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Introducing Building Integrated Agriculture as green/sustainable building concept in MENA countries: approach and constraints

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Abstract
In recent years, the emergence of Building-Integrated-Agriculture (BIA) in developed countries has been seen as a possible solution to promoting models of sustainable and productive building in urban areas. This approach, which is based on the installation of food production methods that combine innovative technology and soil-less growing systems, permit to grow fresh fruits and vegetables in and on buildings, while exploiting their resource outputs creating new synergies between the built environment and the food production system. In this scenario, MENA region has instituted an ambitious policy to promote and foster the concept of sustainable building construction in the coming years, but faces a variety of unique challenges. The main objective of this study is to explore and examine the possibility of implementing BIA as a new approach for sustainable building construction in the MENA region, particularly in Algeria, by presenting a future perspective of the practice, and investigate its conceptual, technological, governmental, social and economic barriers.
Keywords: : Building-Integrated-Agriculture; The Middle East and North Africa (MENA); sustainable buildings; hydroponics

1. Introduction

The intensive anthropogenic processes witnessed in the past two centuries have quickly led to a series of changes, such as the demographic explosion, rapid urbanization, climate change, and over-consumption of energy, that is exacerbating the impact of human activities on our planet. In this scenario, the building is considered one of the most polluting activities on the planet (Yan et al., 2022). According to the Global Monitoring Report on Buildings 2022 (Environment, 2022), total energy consumption and CO2 emissions in the building sector increased in 2021, exceeding pre-pandemic levels. Energy demand from buildings is on the rise, increasing by around 4% compared to 2020, becoming the largest increase in the last decade. CO2 emissions from the operation of buildings have peaked, increasing by around 5% compared to 2020 and by 2% compared to the previous peak in 2019 (Environment, 2022). This has led to a growing interest in the sustainability of cities and the adoption of sustainable construction methods, which are becoming a major issue to be addressed.

The MENA region remains one of the world's fastest-growing areas in the world, with urbanization raising as high as 65% (World Bank data, 2018), where therefore it is crucial to implement present and future urban resiliency plans. Furthermore, urban areas in the Middle East and North Africa (MENA) have suffered considerable damage from environmental degradation, extreme temperatures, and water stress (Worldgbc, 2022). The region is facing structural problems that make it particularly difficult to feed a growing population since the increased frequency of extreme weather events and rising temperatures are having an impact on local agriculture (GBC, 2022). Therefore, most of the urbanized areas in the MENA region rely on distant and global food supply chains, while local production is struggling (world bank data, 2021). In this sense, there is a dire need for new solutions and urban innovations to foster the transition towards more sustainable practices in the building construction sectors and in shortening the food supply chain. As reported in several recently published articles (Thomaier et al., 2014; Specht et al., 2013, D'Ostuni et al., 2022) new food production technologies (i.e. hydroponics, aeroponics, and aquaponics) can be integrated into the construction sector defining a new subtype of Urban Agriculture (UA), namely Building-integrated Agriculture (BIA). The success of this new subtype of UA is linked to its capacity to foster sustainable and local vegetables and fruit production on one hand, while on the other increasing the overall sustainability of buildings using food-productive green infrastructures (D'Ostuni et al., 2022).

Therefore, the presented paper focuses on sustainable building strategies in the MENA region and particularly in Algeria, exploring and examining the possibility of implementing BIA as a new approach for sustainable and productive building in the construction sector of the MENA region. On this trail, this research intends to present future perspectives of this fairly new practice and investigate its hindrances and barriers which could prevent its future development, while offering guidance for overcoming development barriers.

1.1 The concept of Building Integrated Agriculture (BIA)

The concept of Building Integrated Agriculture (BIA) represents a sub-type of Zero acreage farming (ZFarming) and consists of the application of high-performance greenhouse farming methods adapted for use on top of or in buildings (Puri and Caplow, 2009). Typically, the term ZFarming is used to distinguish between forms of urban agriculture related to buildings with those practiced in parks, gardens, urban wastelands, etc., and describe all types of urban agriculture characterized by the non-use of agricultural land or open spaces. (Specht, 2013). While ZFarming mostly refers to several techniques for growing food within and on top of buildings, BIA is characterized by the use of advanced food production technologies to maximize food production within restricted urban spaces (such as rooftops, squares, or courtyards). Therefore, the application of high-tech technologies represents an opportunity to exploit the synergies between the built environment and the farming systems resulting in higher water-use efficiency, better waste management cycles, and building-integrated renewable energy sources (D'Ostuni et al., 2023).

BIA includes soilless culture methods, such as hydroponic, cultivation, a technology that does not use any land, requires around ten times less water than conventional agriculture, and leads to significantly higher yields in smaller areas. The approach of producing food closer to where it is consumed has provoked increasing interest over the last years, the results of the studies revealed that BIA meets the requirements of green building design (Puri and Caplow, 2009). In addition to the aesthetic and functional aspects, this approach is claimed to considerably decrease fossil fuel consumption, improve food security, provide jobs locally, cut transportation costs, and enhance energy efficiency in buildings (Gould and Caplow, 2012; Benis and Ferrao, 2016). The impacts of the practice have been widely justified in the field, and they are classified according to the three dimensions of sustainability: social, environmental, and economic. Different methods of incorporating agricultural practices into architectural structures can be differentiated based on the used technological innovations: this includes vertical facades, rooftop greenhouses, and numerous sorts of indoor growth facilities. Potentially, these systems can recycle and reuse almost every element from the building to the farming process, including energy, water, nutrients, and even CO2. The rooftop greenhouses (RG) method is the most popular because it enables the untapped potential of urban roofs. However, light hydroponic greenhouses do not require a lot of structural support and maximize food production. (Caplow and Nelkin, 2007; Zaffi and D'Ostuni, 2021). The greenhouses work with resource-saving techniques including rainwater collection and hydroponically recirculated systems, to reduce their water requirements. (Gundula Proksch,2017). The energy for heating is provided by solar radiation as well as by the heat absorbed by the building (Zaffi and D'Ostuni, 2021)

1.2. Green Building policies In MENA region

Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life cycle, from siting to design, construction, operation, maintenance, renovation, and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high-performance building. (EPA,2014).

To achieve sustainability in the construction industry, green building is considered an adaptive strategy in the MENA region. To achieve this goal regional MENA network's eco-construction recommendations, address both challenges and opportunities on the ground by ensuring that buildings in the area provide high levels of personal well-being while minimizing negative environmental effects and maximizing economic benefits (wgbc, 2023).

The primary goals of developing environmental building evaluation methods and practices were to lessen or eliminate adverse environmental effects and to have high performance in the areas of conception, building, use, and demolition to minimize or eliminate negative environmental effects. In this context, the Middle East frequently creates its notational systems in addition to those used internationally and establishes its laws and notational systems to suit local circumstances. Qatar started supporting the implementation of global sustainable building standards and green building rating systems, like LEED and BREEAM, in 2001. Qatar recognized the importance of sustainability at that time. The Qatari DIAR investment group announced the first building assessment system in 2004 under the name Qatar Sustainability Assessment System (QSAS). Over time, Qatar developed the first complete sustainability framework through the Qatar National Vision (QNV) (Salim, 2019). One of the top green building rating systems in the Gulf region it has certified more than 128 buildings and launched the Qatar Green Building Council. A clear path for Qatar's future has been established with the unveiling of the Qatar National Vision 2030. (Edgar, 2019) The Housing and Building National Research Centre launched the Egyptian Green Pyramid Rating System (GPRS) in 2009. The major goal of the GPRS is to create sustainable structures in Egypt by increasing public knowledge of the

value of environmentally friendly construction. In 2012, the Egypt Green Building Council was established. Its goal is to help Egypt's community transform and a shining example of sustainable development (Rushdy, 2019). The Egypt Vision 2030 initiative is a step in the direction of inclusive development. building a road to prosperity via social and economic fairness (SDS Egypt). The capital of the United Arab Emirates (UAE), Abu Dhabi, has also created a local ecological assessment tool, The Pearl Assessment System (PRS) followed by the Abu Dhabi Emirate Green Building Rating System, to fulfill its 2030 goal of being one of the world's most sustainable cities (Zinah, 2020). To maintain sustainable growth, the UAE set the Vision 2021 National Agenda, which prioritizes enhancing air quality, protecting water resources, growing clean energy production, and adopting green growth strategies (UAE Vision, 2018).

Jordan launched the Green Building Council in 2009 followed by The Jordan Green Building Guide and Regulations, produced by the Ministry of Public Works and Housing, it serves as a reference manual for more efficient and effective design in accordance with global standards and the local context (Zinah, 2020). Jordan will keep working to address issues relating to climate change (including implementing the Paris Agreement), food security, water availability, and access to renewable energy through the Jordan national Vision and its Roadmap. Since this vision's primary tenet is sustainability (EMV, 2023).

With an emphasis on environmental evaluation and the commercial building rating system, The Lebanon Green Building Council (LGBC) oversees the certification process for the nearly unheard-of ARZ building rating system, which is Lebanon's first worldwide green building project. It was established to encourage the development and acceptance of sustainable building practices in Lebanon. (Zinah, 2020). The Ministry of Housing of the Kingdom of Saudi Arabia created the Mostadam green building grading system, which is managed by Sustainable Building Council. The Kingdom of Saudi Arabia is currently ushering in a new age as it strives to achieve Net Zero by 2060. This declaration is consistent with the larger aims of Vision 2030, which include accelerating the energy transition and achieving sustainability targets (SSV, 2022).

Finally, **table 1** summarises the main green building systems and tools in Mena region, and national development strategies:

Table 1: Rating systems and tools in MENA countries to support green building

Country	Rating system	Rating tools	National development strategies
Qatar	Sustainability Assessment System (QSAS)	Qatar Green Building Council	Qatar's National Vision 2030
Egypt	Green Pyramid rating system (GPRS)	Egypt Green Building Council	Egypt's Sustainable Development Strategy (2030)
UAE	The Pearl Rating System (PRS)	UAE Green Building Council	The United Arab Emirates' National Agenda Vision 21, Abu Dhabi Economic Vision 2030
Jordan	The Jordan Green Building Guide and Regulations	Jordan Green Building Council	Jordan National Vision 2030
Lebanon	The ARZ Green Building Rating System	Lebanon Green Building Council	Lebanon's National Sustainable Development Strategy
Saudi Arabia	Mostadam Rating system	Saudi Arabia Green Building Council	Saudi Arabia's Vision 2030 (2016)

1.2.1. Green Building policies In Algeria:

Algeria, like other countries in the MENA region, is part of this approach and has introduced several strategies to promote sustainable housing in the country. The main characteristics that define the Algerian context are the uneven distribution of the population and economic activities across the nation, desertification, the unwise use of natural

resources, seismic risks, the deterioration of living conditions, the diversity of the population's socio-cultural practices, and the climatic and geographical conditions across the country (Tebbouche, Bouchair,2017). To meet these specific needs, numerous initiatives have been introduced at various levels as well as sustainable development.

On this trail, the National Building Code was created by the CNERIB (Centre national d'études et de recherches intégrées du bâtiment), which is part of the Ministry of Housing and Urban Development. The Algerian government unveiled Law No. 04-09, which encourages the use of renewable energy sources as a component of sustainable development, followed by a national program composing six strategies: professional development, DTR regulation implementation, the Also project, boosting house insulation, and public lighting efficiency. (Tebbouche and Bouchair, 2017). Unfortunately, these strategies have failed to promote the development sustainability in the country. Neo-vernacular architecture is used in Algeria as a green building technique, a sustainable building design that respects the local culture and environmental setting is known as climate-appropriate design, and still working on creating its system of ratings.

2. Material and Methods

Due to the lack of information provided in the literature and the limited general knowledge of BIA practices, it was decided to use a mixed method to understand the possibilities and constraints of BIA development in the MENA region. The mixed method consisted of a first phase of desktop research and database collection, while the second step consisted of the definition of semi-structured interviews that were later presented to practitioners and academics to understand their opinion on BIA.

2.1 Database Collection

The desktop review consisted in the consultation of both academic and grey literature (e.g. World green building Council, The world bank data, etc.). The presented research was limited to seven MENA countries, mostly focusing on those countries that already have developed green building strategies and rating systems. In this sense, the seven analysed countries were: Qatar, Egypt, United Arab Emirates (UAE), Jordan, Lebanon, Saudi Arabia, and Algeria. During the database collection, most of the research was conducted in in academic databases (e.g. Sciencedirect, (Springer, Elsevier) and public other internet sources (Google, and Google Scholar).
When collecting bibliographic information, the keywords used to find the most pertinent papers to topic were: green building, sustainable building, ecologic building, followed by the global name MENA region and then the name of each country (i.e. green building in Algeria). Another specific research was then conducted using the keywords Building integrated agriculture, rooftop greenhouses.

2.2 Semi-structured interviews

After the desktop research, it was possible to define a semi structured interviews that was later proposed to more than 30 professionals and practitioner in Algeria, with the objective to determine the potential and the hinderance of BIA theories development for green building in the country. The semi-structured questionnaire was circulated in different cities in Algeria and involved the participation of different experts in the field including architects, researchers, civil engineers, environmental engineers building contractors and agronomist all working both in the public and private sectors.

Each participant described their area of expertise and level of experience and discussed about its general knowledge concerning green buildings and BIA. Lately, they were asked to answer the following two specific questions:

- What measures, in your opinion, can promote the adoption of BIA as a new sustainable construction concept in Algeria? was one of the most crucial questions.
- What are the obstacles preventing the implementation of BIAs in Algeria?

Finally, to extrapolate the results from the semi-structured survey, it was possible to categorize the professionals' responses into four main areas: technical, social, economic, and governmental (Fig. 1).

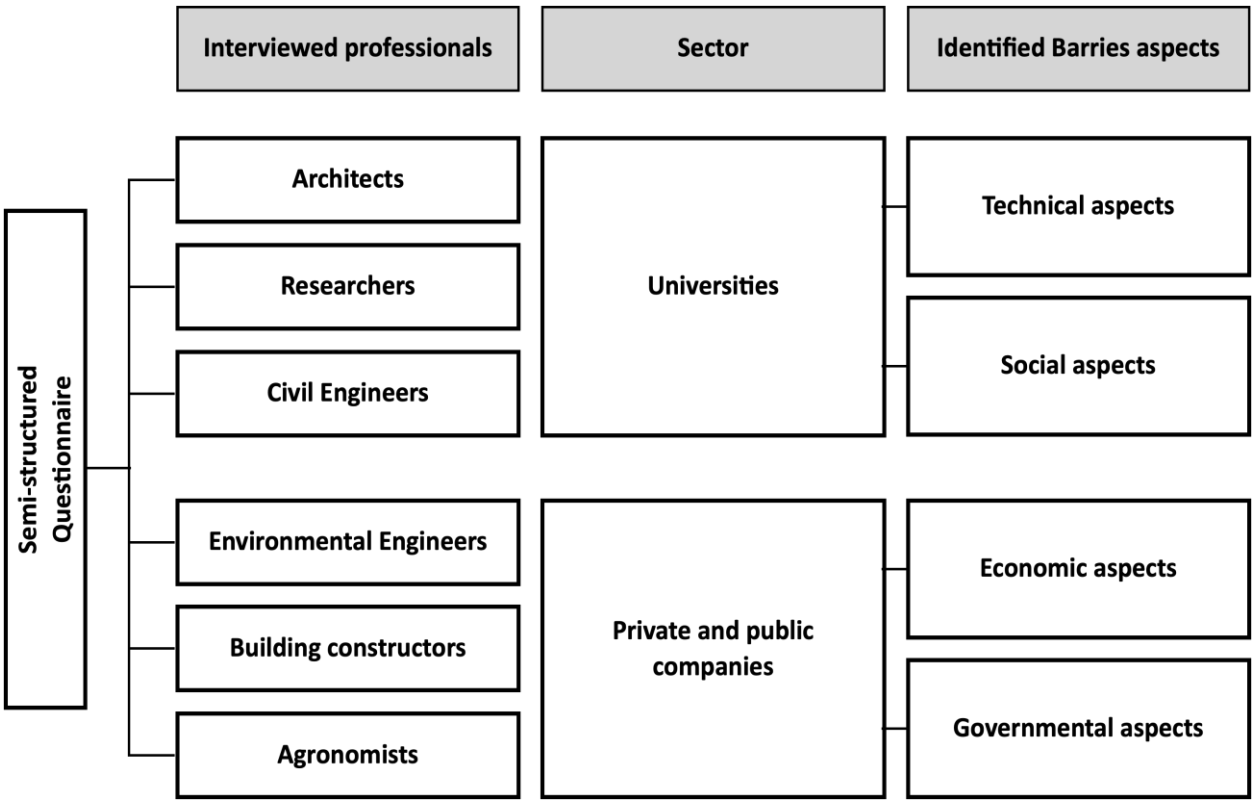

Fig. 1: Semi-structured questionnaire workflow

3. Results and discussion

In the general context of the survey, most of the respondents had no specific knowledge of the topic concerning buildings integrating sustainable agriculture, while they showed a much deeper knowledge and understanding of the concepts of sustainable and green buildings buildings.

However, there were few notable exceptions among the interviewees:

1. A small group of participants stated that they had chosen Urban Agriculture projects as their final thesis for their architecture degree. These people stated that they have deliberately chosen this field of study as interested in acquiring specific knowledge and expertise in the design of sustainable buildings integrated with agricultural and food systems.
2. A second group can be identified in practitioners and project leaders with a specific interest in hydroponic and aquaponics greenhouses showing a particular knowledge of the technical aspects of the soil-less food system.

It is important to note that while these two categories may have specific knowledge or experience around buildings integrating agriculture, this does not necessarily mean that the other survey participants have no experience or knowledge in this area. Each person can bring a unique perspective and complementary knowledge, even without specific prerequisites.

The participants in the survey showed a keen interest in introducing the concept BIA in Algeria. In particular, those with 1 up to 7 years of experience in the construction industry showed more interest in the technology.

Some participants with 10 to 20 years' experience in the construction industry believed that BIA is to be considered a futuristic concept that may work better in countries with a smaller surface area compared to Algeria. Indeed, they suggested that Algeria, with its considerable surface area, should focus more on the expansion of conventional farming.

3.1 Identified barriers in the development of BIA projects in Algeria

Following the responses from participants, the results of the questionnaire showed the hinderances and barriers of implementing BIA projects for sustainable buildings construction In Algeria. These identified barrier were classified into 4 categories: Social, Governmental, technical and Economic barriers (Table 2).

Table 2: Barriers for BIA implementation in Algeria

Social Barriers	Governmental Barriers	Technical Barriers	Economic Barriers
Lack of interest expressed by curtomers and by market.	Lack of government support	Availability of construction materials	High Investment costs
Attitudes, culture lifestyle and behaviours	Absence of national codes and regulations	Project complexity and lack of a specific knowhow	Financial risks and uncertain revenues
	Stakehomder resistance to change	Required technologies ar not available	

3.1.1 Social barriers

Social barriers constitute most of the answers given by the participants (92%). Indeed, most of the mentioned the lack of interest expressed by customers and by the market as a major obstacle to the adoption of this concept in the building sector in Algeria. This suggests that Algerian consumers and the market are not showing sufficient interest in consuming and therefore selling, food grown in cities and integrated into buildings.

In addition, 71.4% of participants have highlighted the importance of attitudes, culture, lifestyle, and behavior as social barriers to the integration of agriculture in the building. This means that social attitudes and values, as well as existing lifestyles in Algeria, can have a negative influence on the adoption of this innovative concept, showing a diffuse skepticism towards new practices of food production.

These results, therefore, highlight the need to raise awareness and educate consumers and the market about the benefits first of soil-less agricultural practices and eventually of integrated agricultural practices in buildings. Some of the respondents stressed that it might be worth running communication campaigns to promote these practices and explain how they can benefit both consumers and the environment. In addition, these results highlight the importance of raising consumer awareness and educating them about the benefits of urban agriculture of building-integrated farming, to encourage wider market acceptance.

In this sense, recent studies conducted in Barcelona on the sociological benefits of integrating rooftop greenhouses in buildings showed a high relation between stakeholders' attitudes about UA and their approval of rooftop farming (Sanyé-Mengual et al., 2014; Sanjuan, 2018). In the reported studies, participants downplayed UA's potential impact on urban food security while highlighting the social aspect of UA. They favored low-tech methods over conventional soil-based farming. Others, though, saw how rooftop gardening might boost food production and open up new commercial prospects. Generally speaking, stakeholders noted the environmental, social, and economic benefits of rooftop farming, but also acknowledged issues including gentrification and worries about air and soil contamination having an influence on food, as well as dangers related to gentrification (Sanyé-Mengual et al.,2016, Sanjuan, 2018).

3.1.2 Governmental barriers:

The majority of respondents (64%) identified a lack of government support as a major barrier. This lack of support can take the form of a lack of clear policies to encourage this practice. Furthermore, 46% of the respondents see a lack of national codes and regulations: without clear regulations, the adoption of such a practice would be very difficult. Finally, almost a third of respondents (28.6%) cited resistance to change from stakeholders as a significant barrier: some stakeholders, such as traditional farmers or the construction industry, may be reluctant to adopt such new concepts, highlighting a diffuse skepticism towards new ways of producing food not only from the customers' side but also from the producers' point of view.

Therefore, to foster BIA practices for green building development, governments must acknowledge the potential advantages and significance of the practice and offer the appropriate assistance through legislative initiatives, financial incentives, and other resources.

Change frequently upsets established routines and procedures, and some stakeholders could be reluctant to adopt novel ideas owing to worries about financial success, job stability, or a fear of the unknown. Effective communication, stakeholder involvement, and the illustration of immediate benefits and possible long-term benefits

of the practice are necessary to overcome stakeholder opposition. Collaboration among many parties can assist reduce opposition and promote the acceptance of the practice, particularly by offering information and support.

3.1.3 Technical barriers:

The report on the survey concerning the technical barriers to buildings integrating agriculture highlights several significant findings: 68% of the questioned participants indicated that the technologies needed for this type of construction are not yet available in Algeria, especially high-performance greenhouses that are not spread or used in the Algerian region. In addition, the integration of energy and water systems between the greenhouse and the buildings is also perceived as an obstacle, lacking technical know-how.

Another interesting technical obstacle identified during the semi-structured questionnaire concerns the difficulties in procuring certain materials for greenhouse construction and installation set-up and their unavailability on the local market. Also, some participants stressed that the structural capacity of the existing building could be a critical point to be taken into account when planning to install a greenhouse on the existing infrastructure.

Finally, the complexity of the project was also identified as a major obstacle. Setting up a building that integrates agriculture requires considerable expertise and coordination. The management of food production systems, irrigation, ventilation, and temperature control requires depth knowledge of the various agricultural technologies.

The integration of agriculture into buildings can be hampered by the difficulty to locate suitable technology since it may reduce the viability and efficiency of such projects. It becomes difficult to develop sustainable and effective systems that allow for the growth of crops without essential technical improvements. (Sanyé-Mengual,2012) A structural assessment of existing the building to determine its capacity to support a greenhouse is recommended. If the structural capacity of the building is insufficient, the necessary reinforcements and modifications must be made. To deal with the complexity of BIA projects, it is important to train qualified personnel to manage and maintain innovation in the building sector. Establish partnerships with local farming organizations, universities, or research institutes to benefit from their expertise, as well as technological transfer from foreign institutions.

3.1.4 Economic Barriers

The results of our survey reveal that economic barriers are among the most frequently cited by participants, 79% of the participants said that the cost of investing in BIA is very high and that the return on investment is long-term and often unknown or unforeseeable. In addition, 40% of participants mentioned the financial risk associated with this project, highlighting the possibility of failure.

Investing in BIA projects is reported to be expensive (D'Ostuni et al., 2022), but there might be several long-term advantages. Therefore, evaluating the product's life cycle cost (LCC) could help get over the revenue uncertainties. To improve the profitability of rooftop greenhouses it is important to develop proper and diversified business models that specify the investments required and the associated benefits, to create a new value chain for the sustainable restoration of construction of future buildings in urban areas. This new value chain should then be characterized by reduced waste, emissions, and energy consumption, fostering circular economy models and resource recovery processes. This model must also include a detailed marketing plan with sales forecasts and should be able to estimate the possible profit and losses (Sanyé-Mengual, 2012).

4. Conclusions

The lack of knowledge about BIA represented a challenge when the questionnaire was being carried out. Providing clear information and raising awareness on this subject is crucial if the goal is to improve a better understanding from the professionals and practitioners in the building and agricultural sectors. Although some participants felt that BIA is more suitable for small countries, there are arguments in favor of adopting these concepts even in larger countries such as Algeria. The final decision will depend on each country's priorities, available resources, and specific objectives in terms of agriculture and sustainable development.

Therefore, to fully comprehend issues and potential solutions for more resilient cities, it is crucial to foster interdisciplinary approaches. So, this document explores Building Integrated Agriculture of agriculture as a new concept in the MENA region. Even if the literature shows that the practice could serve as an element of sustainable urban infrastructure in the cities of the region in the future, it seems that in the analyzed countries this practice is far from being implemented or even studied. However, the Mena region is developing promising strategies to achieve sustainability in the construction sector for the next years, with ranking strategies and Green Building Councils being set up all over the region.

The results shown during this research demonstrate that implementing BIA at the city level is hampered by social, governmental, technical, and economic barriers, all of which need to be addressed. Understanding the advantages and limitations of BIA is essential to developing intelligent solutions that get around these restrictions and allow practitioners and planners to use advanced, integrated soil-less agricultural practices for green building design. In this sense, a wider awareness of the topic as well as the development of a new regulatory framework for the practice is indispensable to spark the integration of food systems into the main cities of the MENA region.

References

1. Basic Information | Green Building |US EPA. (n.d.). Basic Information | Green Building |US EPA. https://archive.epa.gov/greenbuilding/web/html/about.html
2. Belhaj, F., & Soliman, A. (2021). MENA has a food security problem, but there Are ways to address It. World Bank Group.
3. Benis, K., & Ferrão, P. (2017). Potential mitigation of the environmental impacts of food systems through urban and peri-urban agriculture (UPA)–a life cycle assessment approach. Journal of Cleaner Production, 140, 784-795
4. Caplow, T. (2009). Building integrated agriculture: Philosophy and practice. Urban futures, 2030, 48-51. Economic Modernisation vision, Enleashing potential to build future, https://www.jordanvision.jo/
5. Cerón-Palma, I., Sanyé-Mengual, E., Oliver-Solà, J., Montero, J. I., & Rieradevall, J. (2012). Barriers and opportunities regarding the implementation of Rooftop Eco. Greenhouses (RTEG) in Mediterranean cities of Europe. Journal of Urban Technology, 19(4), 87-103.
6. D'Ostuni, M., Stanghellini, C., Boedijn, A., Zaffi, L., Pennisi, G., & Orsini, F. (2023). Evaluating the impacts of nutrients recovery from urine wastewater in Building-Integrated Agriculture. A test case study in Amsterdam. Sustainable Cities and Society, 91, 104449
7. D'Ostuni, M., & Zaffi, L. (2021, July). Nurturing cities–Pathways towards a circular urban agriculture. In World Heritage and Design for Health–Proceedings of the XIX International Forum Le Vie dei Mercanti, Napoli-Capri (pp. 726-735)
8. Environment, U. (n.d.). 2022 Global Status Report for Buildings and Construction. UNEP - UN Environment Programme. http://www.unep.org/resources/publication/2022-global-status-report-buildings-and-construction
9. Ferwati, M. S., Al Saeed, M., Shafaghat, A., & Keyvanfar, A. (2019). Qatar sustainability assessment system (QSAS)-neighborhood development (ND) assessment model: Coupling green urban planning and green building design. Journal of Building Engineering, 22, 171-180., https://doi.org/10.1016/j.jobe.2018.12.006
10. Göll, E., Uhl, A., & Zwiers, J. (2019). Sustainable development in the Mena Region. MENARA Future Notes, 20.
11. Gould, D., & Caplow, T. (2012). Building-integrated agriculture: a new approach to food production. In Metropolitan sustainability (pp. 147-170). Woodhead Publishing.
12. .Homepage: The Progress & Achievements of Saudi Arabia. (n.d.). Vision 2030. https://www.vision2030.gov.sa/
13. Home - World Green Building Council. (n.d.). World Green Building Council. https://worldgbc.org/
14. Kim, T. J., Claus, M., Rank, J. S., & Xiao, Y. (2009). Technology and cities: Processes of technology-land substitution in the twentieth century. Journal of urban technology, 16(1), 63-89.
15. MENA - World Green Building Council. (n.d.). World Green Building Council. https://worldgbc.org/mena/ In-Text Citation: (MENA - World Green Building Council, n.d.)
16. Moussa, R. R. (2019). The reasons for not implementing Green Pyramid Rating System in Egyptian buildings. Ain Shams Engineering Journal, 10(4), 917-927.
17. Nelkin, J., & Caplow, T. (2007, October). Sustainable controlled environment agriculture for urban areas. In International Symposium on High Technology for Greenhouse System Management: Greensys2007 801 (pp. 449-456).
18. Proksch, Gundula. (2017). Creating Urban Agricultural Systems: An Integrated Approach to Design. 10.4324/9781315796772.
19. Puri, V., & Caplow, T. (2009). How to grow food in the 100% renewable city: Building-integrated agriculture. In 100 Per Cent Renewable (pp. 255-268). Routledge.
20. Sanjuan-Delmás, D., Llorach-Massana, P., Nadal, A., Sanyé-Mengual, E., Petit-Boix, A., Ercilla-Montserrat, M., ... & Pons, O. (2018). Improving the metabolism and sustainability of buildings and cities through integrated rooftop greenhouses (i-RTG). Urban Horticulture: Sustainability for the Future, 53-72.

21. Sanyé-Mengual, E., Anguelovski, I., Oliver-Solà, J., Montero, J. I., & Rieradevall, J. (2016). Resolving differing stakeholder perceptions of urban rooftop farming in Mediterranean cities: promoting food production as a driver for innovative forms of urban agriculture. Agriculture and human values, 33, 101-120.
22. Sanyé-Mengual, E., Pérez-López, P., González-García, S., Lozano, R. G., Feijoo, G., Moreira, M. T., ... & Rieradevall, J. (2014). Eco-designing the use phase of products in sustainable manufacturing: The importance of maintenance and communication-to-user strategies. Journal of Industrial Ecology, 18(4), 545-557.
23. Shareef, S. L., & Altan, H. (2016, November). Building sustainability rating systems in the Middle East. In Proceedings of the Institution of Civil Engineers-Engineering Sustainability (Vol. 170, No. 6, pp. 283-293). Thomas Telford Ltd
24. Specht, K., Siebert, R., Hartmann, I., Freisinger, U. B., Sawicka, M., Werner, A., ... & Dierich, A. (2014). Urban agriculture of the future: an overview of sustainability aspects of food production in and on buildings. Agriculture and human values, 31, 33-51.
25. Tebbouche, H., Bouchair, A., & Grimes, S. (2017). Towards an environmental approach for the sustainability of buildings in Algeria. Energy Procedia, 119, 98-110.
26. World Bank Open Data. (n.d.). World Bank Open Data. https://data.worldbank.org
27. Yan, J., Lu, Q., Tang, J., Chen, L., Hong, J., & Broyd, T. (2022). Digital Tools for Revealing and Reducing Carbon Footprint in Infrastructure, Building, and City Scopes. *Buildings*, *12*(8), 1097.
28. Yas, Z., & Jaafer, K. (2020). Factors influencing the spread of green building projects in the UAE. Journal of Building Engineering, 27, 100894., https://doi.org/10.1016/j.jobe.2019.100894.