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Methodological and Ideological Options

Considering water ecological aspects in developing a quantitative climatic model of urban green building using monetary valuations

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ABSTRACT

The need to respect environmental considerations in terms of resource consumption and harmful production has led to formulate regulations for green building. While some countries have started developing green building rating systems, some others are following the existing systems. Iran does not comply with any of the existing systems due to political reasons and does not utilize such a system officially. The purpose of this study is to add environmental water attitudes to Madad's Green Building Model, which was developed solely on the basis of environmental climatic factors. The model of each city is a function of its climatic and demographic conditions and is implemented on the basis of expert advice and AHP methodology. The results of the monetary valuation studies were used to improve the selection of indicators and to accurately define their weighting in the model. The indicators in the current study are to reduce runoff volume, water consumption, and the reuse of grey-water. The assessment results of the study area showed that only 11% of these green building capabilities had been used.

1. Introduction

The urban population has grown twice in compare with the rural population since 1950 (United Nations, 2015). The strong growth in the concentration of the urban population is leading to a deep degradation of the environment, which is more intense in developing countries (El Araby, 2002). Recognizing the energy efficiency factors of the urban buildings is crucial to create opportunities for reducing energy consumption and greenhouse gas emissions under climatic conditions (Zhou et al., 2018). For this reason, since the early 1990s, most countries have either developed their own green building rating systems or followed one of the existing systems (Madad et al., 2019). Surveys of some of the world's best-known green building systems reveal a common priority in reducing energy consumption, which will automatically lead to a reduction in carbon dioxide emissions (Chen et al., 2015).

Although the development of these green building rating systems has been viewed as a good step towards environmental polarization, the criteria and assessments of these systems should also be based on local climatic conditions (Madad et al., 2019). The second important gap in the development of green building systems is the selection of appropriate criteria and weighing methods, which are usually selected based on the views and tastes of experts and their past experiences rather than the quantitative calculations and precise Monetary Evaluations (ME). The lack of using ME in the selection of criteria and the weighting of the model is due to the lack of full coverage of monetary studies on all environmental factors (HK-BEAM, 2004).

One of the most comprehensive studies on the monetary valuation of environmental benefits is a study commissioned by a consortium called GIVAN (Green Infrastructure Value Network). This study has been done in the UK in 2008 and published in 2010 along with an evaluation toolkit (West, 2010). Madad et al. (2019) show that by taking the local temperature into account, they have developed a specific model for each city, better adapted to its climate. Their model criteria are shown as environmental locators and construction components in Table 1.

In Madad study, the results of GIVAN's ME were used to promote the selection of criteria and the weighing of models. Their hierarchy tree structure of the model is shown in Fig. 1. The numerical values and coefficients in Fig. 1 are related to Asad Abad city model (a city located in the cold region). Black font numbers were extracted upon expert judgments, and the red font numbers were derived upon the results of GIVAN's ME and some locally customizations. Numbers with a blue font were calculated based on the resultants of red numbers and black

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Table 1
Climate based environmental and construction components (Madad et al., 2019).

Urban construction components C_UCC	Indoor effects C_ine		Green roof	C_grf
			3 trees or green wall	C_3ts
	Outdoor effects C_oue		Impervious surfaces	C_iss
			Trees	C_trs
			Shrubs	C_shs
			Mown grass	C_mgs
			Rough grass	C_rgs
			Cultivated surfaces	C_css
			Water	C_wtr
			Bare soil surfaces	C_bss
	Power installations C_wpi		Renewable energy	C_rne
			Green electrical devices	C_ged
Environmental effects locators E_EEL	Air E_air	CO_2 emissions E_cen	Power for cooling	E_pfc
			Power network consumption	E_pnc
			Gas for heating	E_gfh
		Urban heat island		E_uhi

coefficients. Although the results of the Madad model calculations are based on monetary terms, only a small fraction of the components were measured directly by the monetary valuation calculations; two arithmetic units have therefore been defined for model assessments. The first, called Residential Benchmark (RB) was defined as a 100 m2 built area with 30 m2 of open space. The second was the UGBU (Urban Green Building Unit), defined as the number of ecosystem benefits of a 1 $_{RB}$ building located in a temperate climate that requires the least energy.

Function (1) presents the model of Asad Abad, in the UGBU unit. In this function, the presence of trees in the open areas around the building (which keeps the building warm) has a higher priority than the green roof (which keeps the building cool), and as it is described in section "2.2.1. Monetary evaluation for heating and cooling" of Madad study, this will be appropriate for a city located in the cold region.

$$1.11 * C\_UCC = 0.57 * C\_oue + 0.45 * C\_3ts + 0.032 * C\_rne + 0.032 * C\_ged + 0.027 * C\_grf \quad (1)$$

In GIVAN Study, eleven green infrastructures including: climate, water, communities, health, land values, Investment, labour productivity, tourism, recreation, biodiversity, and land management have been introduced upon the Millennium Ecosystem Assessment classifications. All qualitative studies have been done. Some of them have successfully completed their quantitative studies and only a few parts have completed their ME. The water sector of this study places a strong emphasis on reducing the amount of runoff, which may be generated due to climatic condition in the British Isles. It is estimated that in the next 100 years, the arid areas of Iran will be drier while the annual rainfall in rainy areas will be increased (Abbaspour et al., 2009). Therefore, it is essential that in addition to reducing the volume of surface water, implement strong ideas to reduce the demand for water (Madani et al., 2016). The use of high-efficient appliances or the reuse of precipitation and grey-water are some of these ideas. Grey-water is wastewater produced in residential units or offices without fecal contamination.

The annual precipitation is the primary influence on flood forecasts due to runoff volume. A flood forecasting approach in large scale has been developed using rain-flow relationship models (Derdour et al., 2018). The size of the city and the population growth are other factors that influence the importance of the policy for reducing storm-water runoff. In parallel with the growth of the urban population, the impervious surface has also been developed; consequently, the accumulation of the surface runoff and its volume growth increase the risk of flooding in different parts of the city (Gibyung, 2018).

Water conservation is one of the basic principles of green building, and the systems should help reduce water consumption (Sheth, 2017). Given the limitations of urban water supply and the reduction of water resources, the use of rain storage and recycling facilities can effectively reduce this problem (Wung et al., 2006). Rainwater harvesting and grey-water reuse are alternative systems to reduce drinking water consumption (Oviedo et al., 2018). In addition, water-efficient fixtures and appliances are increasingly being used to reduce the needs for urban water (Price et al., 2014).

This research adds water attitudes to the green building model developed by Madad et al. (2019). In the Madad model, only the climate component was taken into account, and this study adds the water component. A model has been developed for each city based on annual precipitation, population and water tariffs. By adding it to the associated model developed by Madad, a more complete urban green building model has been realized. The results of the GIVAN's ME were also used to justify the weights.

This paper respectively follows by four sections: the first section gives a brief description of the research steps, and studies ME in water management, the second part describes the implementation of the model framework and the development of the tools needed to generate the model. In the third section the case study introduces the new criteria and the results are discussed. In the fourth section a conclusion will be presented.

2. Methods and materials

In Iran, there is an average annual rainfall of 413 billion cubic meters (bcm) (Madani, 2014) of which approximately 299 bcm evaporates (Vaux and Parkin, 2005). From the remaining water volume that can be exploited, 83bcmis consumed in the agricultural sector and 5.5 bcm is consumed in the household sector (Hojjati and Boustani, 2010).

As a result of the cases mentioned in the literature review along with the expert judgments, it was decided to consider four issues related to the recovery of grey-water and rainwater to implement the model: the use of highly efficient water valves, reduced runoff volume, the reuse of grey water, and urban water tariffs. Fig. 2 depicts the stages of this research. As illustrated, there are two cases of urban water pricing and surface runoff volume, which is included in zoning operations. These zonings have greatly helped avoid the problems caused by the great diversity of cities and reduce the number of categories. Since the tariff classification of the National Gas Company was carried out in four classes, Madad model attempted to generate the zones into four classes too, which would be practical. On the other hand, it was needed to merge the results of this study with the Madad model. In order to provide more consistency, the zonings were also generated into four classes. Effective factors on the surface runoff volume and the computational relationships between them were formed based on the results of GIVAN's ME studies.

After defining the environmental indicators (relating to water), these indicators were merged with the air aspect locators defined in Madad model. A general hierarchical scheme has been devised for the model and taken into account by experts. Then, based on the monetary valuation values obtained in Madad model, the weights of the model became precise and a specific model was developed for each city. Calibration operations were carried out by conducting a case study in one of Tehran's metropolitan areas. In order to facilitate the repetitive endless operations of pairwise comparisons and performing Analytic Hierarchy Process (AHP) (Weiss and Rao, 1987), appropriate software tools have been implemented and used.

2.1. Monetary valuations of water management

The functions (2), (3), and (4) are parts of lengthy formulas extracted from the water management and flood reduction section of GIVAN's monetary valuations toolkit. In the formulas below, green expressions represent the output headers and their units. The red expressions represent the following sub-functions, which can also be

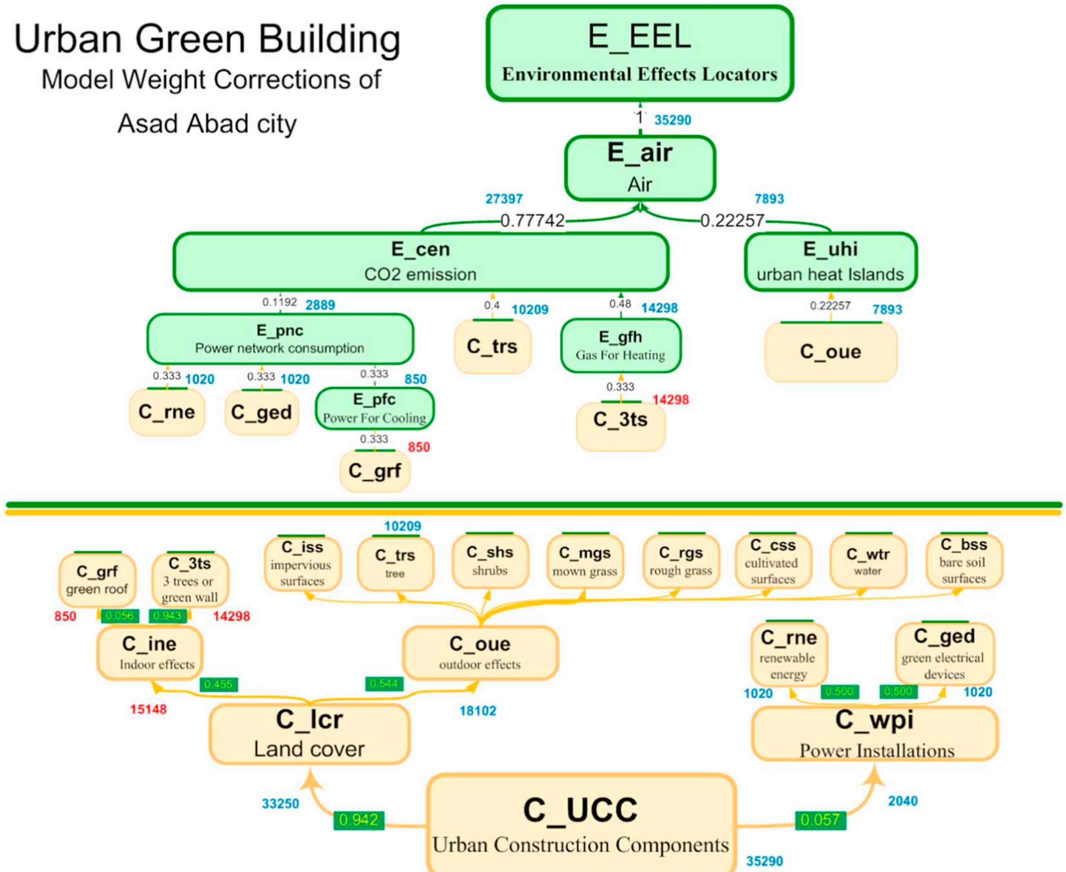

Fig. 1. Numbers with a blue font were calculated based on the resultants of red numbers and black coefficients (Madad et al., 2019).

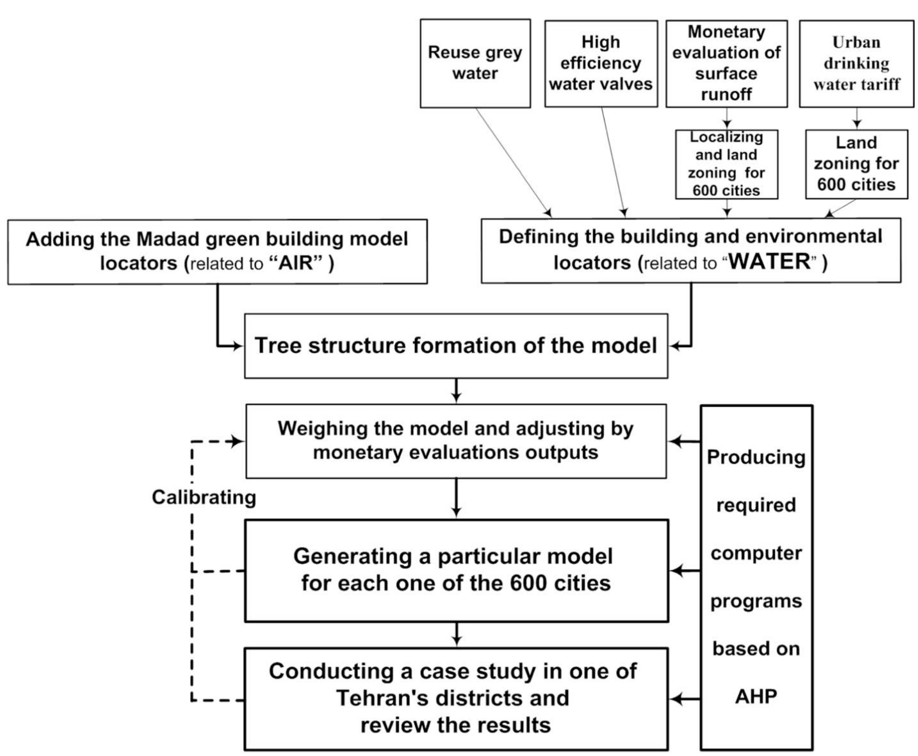

Fig. 2. The steps of the research.

created as reciprocal expressions of other sub-functions or variables. Black expressions also contain brief descriptions of the definition of variables and their units. The names of all the functions and variables are completely identical to those of the GIVAN studies.

```
C41 : ( £/yr value of carbon)  Tool 2.1 output- 2.1 Carbon emissions savings from reduced storm water volume entering due to land cover ( £/yr) ;
C41  =IF('Project Data '!D59=0, 0, C35-C28)
   'Project Data '!D59 : ( )  Is the area serviced by a combined sewer system? If 'Yes' please enter 1 ;
   'Project Data '!D59= User Defined
C35 : ( £/yr)  Value of r carbon saving  (proposed design) -after ;
C35  =E106
C28 : ( £/yr)  Value of current carbon saving -before ;
C28  =E99
```
(2)

```
C42 : ( £/yr value of energy)  Tool 2.1 output- 2.1 Energy savings from reduced stormwater volume entering due to land cover;
C42  =IF('Project Data '!D59=0, 0, C36-C29)
   'Project Data '!D59 : ( )  Is the area serviced by a combined sewer system? If 'Yes' please enter 1 ;
   'Project Data '!D59= User Defined
C36 : ( £/yr)  Value of energy saving  (proposed design) -after ;
C36  =E107
E107 : ( £/yr)  Proposed land cover-Cost saving (energy)  [Note private sector benefit] ;
E107  =E104*'Values library'!C24/100
E104 : ( kWh/yr)  Proposed land cover-Energy saved (from avoided wastewater treatment) ;
E104  =E103*'Values library'!D22/1000000
      E103 : ( l/yr)  Proposed land cover- Water diverted from combined sewer-  Annual rainfall depth multiplied by project area gives annual rainfall volume, minus runoff gives water diverted from sewer ;
E103  =(((IF(SUMIF(D163:AH522,"<>-99.99")>0,SUMIF(D163:AH522,"<>-99.99")/30,C16)/1000)*('Project Data '!E4*10000))-E92)*1000
D163 : ( millimetres)  First day precipitation in Data table for tool 2.1: daily precipitation figures ;
      D163= User Defined
```
(3)

```
C49 : ( £/yr)  Tool 2.2 output for domestic properties -2.2 Reduced in wastewater treatment costs for domestic and commercial water ;
C49  =C48*'Values library'!D27
C48 : ( )  Self sufficient properties for surface drainage- Insert number of properties qualifying ;
   C48= User Defined
   'Values library'!D27 : ( £/yr)  Surface water rebate to domestic customers (Welsh Waters) - (Mid/average) ;
   'Values library'!D27=  45
```
(4)

The three functions are related to reducing runoff volume to reduce the risk of flooding, as well as reducing wastewater treatment and recycling processes. According to the studies conducted in this water management study, the main objective of this issue was to compile the criteria for the construction of urban houses in order to reduce the volume of water runoff. By taking into account the internal relationships of functions (2), (3), and (4), the 9 types of land coverage effectively absorb surface water and reduce runoff volume. The type of hydrological soil is also effective in water absorption. The results of these extractions are shown in Table 2.

Rainwater management is an essential element of the green building to deal with the problems and difficulties related to unfavorable weathering (Wang et al., 2018). As mentioned in the literature review, the importance of this issue depends largely on the annual rainfall and the population of the city. The importance of the runoff volume is directly related to the population and annual precipitation of cities. Whenever the population of a city which is located in a more rainy area increases, this issue becomes more considerable and vice versa. Therefore, in order to classify cities according to the importance of reducing runoff, it is necessary to classify them in terms of population and annual rainfall.

Table 2
Percentage of runoff upon different types of land covers (West, 2010).

Land coverage	Hydrological type of soil				Average
	A	B	C	D	
Buildings	98	98	98	98	98
Other impenetrable surfaces	98	98	98	98	98
Trees	25	55	70	77	44
Shrubs	45	66	77	83	59
Mown grass	39	61	74	80	54
Rough grass	30	58	71	78	48
Cultivated surfaces	67	76	83	86	74
Water	0	0	0	0	0
Bare soil or gravel surfaces	74	83.5	88	90	80

In order to obtain the geographical classification of the country for a correct weighing in the Green Building Model, and to be more compatible with Madad model structure, the annual precipitation zoning map was used in 4 classes: 0 to 100, 100 to 250, 250 to 500 and > 500 mm per year. The population of the cities has been respectively grouped in4 classes: < 100,000 inhabitants, between 100,000 and 300,000 inhabitants, between 300 and 900,000 inhabitants and > 900,000 people. By combining these two classifications, cities have been grouped into 16 different categories, ranging from the most populated city in the rainiest zone to the least populated city in the low rainfall region. Fig. 3 demonstrates the different positions of cities according to their importance of runoff water volume.

2.2. Other parameters

In Iran, the Ministry of Energy has conducted various studies since the early 1990s on the cost and value of water (Abfa_Office, 2011). The price of water in different cities varies according to the type of use and consumption. So, it is impossible to specify a constant number as the representation of the water tariff in a city. In 2010, the Ministry of Energy introduced a final adjustment coefficient of urban water tariffs in each province of the country based on geographical location, extraction conditions, and water quality. The values of these coefficients range from 0.62 in Khorasan-E Jonubi to 1.2 in Tehran (Abfa_Tehran, 2010). In this research, the ratio of the final adjustment coefficient was used as the weighing factor for the social value of urban drinking water.

It was necessary to classify urban water tariffs in a few groups for being able to enter them in the Model. Therefore, to better reconcile themselves with Madad model, tariffs were considered to belong to four groups. Since the number of samples for the process was very small (30 provinces), the K-Means algorithm was used in the R programming environment. The computational complexity in this algorithm is low and the clusters produced are not overlapping (Ng et al., 2006). The k-means algorithm is easily programmable on a computer, and studies have shown that it is theoretically worthwhile (MacQueen, 1967).

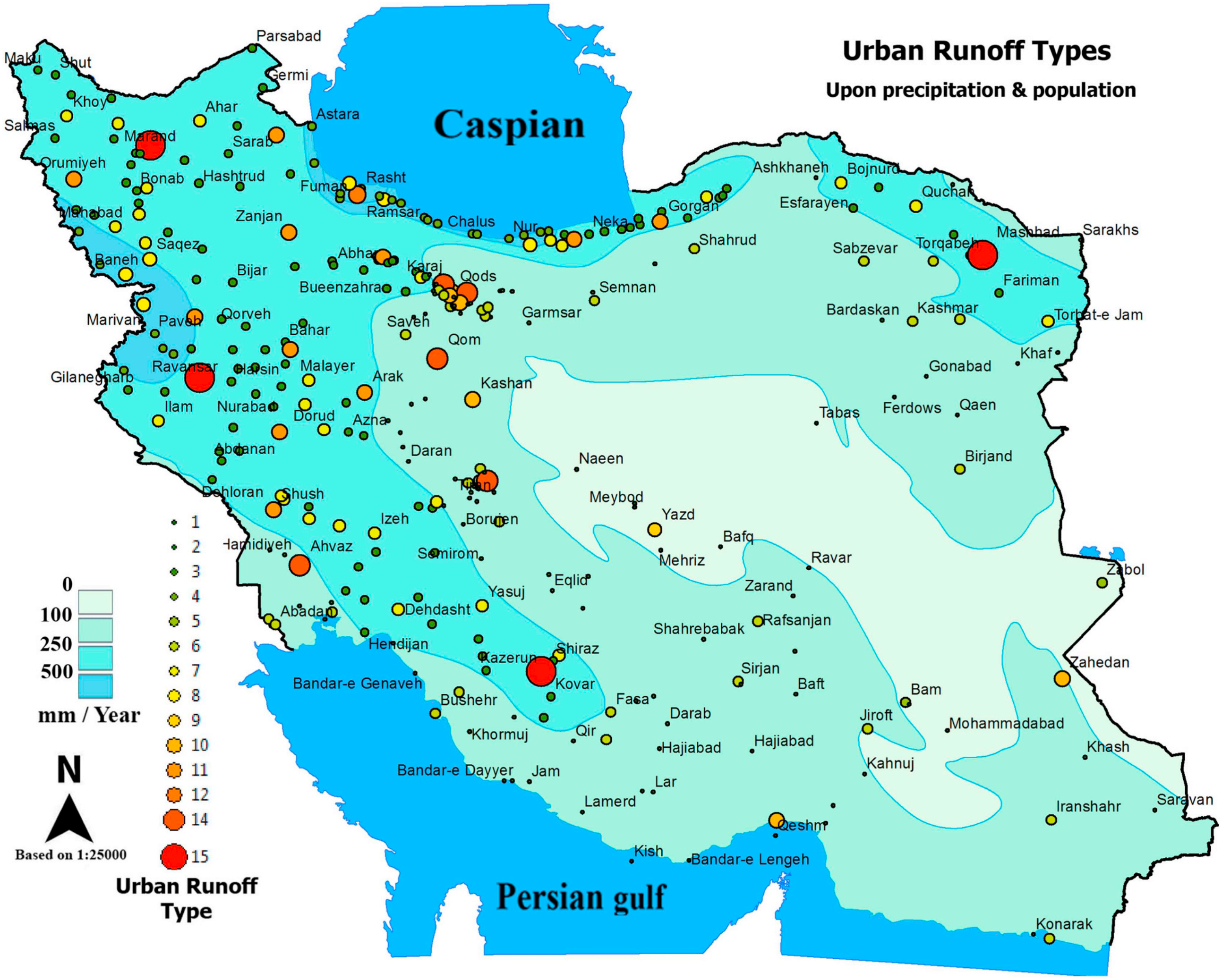

Fig. 3. Classifications of cities runoff importance upon their annual rainfall and population.

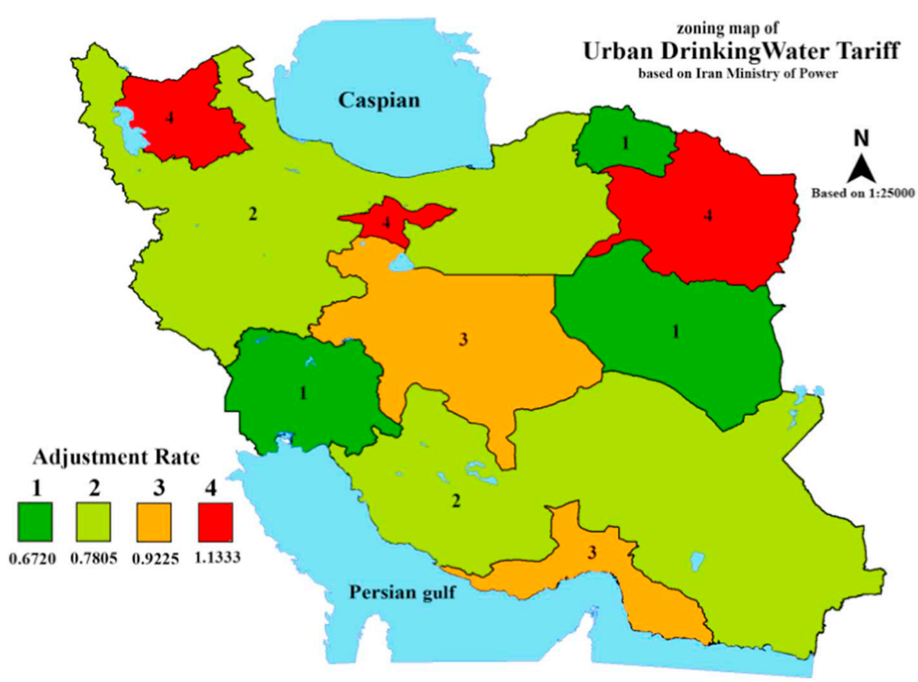

Fig. 4. Zoning map of urban drinking water rates.

Table 3
Construction components and Environmental locators.

Indicators type	Components		Descriptions	Code
Urban construction components C_UCC	Indoor effects C_ine		Green roof	C_grf
			3 trees or green wall	C_3ts
	Outdoor Effects upon soil types A.D C_oue		Impervious surfaces	C_iss
			Trees	C_trs
			Shrubs	C_shs
			Mown grass	C_mgs
			Rough grass	C_rgs
			Cultivated Surfaces	C_css
			Water	C_wtr
			Bare soil surfaces	C_bss
	Water & power installations C_wpi		Renewable Energy	C_rne
			Green Electrical Devices	C_ged
			Efficiency Water Valves	C_ewv
			Reuse Grey-Water	C_rgw
			Reuse Precipitation	C_rpn
Environmental effects locators E_EEL	Air E_air	CO_2 emission E_cen	Power For Cooling	E_pfc
			Power network consumption	E_pnc
			Gas for heating	E_gfh
		Urban heat island		E_uhi
	Water E_wtr	Runoff volume		E_rov
		Water network consumption		E_wnc

These coefficients were classified into four groups, with the average rates of 0.6720, 0.7805, 0.9225 and 1.1333 respectively. The result of these groupings is presented in Fig. 4.

Estimated water consumption in urban areas of Iran ranges from 100 to 200 l per day per person. The outdoor water consumption changes considerably with the weather and the type of green space and can vary from 50 to 100 l per day per person. In dry weather, reducing water consumption for green spaces is often a priority, while in wetlands, conservation programs focus on domestic consumption. The typical water consumption in residential buildings is shown in the supporting documents of the 2006 Teheran Master Plan (Jamab, 2006). The percentage of water saving is calculated based on a house of five people with two showers, two toilets, and three faucets. While domestic consumers represent 75% of all users and the application of "demand management methods" can reduce consumption by 25%, it appears that by applying these methods, the total consumption of drinking water in the country can be reduced by 19%.

Using the equipment which is designed to reduce drinking water consumption can reduce waste by 40% to 50% in different sections. The use of photoelectric valves saves 70% of water compared to conventional valves.

2.3. Urban green building components and indicators

In this study, two categories of components are defined for the development of a green urban construction model. One group of components is linked to building components and the other is related to environmental indicators. Identification of the components and indicators are based on a summary of the results of the Green Infrastructure Valuation Toolkit studies and the results of indigenous studies in the country, which were mentioned in the previous sections.

According to these studies, the effect of reducing energy consumption through the use of "green appliances" compared to the "green roof" is completely high. Hence, it is necessary to consider the positive effect of this component on environmental issues. There is also the same case in the water efficiency valves. The above-mentioned observations and studies led to the identification and selection of 15 building components and their six related environmental indicators. To present the structure and position of each of the model components, Table 3 presents the hierarchical structure of these components with a brief phrase of their descriptions and their coding in the models. Considering this aspect, realizing the schema of the hierarchy tree structure will be more convenient.

3. Implementation

After identifying and selecting green building components in relation to the water factor, and integrating them into the hierarchical tree structure of Madad study, as shown in Fig. 5, a more complete hierarchical tree diagram was created that covers both "Air" and "Water" components. These components should be divided into two general categories: Components specific to each apartment and components related to the public sector, such as the courtyard and the roof. This type of segmentation was necessary for assessing and rating buildings.

The trees of the ecological hierarchy were first weighed on the basis of expert judgments, then for each city, depending on its location in the designated zones, secondary weighing values were defined. Finally, the values of the monetary valuations based on the localized components were generalized to the other components and the final weight of the model parameters for each city was determined.

In this study, the same two arithmetic units (RB, UGBU) were used with the same definitions; however, the numerical value of the UGBU increased (from 31,792 to 103,696) as the water parameters were added to the model. Thus, the UGBU unit of Madad model which just considered the air factor ($UGBU_{air}$), represents about one-third of the UGBU unit of this study which considered both air and water factors ($UGBU_{air+water}$).

3.1. Computer programming

Specific software programs were written by A. Madad – Tehran/Iran to cover the new studied factors based on Table 3 and Fig. 5 structures. The new software programs helped to generate new green building models for all cities upon their particular local conditions. After integrating modeling capabilities into the corresponding computer programs, facilities were created to assess buildings of each city according to their generated green building models.

4. Results and discussions

With the new ecological building model in Tehran, which was equipped with water components, the residential buildings of the case study were re-evaluated and the new results were obtained, as shown in Fig. A1.That district had a total of 1195 residential parcels that use the natural gas network for heating and the electrical network for cooling. The study was conducted on the basis of the "Property Assessment" database from Tehran Municipality in 2006. In order to make a clear comparison between the model that considers only the air components and the one that evaluates the air and water components, the results of the two assessments are to be presented in Table 4.

Function (2) presents Madad model for Tehran metropolitan green building system. It shows that if a 1_{RB} unit of a building in Tehran is fully equipped with the components of the green building model, it will generate an annual yield equal to 1.18 $UGBU_{Air}$ units of environmental benefits. It also demonstrates that the presence of trees in open areas (C_oue) are about twice as effective as the green roof (C_grf) or the green wall (C_3ts).

$$1.18 * C\_UCC = 0.50 * C\_oue + 0.28 * C\_grf + 0.27 * C\_3ts + 0.06 * C\_ged + 0.06 * C\_rne \quad (2)$$

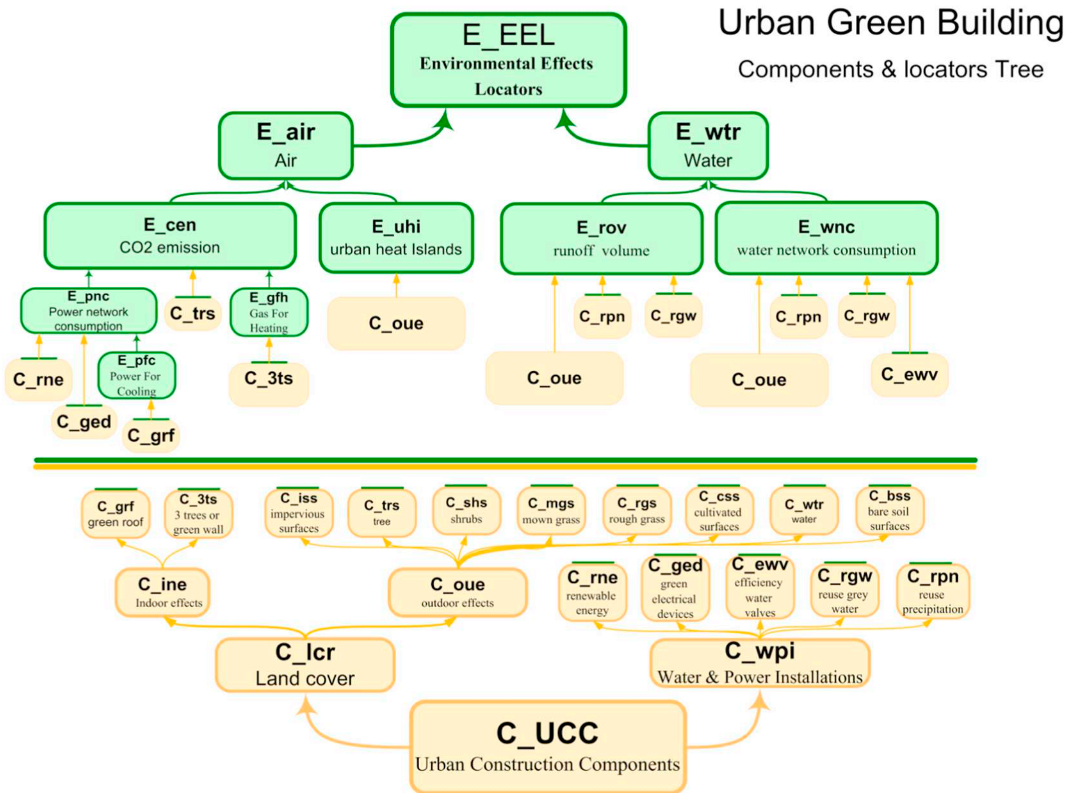

Fig. 5. Tree structure of building components and their environmental locators.

Table 4
The differences in results of case study by adding water considerations in the model.

Model type	Age	Amount	Green-capability[a]	Green-existent[a]	Green-lack[a]	Green-rate %
Just air	Old	296	310	204	106	65 (C)%
	Medium	719	2699	868	1831	32 (E)%
	New	180	2991	488	2503	16 (F)%
	All	1195	6000	1560	4440	26 (F)%
Air + Water	Old	296	1384	204 + 41	1139	18 (F)%
	Medium	719	11,860	868 + 397	10,595	11 (G)%
	New	180	13,454	488 + 819	12,147	10 (G)%
	All	1195	26,698	2817	23,881	11 (G)%

[a] Values are based on UGBU for air/air + water model.

Function (3) illustrates the new model of Tehran metropolitan green building system. It shows that if a 1_{RB} unit of a building in Tehran is fully equipped with the new model of green building components (which added water aspects), it will generate an annual yield equal to 3.494 $UGBU_{Air+Water}$ units of environmental benefits. It also shows that the weight and importance of all water-related components are much more relevant than those related to air. The comparison of these two functions clearly indicates the importance of taking into account the environmental factor of water in the implementation of a green building model.

Table 6
Another important elements of Tehran's green building model that has been very poorly observed.

Age	Amount	Reuse grey-water[a] (C_rgw)	Reuse precipitation[a] (C_rpn)	Efficiency water valves[a] (C_ewv)
Old	296	0%	0%	0%
Medium	719	0%	0%	30%
New	180	0%	0%	70%

[a] Percentage of compliance with the green criterion.

Table 5
The increasing trend of the built/open area ratio in Tehran's buildings.

Age	Amount	Max floors	Built area[a]	Open area[a]	Open/built	Tree in open area[b]	Permeable surfaces in open area[b]
Old	296	4	54'000	37'500	70%	62.7%	72.7%
Medium	719	7	416'000	332'000	80%	29.2%	37.2%
New	180	9	405'000	390'000	96%	9.1%	14.1%

[a] In terms of square meters.
[b] Percentage of compliance with the green criterion.

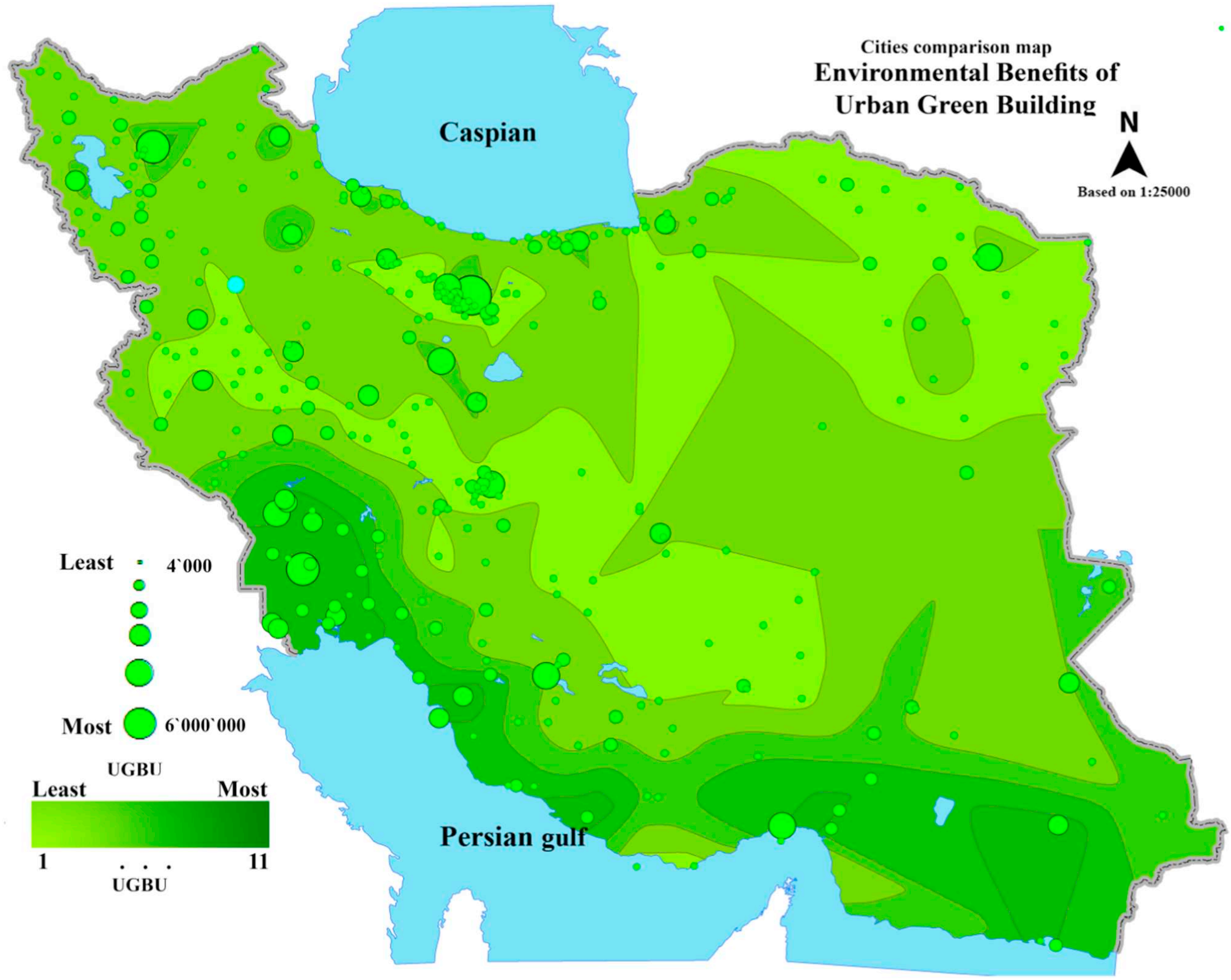

Fig. 6. Comparison of zones and cities of the country in terms of environmental benefits in green building.

$$3.494 * C\_UCC = 1.01 * C\_oueOthers + 0.91 * C\_rgw + 0.76 * C\_rpn + 0.45 * C\_ewv + 0.15 * C\_oueTrees + 0.09 * C\_grf + 0.08 * C\_3ts + 0.02 * C\_ged + 0.02 * C\_rne \quad (3)$$

As previously stated, function (2) is based on $UGBU_{air}$ unit, which represents about one third of the unit of function (3), which is $UGBU_{air+water}$.

Taking the water component into account, it was found that the environmental benefits of green buildings were considerably raised. In contrast, the ranks of buildings had decreased; however, the distance between new and old buildings had reduced from > 4 times to < 2 times. This change in trend shows that while overall compliance with green regulations is relatively low, new buildings perform better with "water" than the older ones.

As shown in Table 5, the information for the study area from Tehran Municipality Real Estate Audit indicates that the ratio of open area to the built area has increased, resulting in increased capacity in the environmental benefits. Therefore, the drop in buildings ranking must be due to the lack of environmental exploitation of the open areas. This means that there is a necessity for municipality's instruction regarding compliance with the environmental regulations of the open area of buildings.

In addition, as it is shown in Table 6, the results of the study assessments and Tehran model (function (3)) indicate that using the water efficiency valves in new buildings has increased their rankings and reduced their distance from older ones. This good event was obtained in accordance with the mandatory provisions of the national building regulations in Iran (NBRO, 2009). A potential threat is the lack of appropriate environmentally use of the site and the roof (runoff absorption and tree planting), which unfortunately is hidden from the eyes of the authorities and it is not exactly specified who has the responsibility of this area.

To get an overview of the green building in the cities of Iran, the results of the case study for one of the districts in Tehran have been generalized to the whole city of Tehran according to the green space of other districts' per capita. In terms of study parameters, Tehran city conditions are roughly similar and results are generalizable. The results, obtained from calculations (without in situ measurements) for Teheran, were then generalized to all the cities of the country based on their green building models and populations. After implementing the spatial analysis, the outcomes of these predictions of urban green buildings, led to the compilation of a map presented in Fig. 6.

The zoning presented on the map is based on the environmental benefits of compliance with green building regulations in a one RB unit building of the cities in each zone. The areas with the most and least need for green building regulations are presented in five classifications, from dark green to light green. As the map shows, the southern regions of the country, more than other parts, are in urgent need of complying with green building standards. Among them, the most critical cities are Ahvaz, Shoshtar, Abadan, Khoramshahr and Borazjan. On the other hand, cities such as Sarakhs, Lordegan, and Ferdows are at least critical (the results are attached as a shape file format).

5. Conclusion

The current imbalance situation, which has been occurred due to the existing sanctions and political constraints, has damaged the field of scientific research, in some cases resulting in irreparable losses. Green building ranking systems are one of such areas of research that the World Green Building Council does not accept membership of Iran, and Iran does not agree to comply with any of the existing green building systems. To overcome this issue, the Ministry of Housing has implemented effective measures in twenty technical topics of building regulations. Although the results of this research have largely underlined the validity of the roadmap of these approvals, it revealed the most important parts that were hidden from view in this area. The absence of appropriate regulations and controls in the use of open areas of buildings, in terms of tree planting and permeable surfaces, has caused a dramatic drop in this component in new buildings compared to older ones. In addition, grey-water and rainwater retrieval facilities, which are of great importance in Tehran model, have never been installed in any of the buildings assessed in the case study. It is necessary to establish appropriate instructions in this regard and monitor their implementation.

The case study of this research was conducted in one of the leading districts of the capital. The results of the case study show that the degree of compliance with regulations on green building and its benefits are extremely low and insignificant: 11%.The old buildings have a relatively better rate of 18% which represents a downward trend. Despite this rapid downward trend, Tehran's Comprehensive Plan vaguely hopes that Tehran will become a green city at the end of its vision horizon.

In this research, the environmental components of water were added to Madad's ecological building model. One of the good characteristics of this model is the effectiveness of the weight of its criteria on local climatic and demographic conditions. A specific model adapted to the local climatic and demographic conditions of the city has been developed for each of the 600 major cities of the country. Another interesting feature of this model is the use of the results of monetary valuation studies to improve the weighing of model parameters. In parallel with the development of monetary assessments of green infrastructure, these types of models will be improved and more reliable.

Despite all efforts, including programming, adjustments, modifications, and well-prepared calibration conditions, it appears that the weight of the water in the model far exceeds that of the air, particularly in terms of surface water absorption index. It is advisable to check further and, if necessary, adjust these weights.

Declaration of competing interest

This manuscript has not been published or presented anywhere else entirely or in part and it is not under consideration by any other journal. Additionally, there are no conflicts of interest to declare.

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Appendix A

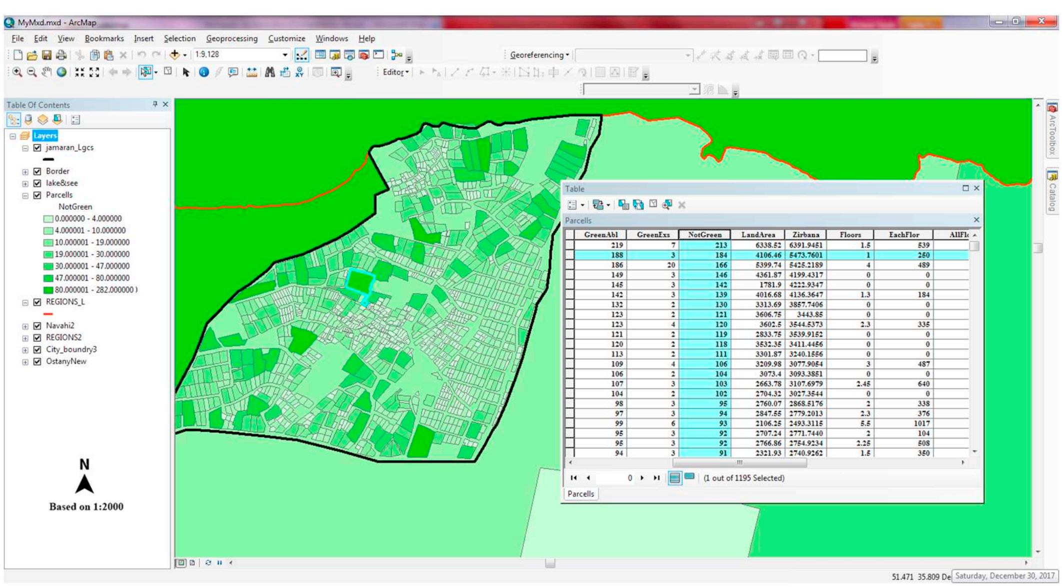

Fig. A1. Results of the developed green building assessment of the case study area

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