**Shiraz University**
**Faculty of Agriculture**


**Ph.D. Thesis in Water Science and Engineering**

# OPTIMIZATION OF WATER DISTRIBUTION MANAGEMENT UNDER DIFFERENT CLIMATIC CONDITIONS TO ACHIEVE OPTIMAL EQUITY AND PRODUCTIVITY IN DOROODZAN IRRIGATION NETWORK


**By:**

**MOHAMMAD MEHDI MOGHIMI**

**Supervised by:**

**ALI REZA SEPASKHAH**



**September-2013**

بسم الله الرحمن الرحیم

In the name of Allah

# Declaration

I, Mohammad Mehdi Moghimi, Ph.D. student in irrigation and drainage engineering declared that this thesis is the results of my researches and I had written the exact references wherever I used other sources. I also declare that my research and the subject of my thesis are not repetitive and I guarantee that I will not disseminate its results and not make them accessible to others without the permission of Shiraz University. 

Mohammad Mehdi Moghimi

September - 2013

IN THE NAME OF ALLAH

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**BY**

MOHAMMAD MEHDI MOGHIMI

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**EVALUATED BY THE THESIS COMMITTEE AS: EXCELLENT**

..................... A.R. SEPASKHAH, Ph.D., PROF. OF WATER ENGINEERING DEPT., SHIRAZ UNIVERSITY (SUPERVISOR)

..................... M. ZIBAEI, Ph.D., PROF. OF AGRICULTURAL ECONOMICS DEPT., SHIRAZ UNIVERSITY (ADVISOR)

..................... T. HONAR, Ph.D., ASSOC. PROF. OF WATER ENGINEERING DEPT., SHIRAZ UNIVERSITY (ADVISOR)

..................... S. M. KASHEFIPOUR, Ph.D., PROF. OF FACULTY OF WATER SCIENCE ENGINEERING, SHAHID CHAMRAN UNIVERSITY OF AHVAZ (EXTERNAL EXAMINER)

..................... D. KHALILI, Ph.D., ASSOC. PROF. OF WATER ENGINEERING DEPT., SHIRAZ UNIVERSITY (INTERNAL EXAMINER)

SEPTEMBER - 2013

**Dedicated to:**

***My dear family***

***for their support and encouragement***

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# ABSTRACT

**OPTIMIZATION OF WATER DISTRIBUTION MANAGEMENT UNDER DIFFERENT CLIMATIC CONDITIONS TO ACHIEVE OPTIMAL EQUITY AND PRODUCTIVITY IN DOROODZAN IRRIGATION NETWORK**

**BY**

**MOHAMMAD MEHDI MOGHIMI**

Efficient use of limited water resources should be considered seriously, especially in arid and semi-arid regions. On-farm water management is the most important factor in water resources management where much of water resources are used in agriculture especially at drought conditions. Furthermore, water resources shortage in agriculture in semi-arid areas mostly appears in summer crop season due to no precipitation occurrence. Therefore, efficient use of irrigation water for summer crops should be considered more seriously. Saving water and improving water productivity, influence the socioeconomic measures like equity that should be considered in water distribution management. In this study at first stage we calculated water productivity (WP), economic WP (EWP) and economic WP ratio (EWPR) for dominant winter crops (winter wheat and rapeseed) and summer crops (maize and rice) of the study area at farm level with different methods of deficit irrigation scheduling (DIS) and different values of water application efficiency ($E_a$) at different climatic conditions. Results indicated that in most cases maximum WP did not occur at full irrigation scenario so that for winter wheat (crop with less sensitivity to water deficit); it occurred at water reduction fraction (WRF) of 0.8. Furthermore, in methods of DIS with full irrigation at the stages

with higher sensitivity to water deficit, WP was higher than when deficit irrigation was applied at these stages with higher sensitivity to water deficit. With increasing $E_a$, WP increased and the maximum WP shifted toward higher WRF. The overall water deficit sensitivity of rapeseed was higher than winter wheat; therefore, if in the critical stages of rapeseed growth full irrigation was applied, the grain yield reduction was low and application of deficit irrigation was economically acceptable. Considering the real cost of water, EWPR decreased greatly and in surface irrigation system, $E_a$ should increase and high WRF (>=0.4) should be avoided. In solid-set sprinkler system, EWPR increased with increasing $E_a$ and application of WRF higher than 0.2 (0.2-0.8 for winter wheat and rapeseed) was acceptable. Tape irrigation of winter wheat was not acceptable even in full irrigation scheduling scenario; however for rapeseed it was acceptable only for WRF less than 0.2 and by decreasing $E_a$, WRF of 0.2-0.4 was also acceptable. Therefore, for application of deficit irrigation the cost of water should be considered.

The overall water deficit sensitivity of maize was higher than winter crops (rapeseed and wheat); therefore if in the critical stages of maize growth (flowering stage) full irrigation was applied, lower grain yield reduction was obtained and its application was economically acceptable. Despite the higher sensitivity of rice to water deficit, results indicated that DIS at different growth stages was economically acceptable with the exception of high $E_a$ (greater than 70%). Considering the real cost of water, EWPR decreased greatly and in surface irrigation system, $E_a$ should increase and high WRF (>=0.4) should be avoided. In solid-set sprinkler irrigation system, EWPR increased with increasing $E_a$ and application of WRF higher than 0.2 (0.2-0.6 for maize) was acceptable. Tape irrigation of maize was acceptable only for WRF less than 0.2 and by decreasing $E_a$; WRF of 0.2-0.4 was also acceptable.

Second stage of this research considered simultaneous optimization of performance measures of water equity and productivity for different scenarios of irrigation water management. This consideration was done in the Doroodzan Irrigation Network for winter wheat (dominant winter crop) and maize (dominant summer crop) using genetic algorithm (GA). For winter wheat, increment of WRF

and $E_c$ resulted in maximum and minimum incremental effect on performance measures. These increments were 212.5% and 37.8% for equity and 107.7% and 16.9% for productivity. These values for incremental effect of $E_a$ were 92.3% and 52.1% for equity and productivity, respectively. For maize, the increment of WRF and $E_c$ (70% to 90%) resulted in maximum (125.7%) and minimum (28.6%) incremental effect on water equity. This value for incremental effect of $E_a$ was 89.2%. Increasing of $E_a$ and $E_c$ have the maximum and minimum effect on increment of water productivity and these increments were 104.8% and 13.8%, respectively. The incremental effect of WRF on the water productivity was 75%. Furthermore, the values of performance measures decreased from wet water year to drought water year for both crops. Solid-set sprinkler irrigation system was considered as the best choice among the irrigation systems for achieving higher values of equity and productivity for winter wheat. For maize, tape irrigation system was considered as the best choice at low quantities of WRF (<=0.4) and for higher values of WRF (>=0.6), sprinkler irrigation system was considered as the best choice for achieving higher values of water equity and productivity. When equity and productivity were considered together for a special method of irrigation scheduling, under specified quantity of irrigation water, with increasing equity the water productivity reduction was negligible. Results also indicated that by enlarging the study area from single channel level to network level the values of water equity and productivity decreased significantly.

**Keywords:** Deficit irrigation scheduling, Water cost, Irrigation application efficiency, Conveyance efficiency, Economic water productivity, Equity.

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