool is not yet perfect: The complete guide attached to the software, Boussole21, remains very general, which may generate a subjective evaluation, and a growing level of uncertainty. Indeed, there is a difficulty of acceptance of the decision by all stakeholders, who have different opinions and evaluations, opening a wide debate. Even if this tool have limitation, it has helped to achieve the objectives of the evaluation to highlight the gaps in the process of the planning policy of Skikda authorities.

7 Conclusion

Through this paper, Boussole21's assessment of the urban development strategy process in Skikda, shows the ambitions of the authorities to improve the performance of the port, and to apply it to international standards. However, the path of urban transition in Skikda as a port city, is still a far from sustainable development and aspects of the smart port city. This shortcoming has many reasons that refer mainly to the unacknowledged of sustainability objectives in planning. The priority of securing economic revenues through unsustainable means, which depend on oil and imports rather than looking for alternative solutions, based on the principles of sustainable development, and the protection of natural and historical heritage, seems to be the last concern of planners. In addition to the lack of dialogue between the various professional actors and all stakeholders, there is also an insufficient link between professionals of the port of Skikda and academic researchers of the fields of urban planning, architecture, and culture entities and with civil society.

Boussole21 is known for its flexibility and simplicity. The tool can be used to evaluate projects of all kinds and at different scales, both spatial and temporal.[14] The strong points of this tool are the accompanying guide, which is very complete and makes it clear that the tool is only one-step in a process and that the evaluators' statements are very important. The spider web graph allows you to see the level of assessment of the 19 criteria at a glance. The clarity of the summary and ease of use is impressive. The weakness of this tool is that it is general and the criteria are not all very clear if you do not read their explanatory text carefully, especially in the economic field. Finally, it should be noted that the criteria are inspired by Swiss regulations and do not cover governance (Bergsma 2012).

The advantage of using a qualitative and partially quantitative method, Boussole21, illustrates the sustainability of the impact of oil expansion in the ports of Skikda. Although this tool is general, it helped penetrate the depths of the deficiencies of the project, and displayed the limitations clearly to the different actors of the project. Boussole21 provided a practical demonstration of the strengths and weaknesses of each scenarios. The logic of the planning in Skikda lacks sustainability, and ignores the complexity of the industrial risk factor that not only threatens the lives of citizens, but also threatens the environment and historical heritage, the rare biodiversity of the small island of Sergina and maritime identity of Skikda.

According to the assessment of Bousole21, the third scenario is more adequate for Skikda. Scenario 3 will avoid disputes between trade activities, the oil industry and cultural values of the maritime identity of Skikda. The port authorities should focus not just on the development of the petroleumscape and the port infrastructures, but also, they should take into consideration the landscape, the seascape and the maritime cultural heritage like an alternative source for durable economic income diversification. The port should also enhance its own energy performance in order to develop its performance and concurrence. This focus may help Skikda in the transition process to a smart port city, supported by technologies and numerical solutions in order to equalize a sustainable port city interface, in front of the challenges of the petroleum scape and the competition between commercial ports. The recourse to sustainability has become a necessity to protect the wealth of Skikda against the port trade industrialization, and the oil dominance.

What appears in this work as factors of innovation is this consideration of human needs, the emergence of new industrial port activities and this tool for evaluating the sustainability of scenarios. This implementation of different means of cross-cutting actions allows an inflection of development towards more sustainability for decision making in the port cities of the southern Mediterranean. Sustainable development in port cities highlights the particular challenges of their redevelopment. To this end, the research examines the case of the port city of Skikda to illustrate how these challenges are addressed at the local level. This type of research initiative is significant in the South with far fewer resources than in the North, where "For some years now, the idea that innovation is not limited to new technologies has become more important. Innovating, from this point of view, is also imagining uses, legal frameworks or even policies likely to improve our living conditions" (Trécourt 2019).

Sustainability is essential in order to facilitate the transition of Skikda into a smart port city. However, this

[14] http://www.boussole21.ch/pdf/jalons8_boussole21_150dpi.pdf

concept does not necessarily imply the import of the intelligent technology or tools, but rather it aims to promote effective reflection for intelligent and local production, through human innovation. In this context, the best model to build a "smart" port city in Skikda, might adopt the process of smart development, by the investment in the technologies, the human resources, intellectuals' experts and the broad public, grouped and organized around a shared urban project within the framework of sustainable development. To conclude, the policy of a smart development process, stimulated by the use of Boussole21, promotes the valorization of the local wealth of Skikda. Deconcentrating of the industry is essential to repair the fracture between the port and the city. Looking for a sustainable investment and a useful seafront for all stakeholders, the smart interconnection between the liquid (water) and the solid (hinterland), will encourage the continuity between the port and the hinterland, and regain the sea in favor of waterfront of Skikda.

Comprehensive tools to evaluate future sustainable spatial developments in well informed conversations with diverse stakeholders can facilitate the interconnected transformation of ports, cities, and territories and are urgently needed. Industrial port city territories have long been key to human development through their industrial activities: people have accepted these negative externalities, as they benefited from working in these places. Today, port city territories need to again offer added value to the localities next to which they are positioned. Contemporary transitions, notably the energy transition, require innovative measures and new tools of assessment and discussion to develop integrated port city territories. A better understanding of the workings of tools such as Boussole21 can facilitate the development of decision making practices for more sustainable development, including in the port cities of the southern Mediterranean where fewer resources are available than in the North. This article illustrates through the case of the port city of Skikda how challenges and opportunities of the energy transition can be addressed in cooperation with local actors.

Funding This research did not receive any specific funding from public, commercial, or non-profit agencies or funding sectors.

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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