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Incentive Policies to Promote Green Infrastructure in Urban Jordan

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***Abstract*—**The wellbeing of urban dwellers is strongly associated with the quality and quantity of green infrastructure. Nevertheless, urban green infrastructure is still lagging in many Arab cities, and Jordan is no exception. The capital city of Jordan, Amman, is becoming more urban dense with limited green spaces. The unplanned urban growth in Amman has caused several environmental problems such as urban heat islands, air pollution and lack of green spaces. This study aims to investigate the most suitable drivers to leverage the implementation of urban green infrastructure in Jordan through qualitative and quantitative analysis. The qualitative research includes an extensive literature review to discuss the most common drivers used internationally to promote urban green infrastructure implementation in the literature. The quantitative study employs a questionnaire survey to rank the suitability of each driver. Consultants, contractors and policymakers were invited to fill the research questionnaire according to their judgments and opinions. Relative Importance Index has been used to calculate the weighted average of all drivers and the Kruskal-Wallis test to check the degree of agreement among groups. This study finds that research participants agreed that indirect financial incentives (i.e., tax reductions, reduction in stormwater utility fee, reduction of interest rate, density bonus etc.) are the most effective incentive policy whilst granting sustainability certificate policy is the least effective driver to ensure widespread of UGI is elements in Jordan.

***Keywords*—**Sustainable development, urban green infrastructure, relative importance index, urban Jordan.

I. Introduction

PROMOTING Urban Green Infrastructure (UGI) is a vital trajectory towards sustainable urban development. Green walls and green roofs are among the main components of UGI [1], [2]. The concept is an essential paradigm in the environmental management lexicon and is prone to multiple interpretations [3]. This research adopted the idea of UGI to be a strategically planned network of connected greenspace in urban areas that contribute to a range of ecosystem services and conserve natural ecosystem values and functions [1]-[5]. UGI includes, but is not limited to, green walls, green roofs, urban trees and hedges [1], [5]. This research confines the concept of UGI to include a green roof and green walls solely.

A. Green Roof

Green roof systems hold various types of vegetation installed wholly or partially on roofs to achieve sustainable, green, and living open space [6]-[9]. The technology of constructing green roofs is well-developed and typically consists of several components and layers. This involve vegetation, substrate, filter fabric, drainage material, root barrier and insulation (see Fig. 1 below). [5]. Characteristically, green roofs are broadly classified into intensive, semi-intensive and extensive green roofs. The intensive green roof often has a greater soil depth (200 mm-2000 mm thick), whilst extensive green roofs have a lower thickness of the plant-growing medium (50 mm-150 mm). Semi-extensive green roof systems combine characteristics of extensive green roofs (i.e., environmental benefits) in addition to the aesthetical value of intensive green roofs [7]-[9], [10]-[16].

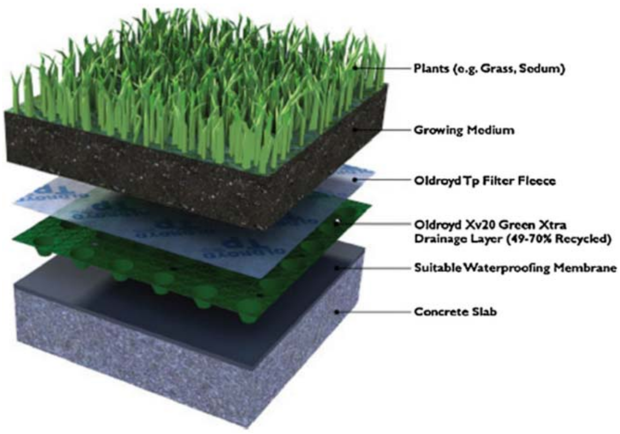

Fig. 1 Layers of green roof [7]

B. Green Walls

Green walls are analogous to green roofs, where the greenery is added to building walls vertically rather than horizontally [17]-[20]. Green walls have many terminologies in the literature, such as living walls, vertical greening systems, façade-integrated greenery and green facades. Typically, there are two types of green walls according to their growing type. The first is a green façade, and this is the simplest; hence, the cheapest form of a 'green wall' is where self-adhering creepers rooting in the soil climb up buildings and infrastructures' walls. The second is the living wall, where plants rooted in compartments directly attached to the wall are often supplied with water and nutrients through artificial irrigation [2], [19], [21], [22].

II. Advantages of UGI

A large number of studies have argued the benefits of UGI on people, built environment, and urban environment [1], [5], [6], [11], [12], [23], [24]. Worldwide, UGI has been used

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extensively to mitigate the negative impacts of urban sprawl and achieve resilient and sustainable cities through:

A. Improving Thermal Insulation of Building

As climate change has become globally recognised, UGI can play an important role to enhance buildings energy performance both in warm and cold climates [5], [9]-[11], [25], [26]. Vegetation used in UGI has the potential to improve the thermal insulation of a building, thus reducing the need for active systems for heating and cooling [1], [3], [7], [13], [15]. The insulation of a building envelop is vital to control the amount of heat transfer between the interior and surrounding environment [7]. In summer, vegetation reduces the indoor air temperature of the building by providing shading [17], [27], [28]. Moreover, plants protect building surfaces from solar radiation and extensive heat fluctuations and act as a wind barrier that reduces energy loss through convective heat transfer [17], [28].

B. Attenuation of Stormwater Runoff

The substrate capacity inherent in the UGI system significantly reduce the water runoff in buildings [1], [3], [6], [15], [23]. For technical benefit, UGI is beneficial in stormwater management by collecting and retaining precipitation, thereby delaying runoff from the roof to the stormwater drainage system [5], [6], [26], [29]. Rainwater can be absorbed by the vegetation or transpired back into the atmosphere [5].

Due to increased ratios of impervious surfaces (i.e. surfaces covered by buildings and asphalt) in the urban environment, in some districts in Amman, the slightest amount of rainfall can result in severe flooding. Delaying water runoff in buildings would mitigate the flow volume into stormwater infrastructure and urban waterways, thus reducing flood risk [6]. Moreover, UGI can not only retain water and reduce the rate of runoff but also improve the water quality by buffering acidic rain, theoretically filtering pollutants and suspended solids [1], [5], [11], [12], [26].

C. Improving the Psychological Well-Being of Urban Dwellers

Several authors argued the benefits UGI could bring for the health and wellbeing of urban residents [1], [10], [30], [31]. UGI acts as a visual relief that provides relaxation and restoration, thus contributing to psychological wellbeing by reducing stress, enhancing positivity and lowering blood pressure [2], [31]. Indoor, living green wall (i.e., bio wall) can improve human health by creating a comfortable interior climate and enhancing indoor air quality [3], [10], [23].

D. Improving Air Quality in Cities

Air pollution has become an urgent issue in most compact cities around the globe [1]. Air pollution in compacted cities of the Global South is even worse due to much-outdated transportation means releasing poisonous gases into the environment [32]. Among several mitigation technologies, UGI is a popular approach that could help to mitigate air pollution in urban environments by carbon sequestration, dust removal and pulling down levels of gaseous pollutants such as nitrogen oxides, lead and zinc [2], [3], [5], [9], [10], [12], [15] [23], [33].

E. Enhancing Urban Ecosystem and Biodiversity

Unsustainable urban development harms local and global natural ecosystems [5], [16], [34]. UGI is an effective remedy for biodiversity enhancement and ecological preservation in the urban environment, particularly in urban centers [1], [13], [16], [29], [31]. Theoretically, UGI replicates natural habitats and partly substitutes the flora removed during construction, supporting many plants such as shrubs and small trees [11], [13], [19]. In addition, UGI provides quality habitat for diverse species (i.e., insects, bees, and birds) and other organisms [1], [3], [10], [11], [13]. For example, green walls are a convenient environment for urban ornithology supporting nesting and shelter resources [19], [22].

F. Reducing Urban Heat Island

With the rapid pace of urbanisation, particularly in the Global South, many cities are under pressure to mitigate the impacts of Urban Heat Island (UHI) [8], [10]. UHI is the difference between the temperature of the urban areas and the surrounding rural areas [8], [17]. Typically, the isotherm pattern of air temperature depicts that urban centres (the island) often have higher urban air temperatures in comparison to surrounding rural areas (the sea) [8], [14]. The increase of concrete structures and reduction in green surfaces boost the absorption of solar heat [8], [25]. UHI enormously increases the demand for electrical power due to an increase in buildings cooling load [25]. Vegetation in UGI, and through the photosynthesis process, is directly associated with lowering the surrounding ambient temperature, hence reducing the impact of UHI [1]-[3], [12], [13], [33].

G. Increasing Property Value

Various studies have highlighted how UGI promote marketability and increase property value; to buildings due to [1], [5], [10], [15], [19], [23]:

- Increase thermal insulation, thus reducing energy consumption;
- Green roofs prolong waterproof membrane layer resulting in reducing maintenance cost and extending roof life;
- Expand utilisation of building's surfaces.

Another frequently mentioned strength associated with property value is the added aesthetical value to the architectural presentation of buildings and their positive effect on urban quality [3], [5], [8], [12], [13], [15], [23], [26], [28], [29], [35]. UGI form a pleasing and attractive style of architecture, thereby improving the aesthetics of the cityscape [2], [6], [19], [31].

H. Improving the Acoustic Characteristics of the Surrounding Environment

Sound insulation is a well-acknowledged benefit of vegetation when incorporated into buildings [2], [10], [22]. UGI reduce sound transmission by absorption of sound waves diffracting over roofs, especially for buildings near airports, factories or busy freeways [2], [3], [5], [10], [13], [19], [22], [29], [31]. Also, UGI can prove to be a good solution for the city's sound pollution, mainly when the street is bordered by buildings on both sides (street valley) [11]. This phenomenon is often called an urban canyon and is apparent in cities that consists of a series of steep hills [20].

III. Urban Green Infrastructure Policy Incentives

A large body of research has shown that government incentive policies play a vital role in the broader implementation of UGI and stimulate the local market [6], [13], [14], [35], [36]. Many cities in the global north (i.e., Europe and North America) have adopted various incentives policies to promote and alleviate the quantity and quality of UGI [1]. Green roofs and walls are thus unlikely to move from niche to regime level [36]. In this, seven factors were drawn from the literature, identified as a driver, and discussed in this section [1], [6], [12], [13], [37]:

A. Direct Financial Subsidies

Direct financial incentives are among the most straightforward policies to encourage UGI construction in urban areas [1], [37]. It takes the form of a cash reimbursement of the construction cost of a green roof or green wall. Many cities around the globe have adopted this incentive policy to promote green roof installations (see Table I below). However, for building owners to access the public financial subsidies, most cities determine a specific criterion of a minimum depth of growing media, minimum maintenance agreement, and minimum vegetation coverage [1].

TABLE I
List of Cities That Adopt Direct Financial Incentives to Promote UGI

City name	Country	Details of the direct financial incentive	Reference
Esslingen	Germany	The local council subsidises 50% of the costs for green roofs	[13], [36]
Darmstadt	Germany	Building developers receive up to 5000 Euro	[13], [36], [38]
Berlin	Germany	Building owners are repaid approximately 50% of green roof construction costs	[37], [39]
North Rhine Westphalia	Germany	The subsidy includes 15 euros for each m^2 converted from impervious surfaces to the green cover.	[37]
Vienna	Austria	Local council subsides building owners up to 2200 Euro per project	[13]
Basel	Switzerland	Building owners are repaid 20% of the cost of a green roof	[40]
Quebec	Canada	the economic incentive is provided per square meter implemented of green roofs	[36]
Chicago	USA	lump-sum payments of $100,000 to be distributed to 20 green roof projects selected competitively on a merit base.	[37]

B. Indirect Financial Incentives

USA and Canada, particularly New York, Minneapolis, Portland and Toronto, respectively, adopt indirect financial incentives to promote green infrastructure in urban areas [26], [37]. Indirect financial incentives could take the form of tax reduction, reduced sewage, public lighting, sweeping and cleaning fees, a credit towards the municipality's stormwater utility fee, or removal of the interest rate related to building construction or operation [1], [36], [37]. Tax property is the annual amount paid by a landowner to the local government to collectively fund the cost of operating and maintaining public services in a city [1]. Moreover, [1] and [36] suggested introducing a density bonus by increasing the footprint area of the surface area and the number of stories granted to buildings that install green infrastructure in their urban plot. The construction permit incentives allow landowners to legally exceed the construction footprint limit assuming that each m^2 of impervious surface increase is compensated by porous structures, including green roofs and other green infrastructure [1].

C. Obligations by Law

According to [1], obligations by law are the second most popular incentive policy globally. Under this driver, new commercial, institutional and residential buildings that exceed a specific footprint area are obliged by law to apply UGI [1], [13], [35]. Both cities of Cordoba (Argentina) and Port Coquitlam (Canada) oblige real estate developers to install UGI for building projects with a covered area of more than 400 m^2, 5000 m^2, respectively [1]. In addition, many successful examples can be noted from cities such as Munich, Copenhagen, Tokyo [13], [26], [36].

D. Agile Administrative Process

Real estate primary stakeholders need fast and cost-efficient building permits. An agile administrative process means that projects that propose any UGI elements in their footprint get greater agility and priority in the licensing process [1]. Prioritizing green buildings projects could also include speeding up all necessary inspections and obtaining utility connections.

E. Promoting Scientific Research and Spreading Awareness

It is of great importance to the widespread UGI to promote collaboration among academics, policymakers and practitioners at the local and international level [1], [3], [13]. Sustainability awareness of the broader population and decision-makers will enable cities to exchange successful results, thus developing context-based strategies for green infrastructure implementation [1], [13].

F. Granting Sustainability Certificate

Rio de Janeiro, Brazil, offers a voluntary certification program to encourage citizens to include sustainable actions and practices. This sustainability certification is analogous to international sustainability certificates such as LEED (Leadership in Energy and Environmental Design) certification but is more tailored to the local context [1]. Such a certificate is granted according to the ratio of vegetation surfaces to the total built-up area [1].

IV. Research Analysis

This study aims to assist policymakers in Jordanian authorities to determine the most suitable strategy to enhance the widespread of UGI in urban Jordan. This research incorporates quantitative and qualitative techniques to improve the validity and reliability of research findings (i.e., triangulation) [41]. In the beginning, the researcher conducted literature reviews of academic articles, textbooks, and published journals to determine the most popular drivers (see Table II below). However, these drivers were tailored to fit its context and may not apply to the Jordanian context due to varieties in the legislative, operational, and cultural context [1], [10], [11], [13], [35]. Therefore, drivers were tabulated in a questionnaire format, and their suitability to the Jordanian context was tested according to the judgments of research participants. Purposive sampling was adopted to select research respondents from policymakers, contractors and consultants. The respondents were invited to give their opinion on the relative suitability of each driver according to the Jordanian context. A questionnaire survey has been distributed through several methods like a hard copy, email, Google forms and in-person interviews. A total of 49 policymakers, 127 consultants and 90 contractors filled the survey questionnaire.

TABLE II
Sequential Diagram of Studies Methodologies

Step 1	Identifying the most common drivers to boost UGI application
Step 2	Questionnaire survey preparation
Step 3	Questionnaire distribution and collection of feedback
Step 4	Analysis of data using RRI
Step 5	Discussion of survey results
Step 6	Conclusion

A. Relative Importance Index

Data are then gathered and analyzed through a non-parametric technique called the Relative Importance Index (hereafter RRI) (see (1) below). RII is considered a reliable technique for analysing structured questionnaires with ordinal measurement of attitudes [42], [43]. The importance of RII lies in the ability to "*[find] the contribution a particular variable makes to the prediction of a criterion variable both by itself and in combination with other predictor variables*" [44, p. 120]. The Likert scale has been used to collect policymakers, consultants, and contractors' opinions in value of 1 (not effective) to 5 (extremely effective) to rank suggested incentives policies. The following equation determined the RII for each incentive policy [45], [46], [47].

$$RII = \frac{5(n5)+4(n4)+3(n3)+2(n2)+n1}{5(n1+n2+n3+n4+n5)} \quad (1)$$

Equation (1) is the Relative Importance Index Equation, where n1; n2; n3; n4; and n5 are the number of respondents who selected: 1, not effective; 2, for slightly effective; 3, for effective; 4, for very effective; and 5, for highly effective, respectively. Moreover, this study adopted the classification guide in [48, p.239] to determine the level of impact of RII for each driver. See Table III below:

TABLE III
Classification Guide to Determine Importance Level of RII

RII values	Importance level
0.8 ≤ RII ≤ 1	High (H)
0.6 ≤ RII < 0.8	High-Medium (H-M)
0.4 ≤ RII < 0.6	Medium (M)
0.2 ≤ RII < 0.4	Medium –Low (M-L)
0 ≤ RII < 0.2	Low

When items are used to form a scale (i.e., Likert scale), it is vital to ensure scale's reliability [49], [50], [51], [52]. Reliability of scale is used to "*calculate the stability of a scale from the internal consistency of an item by measuring the construct*" [50, p. 6]. Consequently, a Cronbach's Alpha was carried out to measure the internal consistency of the sets returned. Typically, The alpha coefficient ranges from 0 to 1, whereby the greater the value is considered more reliable for the study [49], Nunnally (1978) cited in [51]. A minimum value of 0.5 is considered to validate the consistency and reliability of the data collected [49], while others believe that the Cronbach Alpha coefficient should be above 0.7 [45], [53]. Cronbach's alpha (a) is calculated by (2) below, where *n* is the number of questions; *Vi* is the variance of scores on each question; and V_{test} is the total variance of the overall scores (Howitt & Cramer (2008) cited in [51, p.337]):

$$a = \frac{n}{n-1}\left(1 - \frac{\sum v_i}{v_{test}}\right)$$

Equation (2) is Cronbach's Alpha equation and in this research, the Cronbach Alpha coefficient was reported as 0.779. Accordingly, the current study reported an excellent Cronbach Alpha coefficient, thus ensuring the scale's internal consistency.

B. Kruskal-Wallis Test

Kruskal-Wallis Test is a non-parametric analysis of variance that enables researchers to determine the level of agreement on some continuous variable for three or more groups [52, chapter 16]. Kruskal-Wallis Test was adopted to measure the level of agreement between the three groups of policymakers, consultants and contractors' rankings for UGI incentive policies. SPSS was used to perform the calculation of the Kruskal-Wallis Test (see Fig. 2 below).

The *p value* should be less than 0.005 to show level of agreement and consistency [52]. Fig. 2 below indicates a considerable agreement on the most (second column) and least (fifth column) convenient incentive policy according to the Jordanian context.

Test Statistics[a,b]

	Direct financial subsidies in form of cash payment	Indirect financial incentives (tax reductions, reduction stormwater utility fee, reduction of interest rate, density bonus by which an increase to the footprint area)	Obligations by law	Greater agility and priority in the licensing process	Promoting scientific research and outreach program	Granting sustainability certificate
Kruskal-Wallis H	4.642	13.092	6.841	6.844	8.410	10.764
df	2	2	2	2	2	2
Asymp. Sig.	.098	.001	.033	.033	.015	.005

a. Kruskal Wallis Test

b. Grouping Variable: What is your profession?

Fig. 2 Results of Kruskal Wallis test

C. Research Findings

The whole suggested drivers ranked between high-medium to high according to the reference classification guide of RII (see Table III above). Among the six different drivers presented to respondents, granting a green certificate gained their lowest interest. However, indirect financial incentives ranked first by policymakers, contractors and consultants (see Table IV below). The most encouraged form of indirect financial incentives among research respondents was granting building that applies principles of green building (i.e., UGI) density bonuses and then determining the amount of compensation for each square meter of green roof or green wall. While this incentive gained a high RII (0.70), the author believes it would have limited success in Jordan. Without addressing government bureaucracy and enhancing a multi-disciplinary approach among Jordan's local, regional and central government, this program would only be successful in theory.

TABLE IV
Results of RII Analysis

Drivers	Overall mean	Overall RII	Overall Rank	Consultant's RII	Consultant rank	Contractor RII	Contractors rank	Policy makers' RII	Policy-makers rank
Indirect financial incentives (tax reductions, reduction stormwater utility fee, reduction of interest rate, density bonus by which an increase to the footprint area)	3.98	0.79	1	0.8048	1	0.8494	1	1	.68
Promoting scientific research and outreach program	3.69	0.73	2	0.7398	3	0.8	5	2	.62
Greater agility and priority in the licensing process	3.55	0.71	3	0.7495	2	0.728	3	5	.58
Obligations by law	3.53	0.70	4	0.7105	4	0.7617	2	4	.59
Direct financial subsidies in the form of cash payment	3.51	0.70	5	0.7024	5	0.755	4	3	.61
Granting sustainability certificate	3.42	0.68	6	0.6926	6	0.7415	6	6	.55

Despite the popularity of these incentives in Global North cities, direct financial incentives ranked the fifth most effective incentive policy among the other six suggested incentive policies. Research respondents do not strongly believe this policy could be implemented in Jordan due to the philosophy of fiscal conservatism adopted by the Government of Jordan. Generally, general budgets in developing countries and Jordan are no exception, mainly directed to more urging priorities, such as health, security, water supply, sanitation, energy and education issues, etc. [1]. The vast majority of municipalities in Jordan suffer from financial difficulties, thus restricting financial incentives for green infrastructure development. Consequently, indirect incentives discussed above, which do not require spending public fund, has been chosen by research respondents as the most convenient driver towards the widespread application of UGI in urban Jordan.

Promoting scientific research related to Jordan's green roofs and green walls ranked second with an RII of 0.73. Research on green roofs and green walls in the Global South is limited and fragmented compared with the Global North. Typically, scientific research is vital to fill gap in technology, expertise and knowledge [6]. Scientific research equips consultants and contractors with proper knowledge about the technical features of the UGI application [10]. In addition, [6] demonstrate the significant role of academic research in developing incentive policies, context-based technical solutions to manage stormwater, sustainable irrigation solutions, and innovative and sustainable perennial plant.

Granting priority to building projects that adopt UGI is very effective policy in Jordan. It could be considered an indirect financial incentive in developing countries which embrace fiscal conservatism in their public funds. However, this research stresses the significant inter-linkages horizontally and vertically among governmental authorities. Multi-disciplinary policy approach between various authorities included in the building licensing process at the local level (e.g., Municipalities, Civil Defense, Jordan Engineers Association, Jordan contractors, department of antiquities, etc.) and at the national level (Ministry of Local Governance, Ministry of Public Work, Ministry of Environment). Moreover, the author suggests strengthening local governance institutions, encouraging public participation in urban governance, and an integrated policy approach eases the complexity and bureaucracy inherent in the building licensing process in Jordan.

The presence of convenient legislation and regulations has been welcomed by many research respondents and ranked fourth among other drivers with RII 0.70. This study suggests a gradual move towards the forced implementation of UGI starting from obliging mega-development projects in the city to apply elements of UGI. Moreover, regulative bodies conditions ought to be in constant revision to make the greening of Amman easier.

V. Conclusion

This study aims to define the most convenient incentive policy to promote the widespread of UGI in Jordan. An extensive literature review has been conducted to determine the most common incentives policies used worldwide. After, three groups of policymakers, consultants and contractors were asked to rank the most effective policies detected from the literature. RII was used to determine drivers effectiveness according to research participants opinions and judgments.

Research participants agreed that indirect financial incentives are the most convenient and effective incentive policies to ensure the more significant widespread of UGI in Jordan. However, granting a green certificate policy was deemed the least effective policy to encourage primary construction stakeholders to adopt UGI.

This study argues that the implementation of UGI in Jordan could be addressed through a 'smart' strategy adopted at the national level. Smart city policy would aim to improve renewable energy generation and enhance water and air quality in Jordanian cities towards achieving sustainable urban development. UGI can also be included in the Amman City Resilience Strategy adopted in 2014, aiming to enhance urban quality of life by addressing the risk of urbanisation, extensive urban sprawl, and demographic growth.

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