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Assessing the Global Water Productivity of Some Irrigation Command Areas in Iran

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Abstract**—**The great challenge of the agricultural sector is to produce more crop from less water, which can be achieved by increasing crop water productivity. The modernization of the irrigation systems offers a number of possibilities to expand the economic productivity of water and improve the virtual water status. The objective of the present study is to assess the global water productivity (GWP) within the major irrigation command areas of I.R. Iran. For this purpose, fourteen irrigation command areas where located in different areas of Iran were selected. In order to calculate the global water productivity of irrigation command areas, all data on the delivered water to cropping pattern, cultivated area, crops water requirement, and yield production rate during 2002-2006 were gathered. In each of the command areas it seems that the cultivated crops have a higher amount of virtual water and thus can be replaced by crops with less virtual water. This is merely suggested due to crop water consumption and at the time of replacing crops, economic value as well as cultural and political factors must be considered. The results indicated that the lowest GWP belongs to Mahyar and Borkhar irrigation areas, 0.24 kg m^{-3}, and the highest is that of the Dez irrigation area, 0.81 kg m^{-3}. The findings demonstrated that water management in the two irrigation areas is just efficient. The difference in the GWP of irrigation areas is due to variations in the cropping pattern, amount of crop productions, in addition to the effective factors in the water use efficiency in the irrigation areas.

Keywords**—**Iran, Irrigation command area, Water productivity, Virtual water.

I. Introduction

THE effective management of water available for irrigation in arid and semi-arid regions has increased in importance due to limited water supply. There are many studies concerning the increasing threat of water scarcity and vulnerability of water resources at regional and global scales [1,2,3]. The main focus of most water scarcity studies is on the impact on agricultural and food security. Measures have been sought to produce more food with less water by increasing water productivity (WP) through effective development of genotypes and development of new technologies for integrated crop management in the irrigation networks [4,5]. WP expresses the value or benefit derived from the use of water, and includes essential aspects of water management such as production for arid and semi-arid regions.

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Most large-scale irrigation networks in the world are considered to exhibit low degrees of management performance. This includes low cost recovery and low water use efficiencies induced by area-based water allocation and poor water delivery performance [6,7,8]. Recently, some studies have considered both internal and external indicators, but few [9] have related internal process measures to water productivity. Burt and Styles [10] present a rapid appraisal process for evaluating irrigation projects. They provide many of the same external performance indicators as Molden et al. [11], they also provide a series of internal performance indicators that they place in several groups. These groups are: water delivery service, main canal characteristics, sub-main canal characteristics, budgetary, employees, water user associations, and other. Clemmens and Molden [12] suggested that crop-scale irrigation uniformity can be examined at a project scale by understanding how field, farm and project irrigation systems contribute to non-uniformity. They also discuss the interrelation between project scale uniformity and the relative irrigation water supply, and their combined impact on project water productivity.

Modernization and optimization of the systems can improve the global water productivity (GWP) status of the irrigation networks. The GWP of irrigation networks may be affected by many factors. An analytical framework and associated terms were proposed to better serve the needs of technical specialists from all water-using sectors, policy-makers and planners in achieving more water productivity and tracing the implications of interventions on all uses and users in the irrigation networks [13].

The present paper aims to estimate and assess the global water productivity (GWP) within the major irrigation command areas I.R. Iran. Attention will be paid to the role of irrigation system management on the GWP values of the proposed irrigation command areas.

II. Material and Methods

A. Irrigation Command Areas

In general, I.R. Iran has a Mediterranean climate characterized by semi-arid and arid conditions, by long, hot dry summers and short, cool, rainy winters. In this study, fourteen irrigation command areas where located in different areas of Iran were selected. Cropping patterns and cultivated areas, irrigation management and quantity scenarios, and geographical situations were different in the proposed irrigation areas. Table I presents the summarized details of the proposed areas. In the irrigation areas, the command area value varies from 2300 ha to 284180 ha for Saveh and Sefidroud irrigation systems, respectively. In the study irrigation areas, the average annual rainfall, temperature and evaporation is varied between 120 and 1100 mm, 14 and 27°C, 773 and 1101 mm, respectively. Fig. 1 shows the location of irrigation areas in Iran.

B. *Data and Analysis*

The study is limited to agricultural commodities, since they are responsible for the major part of global water use. The five-year average water productivity of each crop within cropping pattern was calculated as the ratio of the crop yield production to the corresponding volume of water used during the entire period of crop growth. Two components of effective rainfall (green water) and irrigation water (blue water) were considered to determine the volume of water used to grow crops in the field. The climate data have been taken from the most appropriate climatic stations located in the each of irrigation command areas. The total water use of each crop is considered the sum of the green and blue components. In order to calculate the global water productivity of irrigation command areas, all data on the delivered water to cropping pattern, cultivated area, crops water requirement, and yield production rate during 2002-2006 were gathered [14]. The GWP of each irrigation command area was calculated regarding to the water productivity of its cropping pattern.

III. Results and Discussion

A. *Virtual Water of the Proposed Irrigation Areas*

Table II shows the annual virtual water of each irrigation areas from water resources during 2002-2006. The results indicates that Dez command area with the water use of 2568.14 MCM y^{-1} had the highest delivered water and Borkhar command area with the water use of 47.2 MCM y^{-1} stood at the lowest rank.

B. *The GWP of Irrigation Command Areas*

The actual GWP of each irrigation command area was determined based on its cropping pattern and yield crops, and annual crop water use (Fig. 2). A GWP range is presented for each of irrigation networks in this figure. The results showed that the lowest GWP belongs to Mahyar and Borkhar irrigation areas, 0.24 kg m^{-3}, and the highest is that of the Dez irrigation area, 0.81 kg m^{-3}. The difference in the GWP of irrigation areas is due to variations in the cropping pattern, amount of crop productions, in addition to the effective factors in the water use efficiency in the irrigation areas.

The GWP may be considered in order to assess the status of water use efficiency and performance of irrigation command areas. Considering the error bars values in Fig. 1, the variation margins of the GWP of proposed irrigation networks may be divided into two classifications. The water-use efficiency of irrigation networks within these margins was defined as:

a. Efficient ($GWP \geq 0.60$)
b. Semi- efficient ($GWP < 0.60$)

where GWP is in kg m^{-3}.

Hence, the water management status in irrigation command areas can be evaluated as shown in Table III. The findings demonstrate that water management in the Sefidroud and Dez irrigation areas is efficient. Furthermore, water management in the others is a semi-efficient state. Such findings in an irrigation command area could be the basis of better planning and management of the limited water resources of the study regions. Further attention to the cultural issues, cover of the canals, status of regulation and distribution structures and the available water for distribution could have a major role in increasing the GWP of irrigation networks. That is why irrigation systems such as Dez and Sefidroud, which are relatively better of in these factors achieve higher GWP. Thus, as an approach to improve the current situation of global water productivity of irrigation networks is to focus on management issues and criteria, which have the highest relative influence in this matter. In this way, with a slight improvement in the quality of these management criteria, more efficient and water productivity of irrigation networks could be obtained.

Table IV shows the water productivity value of wheat in the different irrigation command areas. The lowest wheat WP value belongs to Gotvand irrigation area, 0.43kg m^{-3}, and the highest is that of the Dez irrigation area, 0.85 kg m^{-3}. The average WP of this crop is determined as 0.59kg m^{-3} for the proposed irrigation areas. It was considered that wheat WP value in the irrigation command areas is relatively low. In each of the command areas it seems that the cultivated crops have a higher amount of virtual water and thus can be replaced by crops with less virtual water. This is merely suggested due to crop water consumption and at the time of replacing crops, economic value as well as cultural and political factors must be considered.

IV. Conclusion

The results demonstrated that O & M management in the Sefidroud and Dez irrigation command areas is efficient. Furthermore, water management in the Moghan, Qazvin, and Varamin is in a semi-efficient state and in a relatively inefficient status in the other irrigation areas. Hence, improvement in current efficiencies of water use and conservation, i.e. to produce more with the existing resources with minimum deterioration of land and water resources, may serve as an essential component of sustainable agricultural water management in the study regions. In each of the command areas it seems that the cultivated crops have a higher amount of virtual water and thus can be replaced by crops with less virtual water. This is merely suggested due to crop water consumption and at the time of replacing crops, economic value as well as cultural and political factors must be considered.

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TABLE I
SUMMARIZED DETAILS OF THE PROPOSED IRRIGATION COMMAND AREAS

Irrigation network	Latitude	Longitude	Main crops	Cultivated area (ha)	Average annual rainfall (mm)	Average annual Temperature (°c)	Average annual evaporation (mm)
Abshar	32°28'E to 32°35'E	51°42'N to 51°57'N	Wheat, barely, alfalfa, sugar beet	26000	120	14	939
Borkhar	32°42'E to 32°55'E	51°32'N to 51°56'N	Wheat, barely, alfalfa, sugar beet	7600	120	14	939
Mahyar	32°16'E to 32°24'E	51°20'N to 52°14'N	Wheat, barely, maize, sugar beet, orchards	11300	120	15	939
Nekoo Abad	32°22'E to 32°40'E	51°22'N to 52°39'N	Wheat, barely, rice	40000	120	14	939
Roodasht	32°22'E to 32°34'E	52°03'N to 52°32'N	Wheat, barely, alfalfa, sugar beet	19600	120	14	939
Dez	32°00'E to 32°35'E	48°24'N to 48°24'N	Wheat, barely, tomato, potato, onion, green house crops	93750	370	27	943
Gotvand	32°14'E to 32°14'E	48°48'N to 48°48'N	Wheat, alfalfa, onion, green house crops, water melon, egg-plant	38000	324	26	1031
Karkheh	31°21'E to 31°29'E	48°26'N to 48°48'N	Wheat, cucumber, sesame, lettuce, green house crops	12720	207	26	1101
Maroom	30°15'E to 30°26'E	50°14'N to 50°20'N	Wheat, maize, water melon, sesame	16402	356	25	959
Qazvin	36°00'E to 36°20'E	49°45'E to 50°30'N	Wheat, barely, alfalfa, maize, corn, orchards	30621	478	13.9	903
Moghan	39°25'E to 39°42'E	43°00'N to 47°00'N	Wheat, barely, alfalfa, cotton, sugar beet	6362	299	15	804
Saveh	34°45'E to 35°03'E	50°08'N to 50°50'N	Wheat, barely, cotton, melon, orchards	12000	180	17	916
Sefidroud	36°34'E to 38°27'E	48°53'N to 50°34'N	Rice	169800	1100	14	773
Varamin	35°05'E to 35°30'E	43°35'N to 51°40'N	Wheat, barely, tomato, maize	60000	145	16	929

TABLE II
VIRTUAL WATER OF THE PROPOSED IRRIGATION COMMAND AREAS (FROM WATER RESOURCES)

...ion ...and ...	Abshar	Borkhar	Mahyar	Nikooabad	Roodasht	Dez	Gotvand	Karkheh	Maroon	Qazvin	Moghan	Saveh	Sefidroud	Varamin
...al ...r ...y^{-1})	147.02	47.20	50.12	227.32	68.00	2568.14	901.90	111.64	258.02	199.56	244.53	61.36	526.80	219.16

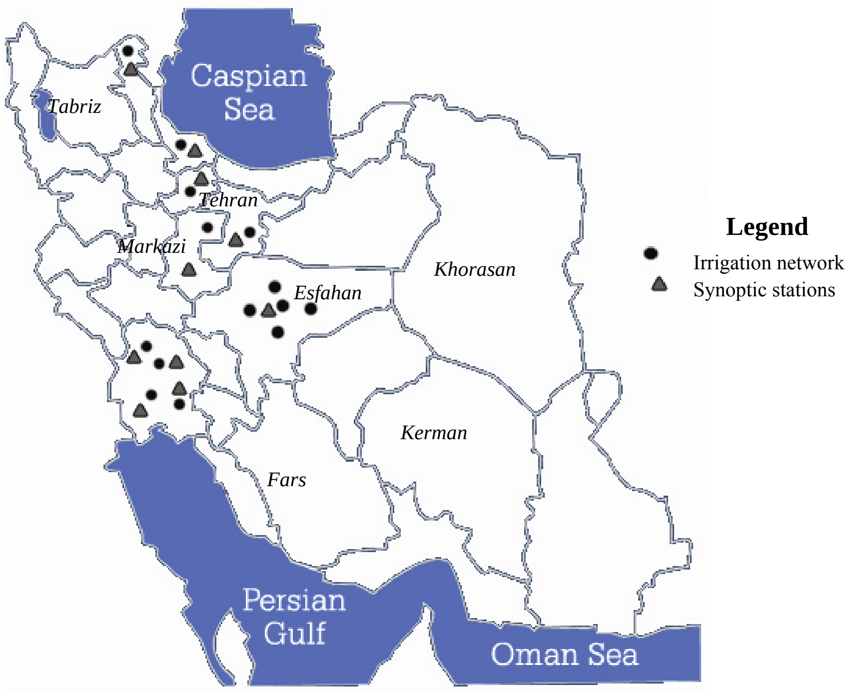

Fig. 1 Location of the irrigation networks in Iran

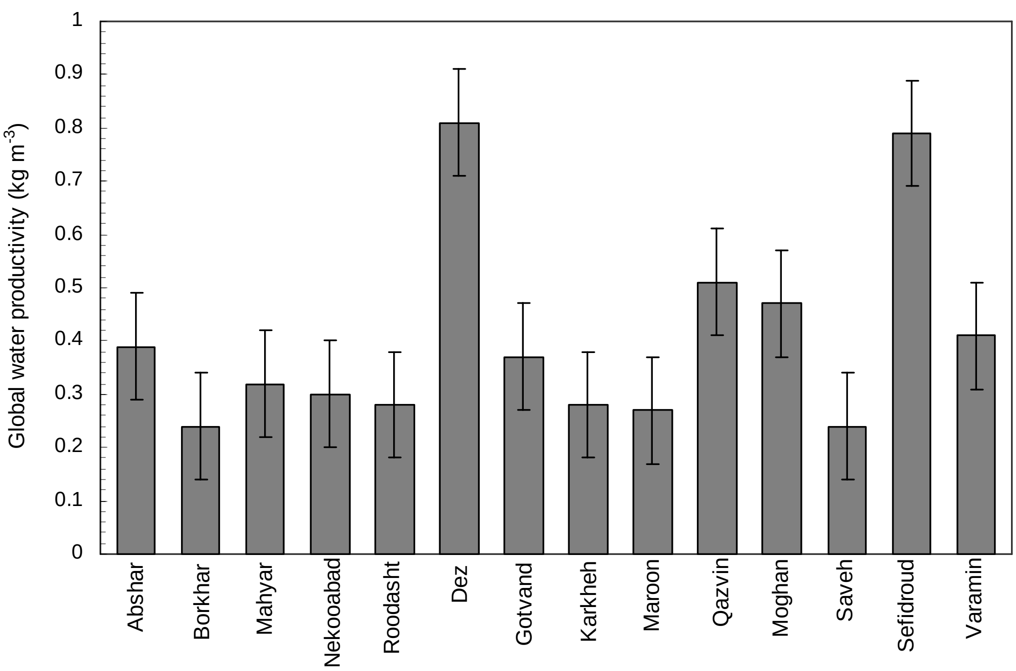

Fig. 2 Global water productivity of

TABLE III
WATER MANAGEMENT STATUS OF THE PROPOSED IRRIGATION NETWORKS

Irrigation command area	Management status
Abshar	SE
Borkhar	SE
Mahyar	SE
Nekooabad	SE
Roodasht	SE
Dez	E
Gotvand	SE
Karkheh	SE
Maroom	SE
Moghan	SE
Qazvin	SE
Saveh	SE
Sefidroud	E
Varamin	SE

E= Efficient; SE= Semi-efficient

TABLE IV
WATER PRODUCTIVITY VALUE OF WHEAT IN THE DIFFERENT COMMAND AREAS

Irrigation command area	Water productivity (kg m^{-3})
Abshar	0.55
Borkhar	0.48
Mahyar	0.49
Nekooabad	0.50
Roodasht	0.60
Dez	0.85
Gotvand	0.43
Karkheh	o.62
Maroom	0.68
Moghan	0.70
Qazvin	0.72
Varamin	0.52

REFERENCES

[1] S.L. Postel, G.C. Daily, and P.R. Ehrlich, Human appropriation of renewable freshwater. Science, 271: 785–788, 1996.

[2] W.J. Cosgrove, F.R. Rijsberman, World water vision. Earthscan Publications: London, 2000.

[3] T. Oki, and S. Kanae, Global hydrological cycles and world water resources. Science, 313: 1068–1072, 2006.

[4] J.W. Kijne, R. Barker, and D. Molden, Water productivity in agriculture: limits and opportunities for improvement. Comprehensive assessment of water management in agriculture series 1. CAB7IWMI, Wallingford: Colombo, 2003.

[5] B.A.M. Bouman, A conceptual framework for the improvement of crop water productivity at different spatial scales. Agricultural Systems, 9: 43–60, 2007.

[6] H.L. Plusquellec, K. McPhail, and C. Polti, Review of irrigation system performance with respect to initial objectives. Irrigation and Drainage Systems, 4(4): 313–327, 1990.

[7] S. Postel, The Last Oasis, facing water scarcity. Earthscan Publications: London, 1992.

[8] A.F. Bottrall, Overview: irrigation management research—old themes, new contexts. Water Resources Development, 11(1): 5–10, 1995.

[9] I. Hussain, R. Sakthivadivel, U. Amarasinghe, M. Mudasser, and D. Molden, Land and water productivity of wheat in the Western Indo-Gangetic Plains of India and Pakistan: a comparative analysis. IWMI, Colombo, vol vi, 50p (IWMI research report 65), 2003.

[10] C.M. Burt, and S.W. Styles, Conceptualizing irrigation project modernization through benchmarking and the rapid appraisal process. Irrigation Drainage, 25(2):145–154, 2002.

[11] D.J. Molden, R. Sakthivadivel, C.J. Perry, C. de Fraiture, and W. Kloezen, Indicators for comparing performance of irrigated agricultural systems. Research report no. 20. International Water Management Institute, Colombo, 1998.

[12] A.J. Clemmens, and D.J. Molden, Water uses and productivity of irrigation systems. Irrigation Science, 25: 247-261, 2007.

[13] C. Perry, Efficient irrigation; inefficient communication; flawed recommendations. Irrigation and drainage, 56: 367-378., 2007

[14] Iranian Water Resources Management Company (IWRMC), Annual information and data on performance assessment of modern irrigation networks (annual report 2002-2006), 2006.