

## Urbanization Impact on the Water and Food Security and Assessment of Wheat Production and its Irrigation Water Requirements Using CROPWAT Model in IRAN: A Case Study of City Tehran

Gholamreza Hashemi<sup>1\*</sup>, Seyed Pooyan Mirheidari<sup>2</sup> and Connie Galvez Durand Santivanez<sup>3</sup>

<sup>1, 2 & 3</sup>Department of Civil and Environmental Engineering, Polytechnic University of Milan, ITALY

\* Correspondence E-mail: [gholamreza.hashemi@mail.polimi.it](mailto:gholamreza.hashemi@mail.polimi.it)

(Received 24 Dec, 2017; Accepted 30 Dec, 2017; Published 29 Jan, 2018)

**ABSTRACT:** In the modern world, the equal allocation of amenities amongst the society individuals has been affected by the phenomena of Urbanization and urban development. Tehran, the capital of Iran, is always the main destination of migrants from all over the country because of its dominant modernistic urban attractions. The latest official national census in 2006 showed that during 1921 to 2006, in the last 85 years, Tehran's population has multiplied by 37 and its area has multiplied by 100. This rapid Urbanization has replaced a huge area of agricultural land, fertile arable land. In addition, Tehran total water consumption with an average annual growth rate of 23.1 percent reached to more than 990 million cubic meters in 2008 which all of these elements emphasize on a much more sustainable consumption pattern requirement and more attention to the Tehran's water and food security. For instance, in this research for the first time indicated that the domestic production of wheat in Tehran city just covers 6% of Tehran's population wheat requirement while it consumes 25% of water consumption of Tehran city.

**Keywords:** Urbanization; Tehran; Water security; Food security; Water consumption and Wheat.

**INTRODUCTION:** Urbanization is a global phenomenon which is occurring rapidly in many less developed countries. It is expected that most urban growth occurs in Asian countries related to two main factors, unplanned rural to urban migrations and natural increase of population (excess of births over deaths) for these reasons there are near 300 cities with a million inhabitants and most of these are in the developing world. The growth rate of these cities was 10-fold between 1950 and 1990. Some of these cities, such as Abidjan, Amman, Dhaka, and Harare, are now defined as megacities with 10 million inhabitants.<sup>1</sup>

Urbanization process has intensified sharply in the early of the twentieth century. Available statistics appear that more than half of the world 6.6 billion individuals live in urban areas, swarmed into 3% of the earth's land area.<sup>2</sup> The extent of the world populace in urban zones was less than 5% in 1800, it raised to 47% in 2000. And it's anticipated to reach 65% in 2030.<sup>3</sup> However, more than 90% percent of future populace development will be concentrated in cities in developing countries and a huge rate of this population will be destitute. In Africa and Asia where urbanization is still in its infancy (40 percent), both are predicted to be 54% urban by 2025.<sup>4,5</sup> Quick urban development is responsible for numerous socio-economic and natural changes. Its impacts are emphatically related to the worldwide issues. Today, the

relationships between human societies and their natural environment have been strongly affected by urbanization and urban development. Considering an increasing urban population, the result of urban expansion is to obtain retrievals in the form of environmental effects such as climatic change, water pollution, noise pollution, thermal pollution, and changes in the water cycle system due to waste and other impacts,<sup>6-8</sup> the loss of environs, agricultural lands, and orchards,<sup>9-11</sup> increasing socioeconomic inequality,<sup>12</sup> endanger the people health and their food and water security<sup>13</sup> and so on.

It has been seen by diverse studies that, environmental degradation is caused by a couple of components including fast urbanization due to overpopulation, accelerated industrialization, impromptu and uncoordinated physical improvement due to poor urban administration and ineffectual control policies.<sup>14-15</sup>

Sketch have shown that urbanization induces changes in rainfall pattern and amounts due to low gentle wind wet, the urban heat island intensiveness, atmospheric instability, and the presence of cloud condensation nuclei. 16-17 The urban heat island impact changes the convection of air masses and increments the greatness and recurrence of late spring high-intensity storm.<sup>18-19</sup>

During the procedure of urbanization, the reflectivity of the land surface is savagely changed when a lot of natural or agricultural lands are converted to built-up surfaces. These progressions emphatically influence the environment/land surface energy exchange.<sup>20</sup> in addition, nearby climate, and atmosphere regimes.<sup>21-22</sup> With respect to the hydrological cycle, the greater part of the procedures amongst land and atmosphere, surface, and subsurface<sup>23-24</sup> are totally impacted by the procedure of urbanization. For instance, a study carried out in Nepal country by the Kathmandu Valley Town Development Committee in 2001 revealed that, between 1984 and 2000, agricultural land has been declining on an average at 2.04 percent per annum.<sup>25</sup> In 1981, three-fourths of the residents were involved in agriculture which in 1991 slumped to one third.<sup>26</sup> Similar actions are seen in China, Indonesia, and Nigeria.<sup>27-29</sup>

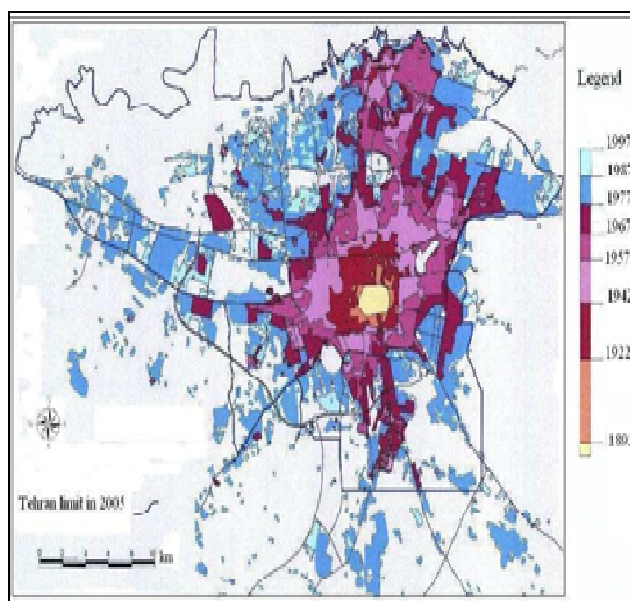
This paper endeavors to cause a superior comprehension of the Urbanization and Its Effects on Water and Food Security in Iran: A Case Study of the City of Tehran by gathering, figuring, and computing at measurements information from distinct contexts.

**MATERIAL AND METHODS:**

**Tehran and Its Population Growth:** The Tehran’s growth has undergone an incredible acceleration both in physical and population aspects from the 1920s. The procedure of extension of Tehran over various timeframes has showed that, over the most recent twenty years, this city meets inverse procedures of expansion and disintegration. In 1956, when the first official census was taken, it showed a population of 1,510,000 and a city area of 100 km<sup>2</sup>.<sup>30-34</sup>

From this time, more than 120 villages, along with two other cities, were combined by Tehran and owing to this extremely prolific city growth, in 1980, the Tehran municipality had to expand the scope of its services like, for example, to change the legal expansions from 225 to 520 km<sup>2</sup>, and to increase the number of municipal districts from 12 to 20.<sup>31, 32 & 35</sup>

The latest official national census in 2006 showed that Tehran registered a population of 7,700,000 and a city area of 800 km<sup>2</sup>. This fast city growth has been repeated time after time till now. Finally, it was recognized that the population density of the city during all these periods has appearance a descending trend from 291 to 96 persons per hectare from 1921 to 2006, as can be seen in Table 1. To sum up, we can say that in the last 85 years, Tehran’s population has multiplied by 37 and, what is more, its city area has multiplied by hundred. Despite this, under this rapid physical growth, the city’s expansion was unplanned, and desultory, as can be seen in Figure 1.

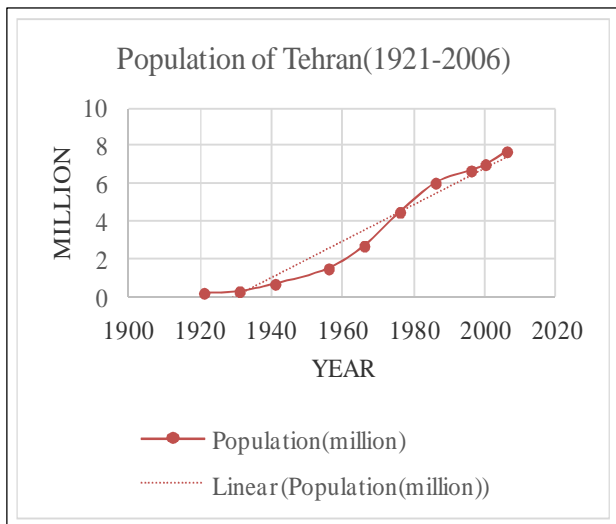


**Figure 1: The physical development of Tehran.**<sup>31, 32, 36 & 37</sup>

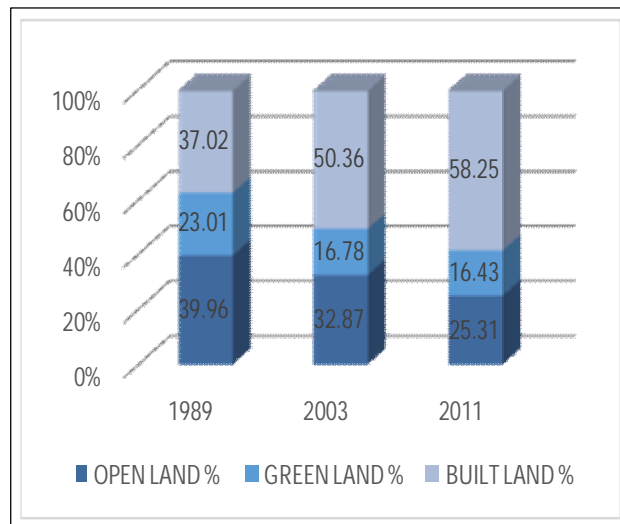
**Land Use Changes in the Tehran Plain:** In Figure 4 extent of land cover in three floors of green, open, and built in years 1989 and 2003 and 2011 according to satellite photos of Tehran city is shown. As shown in Table 1, the population of Tehran grew about 5-fold during the period of 1956–2006, while the urban occupied land grew 8-fold during the same period. In addition, the urban land size of Tehran in 1956 and 2006 were 10000 and 80000 ha, respectively.<sup>39</sup>

**Table 1: Changes in population, area, density and numbers of private cars in Tehran for different years.**<sup>31, 36 & 38</sup>

YEAR	1921	1931	1941	1956	1966	1976	1986	1996	2000	2006
<b>Population(million)</b>	0.21	0.3	0.69	1.51	2.71	4.5	6.04	6.7	7.02	7.711
<b>Area(hectare)</b>	720	2420	4500	10000	19000	32000	62000	73950	78900	80000
<b>Density(p/ha)</b>	291.6	124	154	151	143	141	97.4	91	88.9	96.3
<b>Private car (number for 1000 people)</b>	-	-	-	5	25	31	61	74	83	90



**Figure 2: Changes in the population for different years and its linear approximation.**

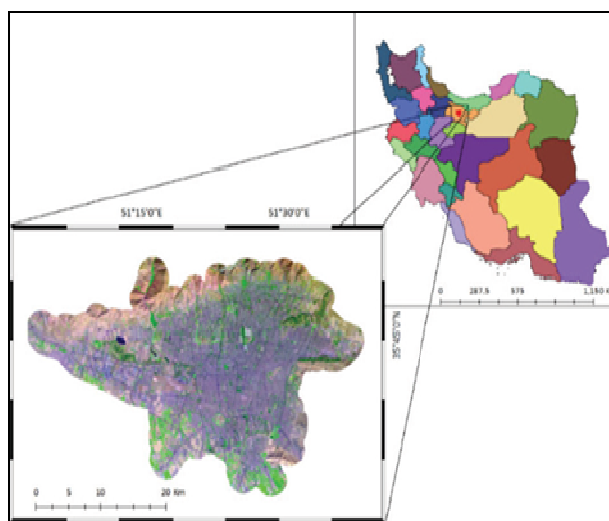


**Figure 5: Land Use Changes in the Tehran.**

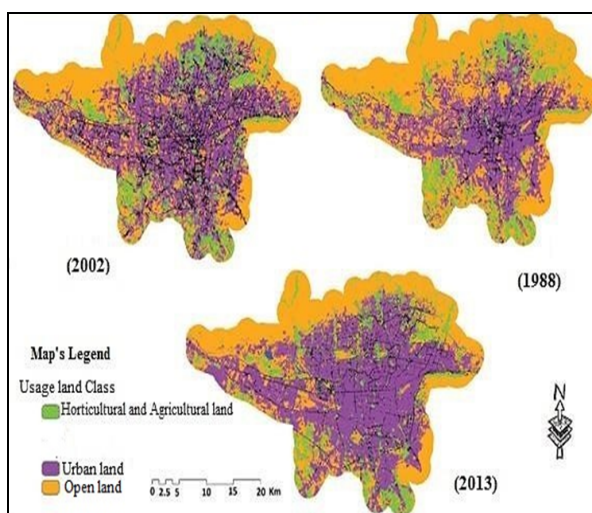
According to Figure 4, the area of green lands and open lands decreased gradually and there is a huge increase in built area.

It is obvious in 1989 only 37 percent of the present situation of Tehran was built while in 2011 the built area rises to 58 percent of total area.<sup>40</sup>

Moreover, increasing urban population and concentrating different activities in cities need the change in land and natural areas to constructed areas. Land areas with vegetation cover in Tehran city in the period between 1989 and 2011 declined to about 4052 hectares. Also, the number of open areas and arid in this period decreased about 1057 hectares. In basin areas of Tehran city amount of vegetation cover dropped from 23 percent of total area in 1989 to 17 percent in 2011.<sup>40</sup>



**Figure 3: Tehran Location in Iran.<sup>39</sup>**



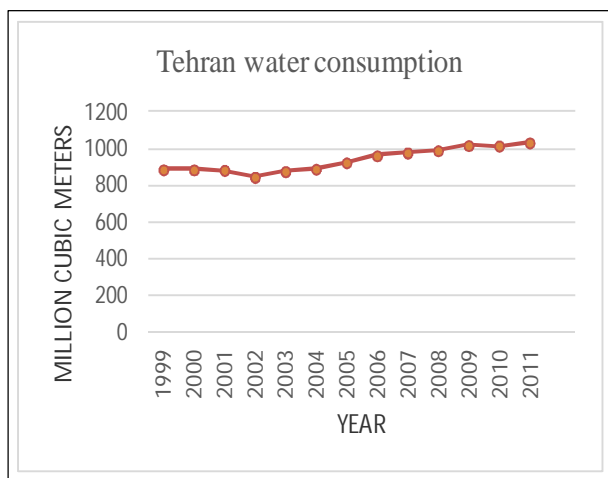
**Figure 4: Land Use Changes in the Tehran.<sup>39</sup>**

**Urbanization and Its Effect on Water consumption and Water Resources:** Tehran total water consumption in 1999 was 886 million cubic meters which with an average annual growth rate of 23.1 percent it is reached to more than 990 million cubic meters in 2008. Tehran daily water consumption from 99 liters per person per day in 1967 is reached to 350 liters in 2014. This is while Tehran's population of two million and seven hundred thousand persons in this period have already grown to more than eight million people.<sup>39-40</sup>

Based on the figures published by Tehran's Water and Sewage Company, the measure of water supplied in Tehran area is more than 703 million cubic meters which 71.7% is the surface water and the rest is sub-surface water.<sup>41</sup>

Underground waters are one of the most important resources of Tehran city which in dry seasons until

50% of Tehran drinking water was from underground waters. In conclusion, quality of Tehran underground water is very important.



**Figure 6: The trend of whole water consumption of Tehran.**

Study results on hydrograph underground water of Tehran and Karaj with attention to their area about 1069 and 587 km<sup>2</sup> respectively show that the level of underground water surface from years 2008-2009 to 2010-2011 is slumped for Tehran basin about 5.65 cm and for Karaj, it decreased 7.18 cm.<sup>42</sup>

It means only in Tehran desert basin the underground water volume has declined about 20.1 million cubic meters for each year and in Karaj desert basin the underground water volume has decreased about 33.1 million cubic meters during the years 2008-2011 totally with an average yearly reduction about 10.1 million cubic meters.

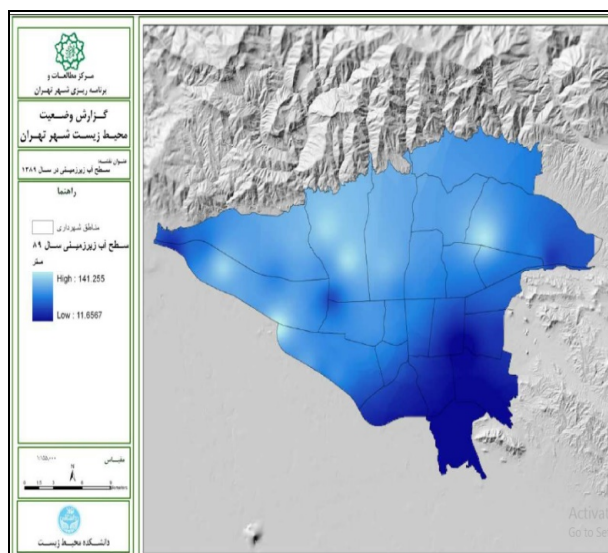
Picture 7 shows the surface level of the underground water in different parts of Tehran city during the years 2010-2011.

**Urbanization and Its Effect on Food Security:** During the 1956 to 2007 years, Agricultural land and the garden area declined to 22 percent and reach to 3500 ha in 2007. This means a significant reduction in the size of gardens and agricultural land in the city which is an outstanding threat to the food security of Tehran city. Figure 6 shows that the volume of water used annually in the city for varied purposes escalated to 16.6 percent in the period of 1999–2011. This was a distinctive reduction in agricultural water and may impact on agricultural production and food security in general.<sup>40</sup>

Alterations in land use in the Tehran Plain, because of rapid urbanization, were very high and have seriously reduced agricultural and horticultural production and created a significant problem for the individuals in the city. vegetation cover land in Tehran in the period

between 1989 and 2011 decreased about 4052 hectares. In basin areas of Tehran city, the amount of vegetation cover dropped from 23 percent in 1989 to 17 percent in 2011.<sup>39</sup>

The jungles area included woodlands around Tehran from 28,174 ha declined to 24,168 ha during 2009 to 2015 respectively.<sup>43</sup>



**Figure 7: level of the underground water surface in Tehran city.<sup>40</sup>**

**Iranian Diet and its relationship with water consumption case study Tehran people:** In Iran Most people's diet is based on rice - meat and bread, which bread is the leading factor in people's daily diet.

The Persian eating habits (in terms of meal sizes and timing) would be generally quiet the Mediterranean-A standard, simple breakfast, a large lunch, and a light Dinner-Tehran also follow the same principle and bread there is in a variety of meals.

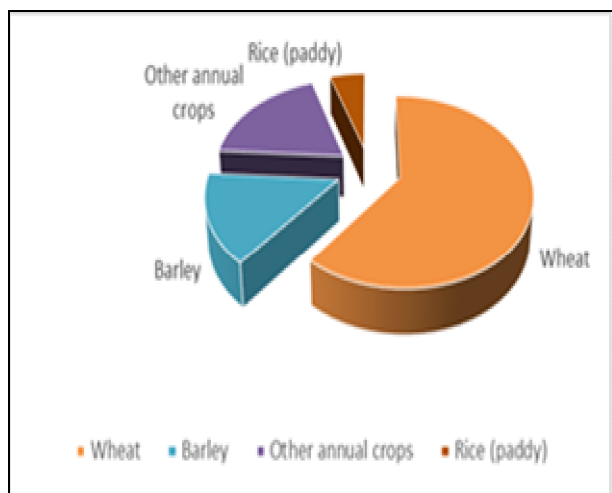
Bread is a major part of Iran and Tehran people diet and in continue, wheat is a vital crop for its production as is shown in figures 8 and 9, a wide range of total agricultural area (about 60 %) in Iran is under wheat cultivation. Wheat and barley are the main crops cultivated in the country. Wheat is the dominant cereal crop, accounting for almost 70 percent of the aggregate cereal production.<sup>44-45</sup>

**Wheat production and its Irrigation water requirements using CROPWAT model in Tehran in 2011:** With attention to previous part, Iran after China, India, Russia, America, and Pakistan is the sixth major consumer of wheat in the world.<sup>47</sup>

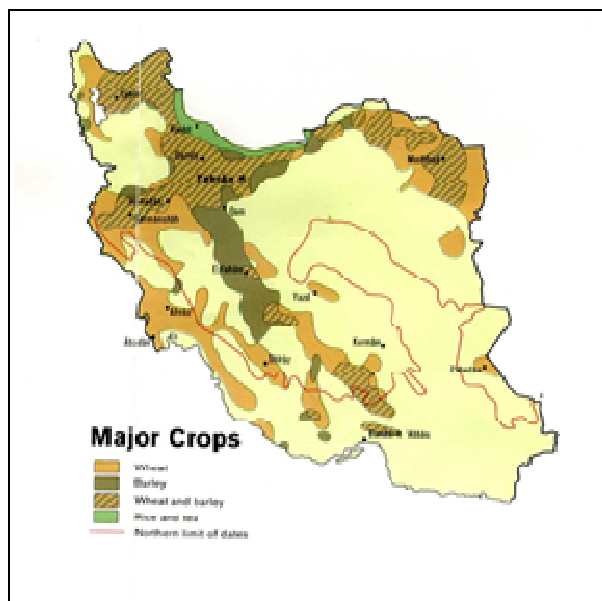
During 2010- 2011 approximately from 12 million hectares harvest crops, about 8.76 million hectares equivalent to 73.9 percent of the total harvest is associated with grain harvest.



According to Figure 8, about 53.8 percent of grain harvest area is related to wheat production; also the major crop which is imported to the country is this crop, which reflects the importance of this product.<sup>43</sup>



**Figure 8: The cultivation Area of annual crops in Iran Iranian.**



**Figure 9: Major Crops of Iran 1978.<sup>46</sup>**

For this reason, in this research During 2010- 2011 the wheat requirement water is calculated by CROPWAT software and as is clear from the results although a distinguishing amount of water produced in Tehran in agriculture and solely for wheat production is spent. (about 288.567 million cubic meters (MCM) per year).

It should be noted that in this study based on CROPWAT model and simplification we only consider the Green and Bluewater in the water footprint (WF) of Tehran wheat production. In other words, the gray and whitewater are not computed in our calculation.<sup>48</sup>

In addition, by comparison of wheat requirement water and the key ingredient of wheat in bread preparation and its key role in daily dietary of Tehran people the more sustainable methods in irrigation and production of this crop is necessary. Based on a consumption survey performed in Iran since 2001-2003 Average consumptions of bread is 286 g per day per person.<sup>49-50</sup> In addition, Average consumption of wheat flour in Iran is 416 g per day per person.<sup>50-51</sup>

**Assumptions:**

Tehran inhabitants: 8 800 000

Average diet – IRAN – 2011: 3235 kcal/cap/day.<sup>44</sup>

Soil type: black clay

Agricultural Area in Tehran under wheat cultivation: 61008 ha.<sup>43</sup>

The yield of wheat in 2011: 13608 Hg/ha.<sup>44</sup>

Wheat Calories Content: 334 kcal/100g.<sup>44</sup>

From CROPWAT Model:

Blue Water: 384.8 mm

Green Water: 88.5 mm

For a given month, the crop water balance can be expressed as follows<sup>52</sup>:

$$IWR = K_c \cdot E_t_0 - P$$

Where;

IWR is the net irrigation water requirement needed to satisfy crop water demand.

$K_c$  is a coefficient varying with crop type and growth stage.

$E_t_0$  is the reference potential evapotranspiration, depending on climatic factors.

P is the precipitation.

Actual irrigation Water requirement in a year = 421.7 mm  $\approx$  422 mm

**Estimation of Tehran requirement wheat and it's Irrigation water requirement:** Following CROPWAT results the necessary water for wheat production in Tehran is approximated:

422 mm\*61008 ha=2.574\*10<sup>11</sup> Liter, which is equal to 257.453 million cubic meters or 25% of the Total Water Consumption of Tehran city in 2011. (about 1030 million cubic meters according to Figure 6)

Additionally, Tehran Wheat Production can be assumed:

$$61008ha * 13608 hg/ha = 830196864hg$$

And with attention to FAO database Wheat produced Calories in Tehran is computed:

$$830196864\text{hg} * 334\text{kcal}/100\text{g} = 2.77286 * 10^{11} \text{ kcal/year}$$

Moreover, Average Diet of Tehran in 2011 can be attained thanks to FAO database by interpolating between years 2000 and 2014 equal to 3235 kcal (cap/day). It is clear Total Requirement Calories of Tehran city would be  $1.0391 * 10^{13}$  kcal per year because:

$$3235 * 365 * 8800000 = 1.0391 * 10^{13} \text{ kcal/year}$$

The total requirement calories of Tehran's inhabitants supported by wheat for each year will be equal  $4.4628 * 10^{12}$  kcal/year should we assume average consumption of wheat flour in Tehran is 416 g per day per person (equivalent to 1389.44 kcal/day).<sup>50-51</sup>

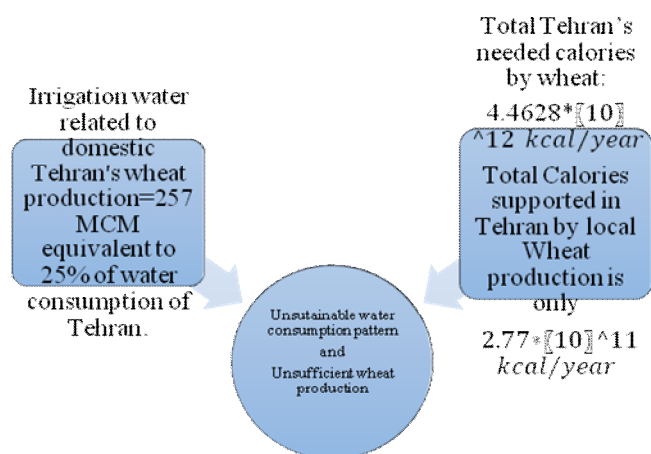
$$1389.4\text{kcal}/\text{day} * 8800000 * 365 = 4.4628 * 10^{12} \text{ kcal/year}$$

On the other hand, according to previous calculations, the Total Calories Produced in Tehran by Wheat is only  $2.77286 * 10^{11}$  kcal/year

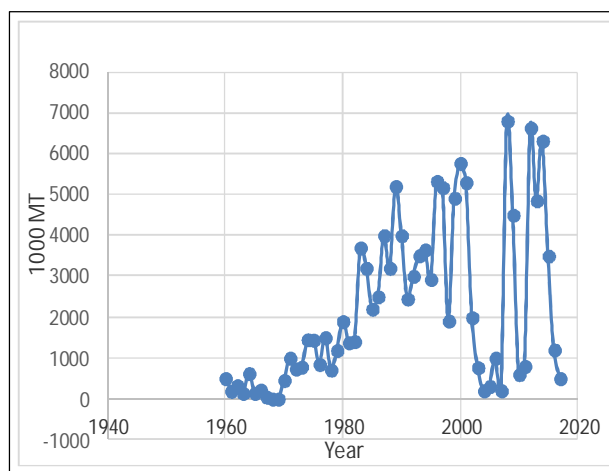
Since the Total Calories endorsement by wheat in Tehran is less than the vital Equivalent Calories Consequently, due to compensating it is necessary to government import the rest of the needed wheat. In fact, the Tehran city must import the amount of 1170128 tons of wheat per year.

$$4.4628 * 10^{12} \text{ kcal/year} - 2.77286 * 10^{11} \text{ kcal/year} = 3.9082 * 10^{12} \text{ kcal/year} = 1170128.14 \text{ ton/year}$$

**RESULTS AND DISCUSSION:** In other words, the domestic production of wheat in Tehran city just covers 6% of Tehran's population wheat requirement while it consumes 25% of water consumption in Tehran city.



**Figure 10: Brief report of Wheat and its Irrigation Water requirement in Tehran in 2011.**



**Figure 11: Wheat Imports by Year, Islamic Republic of Iran, Unit of Measure 1000 MT.**<sup>53-54</sup>

These results reflect the imbalance of supply and demand of wheat production and unsustainable water consumption due to the wheat irrigation and production.

Harvesting of the 2017 winter wheat started in June and will continue until mid-July. In 2017 The Government intends to locally purchase 11 million tons of wheat, about the same as last year, to decrease reliance on imported wheat over the next four years.<sup>44</sup>

**CONCLUSION:** The preliminary analysis in this study, through the case study of Tehran, shows that unplanned and rapid Urbanization of cities in Iran in the past has threatened not only water and food security but also created dramatic predicaments for the individuals who live in cities.

In this paper for the first time by using CROPWAT model a very precious estimation of wheat and it requires irrigation water for Tehran city is done. According to the results, the water and food security and food availability base on the local wheat production is not reliable and is not supported, because the wheat production endorses only 546758 inhabitants or it covers only 6.2 % of the total requirement calories of Tehran's inhabitants for each year. With comparing the results of Figure 10 and Figure 6 it is obvious that more than 25 percent of total water usage in Tehran during 2010- 2011 is just related to the production of the Wheat crop and it shows the Tehran water management and consumption are not in a sustainable way. It should be noted that this Water usage is measured only in terms of water volumes consumed and the volume of polluted water is not considered.

Finally, to carry out good environmental sustainability in Iran urban centres like Tehran, the study has proffered the following recommendations:

Promoting sustainable, fair, and efficient water use through the development of shared standards on water footprint accounting and guidelines for the reduction and offsetting of impacts of water footprints.

To attain sustainable growth requires that all stakeholders must be actively mobilized towards ensuring that the following strategies; some of which have been outlined in the UN Millennium Project are realizable.<sup>55</sup>

The high-ranking authorities should ensure that adequate funds are disposed of for educating and raising people's awareness to convert in their patterns of water and energy resource consumption, alteration in their diet and lifestyle especially for the vulnerable group of the urban population.

Existing rules and regulations relating to housing and urban development should be reviewed. Regional planning laws of the country should also be reviewed to allow for effective poor neighborhood upgrading and urban renewal.

The high-ranking officials on its own part should take a holistic approach by embracing and incorporating the development of rural communities into the sustainable plan agenda to reduce the rate of rural-urban migration as well as the poverty and inequality bedeviling the nations socially, culturally, and economically.

**ACKNOWLEDGEMENT:** This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

## REFERENCES:

- Desai V., Potter B. R. (2002) The companion to de-velopment studies, (Oxford University Press Inc., New York).
- UNFPA (1993) Reconceptualization of Population education, New York. United Nations Popula-tion Fund.
- United Nations. (1991) world population prospects.1990. United Nations. Department of Economic and Social Affairs. Population Division. New York.
- United Nations. (1995b) World Population Prospects: The 1994 Revision, New York. Population Division, United Nations.
- United Nations. (2002) World Population Prospects: The 2001 Revision. Data Tables and Highlights. United Nations. Department of Economic and Social Affairs. Population Division. New York.
- UNCED (United Nations Conference on Environment and Development, (1992) Agenda 21, Rio de Janeiro.
- Shakoor, A., Roshan, G. R., Khoshakhlagh, F., He-djazizahed, Z. (2008) Effect of climate change process on comfort climate of Shiraz station, *Iran. J. Environ. Health. Sci. Eng.*, 5(4), 269-276.
- Golmohammadi, R., Abbaspour, M., Nassiri, P., Mahjub, H. (2009) A Compact model for predicting road traffic noise, *Iran. J. Environ. Health. Sci. Eng.*, 6(3), 181-186.
- Jeffrey, A. C.; Foley, J. A. (2003) Agricultural land-use change in Brazilian Amazonia between 1980 and 1995: Evidence from integrated satellite and census data, *Remote Sens. Environ.*, 87, 551–562.
- Tan, M.; Li, X.; Xie, H.; Lu, C. (2005) Urban land expansion and arable land loss in China-A case study of Beijing–Tianjin–Hebei region, *Land Use Policy*, 22, 187–196.
- Brabec, E.; Smith, C. (2002) Agricultural land fragmentation: the spatial effects of three land protection strategies in the eastern United States, *Landsc. Urban Plan*, 58, 255–268.
- Brueckner, J. K. and Largey, A. G. (2007) Social interaction and urban sprawl., *J. Urban Econ.*, 10, 1–17.
- Esfandiari-Baiat, M., Barzegar, Z., Yousefi, L., Maheshwari, B. (2014) Urbanization and Its Effects on Water, Food Security, and Energy Need in Iran: A Case Study of the City of Shiraz, The Se-curity of Water, Food, Energy, and Liveability of Cities, 101-112. [http://dx.doi.org/10.1007/978-94-017-8878-6\\_8](http://dx.doi.org/10.1007/978-94-017-8878-6_8).
- Jiboye A. D. (2005) Globalization and the Urban growth process in Nigeria. In, W. Fadare et al., (Eds.). Proceedings of the Conference on Globalization, Culture and the Nigerian Built Environment. Vol. II. Obafemi Awolowo University, Ile-Ife, Nigeria.
- Oladunjoye, A. O. (2005) Nigeria: Implementation of the Sustainable Cities Programme in Nigeria. Sustainable Cities Programme. Localizing Agenda 21 Programme. United Nations Programme for Human Settlements.
- Shepherd JM. (2005) A review of current investigations of urban-induced rainfall and recommendations for the future, *Earth Interactions*, 9, 1–27.
- O'Driscoll M., Clinton S., Jefferson A., Manda A., McMillan S. (2010) Urbanization effects on watershed hydrology and in-stream processes in the southern United States., *Water*, 2, 605–648.
- Bornstein R, Lin Q. (2000) Urban heat islands and summertime convective thunderstorms in Atlanta: Three case studies, *Atmos Environ.*, 34, 507–516.

19. Dixon PG, Mote TL. (2003) Patterns and causes of Atlanta's urban heat island-initiated precipitation, *J Appl Meteorol.*, 42, 1273–11284.
20. Grimmond, C. S. B., and Oke, T. R. (1995) Comparison of heat fluxes from summertime observations in the suburbs of four North American cities. *J. Appl. Meteorol.*
21. Changnon, S. A. (1992) Inadvertent weather modification in urban areas: Lessons for global climate change, *Bulletin of the American Meteorological Society*, 73, 619-627.
22. Oke, T. R. (1987) *Boundary Layer Climates*. Volume 632 of University Paperbacks Published by Methuen 1987).
23. Grimmond, C. S. B., and Oke, T. R. (1991) An evapotranspiration-interception model for urban areas, 27(7), 1739–1755.  
<http://dx.doi.org/10.1029/91WR00557>
24. Hammer, T. R. (1972) Stream channel enlargement due to urbanization, *Water Resour. Res.*, 8(6), 1530–1540.
25. Shrestha, R. M. (2006) Urbanization and Changes in Cropping Patterns at Kathmandu Valley. Nepal, *Journal of Sciences and Technology*, 7, 113-118.
26. ICIMOD. (2007) Kathmandu Valley Environment Outlook. International Center for Integrated Mountain Development, Ministry of Environment, Science, and Technology (MoEST) and United Nations Environment Programme (UNEP), Kathmandu, Nepal.
27. Verburg P. H., Veldkamp T. H., Bouma J. (1999) Land use change under condition of high population pressure: the case of Java, *Glob Environ Change*, 9, 302–312.
28. Weng Q. (2002) Land use change analysis in the Zhujiang Delta of China using satellite remote sensing, GIS, and stochastic modelling, *J Environ Manage*, 64, 273–284.
29. Muhammed, S. N., Sabiu, N. and Khalil, M. S. (2015) an overview of urbanization and its challenges on sustainable development in Nigeria, *Dutse Journal of Pure and Applied Sciences*, 1(1), 19 – 29.
30. Habibi, M.; Hurcade, B. Atlas of Tehran Metropolis. (2005) published by Analysis and Urban planning, Tehran municipality. 50–57 (in Persian).
31. Abdolazim Ghanghermeh, Gholamreza Roshan, José A. Orosa , José L. Calvo-Rolle and Ángel M. Costa. New Climatic Indicators for Improving Urban Sprawl: A Case Study of Tehran City, published by Entropy, 15, 999-1013. doi:10.3390/e15030999
32. Roshan, Gh. R.; Shahraki, S.Z.; Sauri, D.; Borna, R. (2010) Urban sprawl and climatic changes in tehran Iran, *J. Environ. Health. Sci. Eng.*, 7, 43–52.
33. Mehdizadeh, J. Period of rehabilitation and formation of Tehran metropolis (in Persian).
34. Iranian Statistics Center. (1986) Second Report in Censes of People and Housing, Tehran, Iran. (In Persian).
35. Dehaghani, N. (2004) An analysis of urban planning features in Iran, Science and Technology University of Iran Press, Tehran, Iran, (in Persian).
36. Roshan, Gh. R.; Rousta, I.; Ramesh. (2009) M. Studying the effects of urban sprawl of metropolis on tourism-climate index oscillation: A case study of Tehran city, *J. Geo Reg. Plan.*, 2, 310–321.
37. Shahraki, S.Z. (2007) The analysis of Tehran urban sprawl and its effect on agricultural lands. M.A. Thesis in Geography and Urban Planning, University of Tehran, Iran. (In Persian).
38. Pars Fuel (2010) The Company of Fuel and Oil Products in Iran. data service, Tehran, Iran. (in Persian).
39. Islamic Republic of Iran Organization of Tehran Municipality. (2017)  
<http://tehran.ir/Default.aspx?tabid=323>
40. Islamic Republic of Iran Organization of Tehran Municipality. (2012) status report on Tehran environment.
41. Islamic Republic of Iran Organization of Tehran Municipality Atlas of Tehran Metropolis. (2017)  
<http://atlas.tehran.ir/Default.aspx?tabid=227>
42. Iran water resources management company (2011). <http://wrm.ir/index.php?l=EN#Info>
43. Islamic Republic of Iran -Agricultural-Jihad Ministry.  
<http://maj.ir/portal/Home/Default.aspx?CategoryId=2fef674f-87d9-42d5-b067-ff34a34c14c1>
44. Food and Agriculture Organisation. (FAO) of the United Nations.  
<http://www.fao.org/giews/countrybrief/country.jsp?code=IRN>
45. Iran Statistical Centre. (2006) General population and housing census 2006 and 1996. Shiraz, Iran.
46. U. S. Central Intelligence Agency map of Iran. Major Crops (1978).
47. Mekonnen, M., & Hoekstra, A. Y. (2010) A global and high-resolution assessment of the green, blue and grey water footprint of wheat. (Value of water research report 42; No. 42). Delft, the Netherlands: Unesco-IHE Institute for Water Education.
48. B. Ababaei, H. R. Etedali. (2014) Estimation of Water Footprint Components of Iran's Wheat Production: Comparison of Global and National



- Scale Estimates, *Environ. Process.*, 1, 193–205. <http://dx.doi.org/10.1007/s40710-014-0017-7>
49. National Nutrition and Food Technology Research Institute. (2004) Comprehensive Study of Food Basket Pattern, and Nutrition Status in Iran during 2000-2002. Shahid Beheshti University of Medical Sciences, Tehran 24.
50. Yazdanpanah. H, Zarghi. A, Safaati. R. A., Foroutan. M. S, Fathi. A. F, Khodam. A and Nazari. F, (2012) Exposure Assessment of the Tehran Population (Iran) to Zearalenone Mycotoxin, *Iranian Journal of Pharmaceutical Research*, 11 (1), 251-256.
51. Lyddon C. (2010) Focus on Iran Government plan to move away from grain subsidies may have significant impact on milling industry. world-grain.com.
52. Faures J., et. Al. (2002) The FAO irrigated area forecast for 2030, Rome, Italy, FAO.
53. U. S. Department of Agriculture-<https://www.usda.gov/contact-us>
54. IndexMundi-  
<https://www.indexmundi.com/agriculture/?country=ir&commodity=wheat&graph=imports>
55. UNDP. (2005) Investing in development. A practical plan to achieve the Millennium Development Goals. Overview. UN Millennium Project. Pdf Version.