Aspects for Agricultural Water Management in Water Stress Conditions: Case Study of Konya Plain, Turkey

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Abstract— *The major aim of the study was to propose sustainable agro-water management strategies, particularly for water poor-ecologies. In current work, information was obtained from worldwide previous findings of studies relevant to the water management. In order to maximize water productivity in those environments exposing climate changes following applicable suggestions were presented: changing crop pattern in accordance of available current water resources, increasing utilization areas in favor of modern irrigation systems, if possible converting of water delivery networks to pipe systems, improving share of low water consuming crops in current crop patterns, practicing deficit irrigation program, collecting water charges based on volumetric basis, more uses of rainwater harvesting systems, training of farmers about irrigated agriculture, and if possible transferring some water from neighbor basins to irrigation farms.*

Keywords— Climate Change, Crop Pattern, Irrigation, Water Management, Water Shortage.

I. INTRODUCTION

Climate change is one of major global crisis and its effects have increased gradually due to global warming. Agriculture is one of the activities mostly affected by climate change. The spatial and temporal fluctuations of precipitation together with rising in temperature may have a negative impact on crop yield and quality [1]. As known, the amount of water resources on earth surface is constant but rainfall distribution is not homogenous in time and space. The amount of water on global about $1.35x10^9$ m^3/year but the most of it, about 97.4%, is available at seas with saline form. The most of fresh water about 69% exists in glacier, 30% of at groundwater reservoir, and the rest (1%) at surface water supplies. The only 5% of groundwater resources are available at present [2]. Climate change has impacts on many sectors such agriculture, fishery, forestry, and so on. Agriculture, relies directly on environmental factors, has been influenced by climate change and in turn, has also had an impact on climate change [3]. There are three climates in Turkey namely, Mediterranean, Black Sea and Continental climates. Continental climate has observed mainly at inlands with large-sized farmlands having hot in summer, and cold in winter [4] so farming activities based on water savings are vital important for sustainable utilization of water resources particularly at those kinds of water-starved ecologies.

In recent years, water reductions of wells are getting increase gradually in Turkey. Annual depletion of groundwater level is about 1.5 m depending on regions. Konya Closed Basin is forefront in groundwater reduction within whole river basins. The reasons behind such water depletion could be increase of crop patterns in favor of high-water consuming crops, and unnecessary or poor uniformity of rainfall. This situation has forced farmers to extract over water pumping from groundwater resources which resulted in land subsidence in some part of the region. In basin, total available water potential is about $4.5x10^9$ m^3/year, but actual use is about $6.5x10^9$ m^3/year. In that regard, there is $2x10^9$ m^3/year water deficiency in basin resources each year.

The farmers have great experiences about all farming activities in such basin. They produce plenty different field crops such as sugar beet, corn, alfalfa, squash, sunflower, cereals, legumes etc., and various vegetables such as tomato, lettuce, pepper, carrot, egg plants, and plenty fruit plants such as apple, cherry, plum, apricot, grapes, pear and so on. In addition, having the highest animal population in Turkey that basin is well-known as an animal production center. Due to the recent climate changes, all crops including cereals have produced under irrigation for obtaining economical benefits [5]. It is noted that irrigation is main factor increasing crop yield particularly in arid and semi-arid climates such as Konya plain of Turkey. Like average of worldwide, more than 70% of fresh water resources have been used in irrigation practices in those environments [6, 7, 8].

In Konya basin, there are about 10-25 mm rainfall reductions in last 30 year sifting such basin to arid climate. Rainfall of basin is not uniform and insufficient and only 30% of rainfall has recorded at crop vegetation period [9]. Over water extraction from groundwater reservoir for irrigation purpose has resulted serious environmental problems [10]. Sprinkler irrigation systems are common irrigation method in region. Drip irrigation system is gaining the popularity for irrigation of some field crops such as corn and sunflower, and vegetables since water application efficiency is about greater than 90% in that system under well management.

In water shortage environments, growing drought resistance crops, changes in calendar of sowing date in accordance of crop patterns, mixing crop system, improvement of water productivity and planting of trees are practical solutions for minimizing climate change inverse impacts particularly in water scant ecologies [11].

The main target of this paper is to present practical recommendations for enhancing water productivity in water scant ecologies.

II. MATERIALS AND METHODS

In this study, water saving strategies was examined particularly at arid and semi-arid regions such as Konya plain of Turkey. The sample region, Konya basin, is semi-arid climate characteristics in accordance of long-term average annual rainfall of about 320 mm. It is within the second drought areas of Turkey and irrigation is very important role to play for obtaining satisfactory production. Even, it is almost impossible for farmers to get desired economical returns without irrigation particularly in semi-arid Middle Anatolian Region of Turkey. In current study, findings of previous studies relevant to agricultural water management were used and practical recommendations about productive water utilization in agriculture were analyzed with detail for water-starved environments.

III. RESULTS AND DISCUSSIONS

The five main effective aspects for better agricultural water management particularly for arid or semi-arid environments were as follows;

3.1 Changing crop pattern in favor of less water use crops

The land sizes of farmlands with high water consuming crops such as sugar beet, alfalfa and corn are big in Konya basin due to the resulting well economical returns. Konya province is also in first rank in accordance of animal breeding in Turkey. However, the highest cost for animal sector is feeding materials in Turkey so farmers have to produce most feeding materials under irrigation. The irrigation cost is maximum share within whole production costs in agriculture particularly by using pressured irrigation systems. Alfalfa having rich of nutrient contents and silage corn are first preference forage plants in region. Sugar beet, alfalfa and corn crops have used high water around 800-1400 mm in season. Therefore, productive utilization of irrigation water has resulted water and energy savings as well as reducing irrigation energy costs. Increase of farming areas of sugar beet, alfalfa and corn plants has resulted also serious environment problems such as groundwater depletion or formation of sinkholes in Konya plain. In result, reason behind over water pumping from ground water reservoir is current crop pattern.

In brief, increasing of production areas with low water consuming crops like pumpkin [12], sunflower, and cereals can be practical way for sustainable use of water resources in semi-arid environments such as Konya plain, Turkey.

3.2 Practicing water saving irrigation technologies

It is recommended to use pressurized irrigation systems in arid and semi-arid regions. There are plenty advantages including water saving, more uniform water application for crops, very little labor requirement, productive utilization of plant nutrients due to the almost no fertilizer percolation towards to lower parts of root systems, resulting high and quality yields and so on by use of those irrigation techniques under well management.

Those irrigation systems are strongly recommended for better water productivity, even at least 50% water saving could be accomplished by correct selection of irrigation system such as drip irrigation [13] in areas having limited irrigation water resources.

Irrigation system performance can be maximized with proper selection of irrigation system, adequate design, right choice and dimensioning of system components, proper installation and management. As a result, uniform water application by irrigation systems for crops has resulted desired crop yield and quality [14].

In Konya plain, permanent sprinkler irrigation systems with sprinklers having low flow rates are getting popularity due to the less labor requirement. Sprinkler irrigation systems have used in large farmlands of Konya plain especially for field crops. The application efficiency in such irrigation technology is satisfactory, even higher than world average, at semi-arid Konya region. Labor cost in agriculture is also very high in Turkey so irrigation systems requiring less manpower result more economical benefits. Beside that drip irrigation is getting great interests and has been used for irrigation of some field crops such as maize and sunflower, and some vegetables plants likes tomato, pepper, egg plant in Konya province.

3.3 Practicing of deficit irrigation

There is no doubt that maximum and qualified yield can be obtained from full irrigation treatment. Therefore, full irrigation can be applied particularly in regions having no water stress conditions [15]. The performance of deficit irrigation, DI, is highly relevant to cost of applied water, and price of agro-products as well as yield response to deficit irrigation.

Field trials relevant to different irrigation regimes effect on water productivity, WP, have indicated that increments of WP were 28-29% for wheat crop, and 24% for corn plant under 33% and 20% DI, respectively. The average yield reductions for wheat and corn plants were around 15%, and 2.7%, respectively in those treatments [16]. DI by drip-irrigated sugar beet, grain maize, potato and pumpkin plants at semi-arid Konya Plain of Turkey showed that 25% deficit irrigation had no result remarkable yield reduction comparison to full irrigation treatment so it was highly recommended in case the main goal of the farmers is to put more areas into the production consequently obtaining higher economical incomes at water shortage regions [17 - 20]. DI has caused also reducing irrigation energy cost, maximum rate within the all agro-production inputs in Turkey, due to the less amount of applied water during the irrigation season. In that regard, DI irrigation is friendship irrigation strategy for sustainable water utilizations of current water supplies particularly at water poor regions.

3.4 Water charge in accordance of volumetric basis

Water fees in accordance of amount of water use may be a realistic and practical solution that would push farmers to make more efficient use of irrigation water. By this way, farmers will apply water to crops with great care for minimizing irrigation cost.

Types of water resources influence water charges e.g taking water from groundwater had resulted 2.5 times greater water charging per ha over gravity water in Turkey [21]. Water price in accordance of applied water will improve water productivity thereby increase irrigation areas as well as enhancing works relevant to the evaluation and water collection dues so it can be recommended [22].

3.5 Training farmers about water management at farm levels

In farmlands, end user of water is a farmer so deep experiences of farmers have affected water productivity positively. Particularly pressurized irrigation systems need technical information. In that regards, farmers should be trained about agricultural water management at farm level. Proper training program for farmers can be done by organizing field days on sample farms. In addition, farmers should be supported by videos showing correct design, installation, and maintenance-repair works of those irrigation systems. In result, training of farmers with visual documents will be very efficient way. The more training farmers about irrigation water management leads to more water savings.

IV. CONCLUSION

Water productivity in agriculture is necessarily prerequisites particularly in water shortage ecologies. Farming activities have used about 70% fresh water in worldwide so water saving should be done in irrigation at first. In arid and semi-arid climates, following suggestions could be underlined for sustainable uses of water resources: 1- Land sizes of cultivated crops with irrigation should be planned in accordance current water resources of region, 2- New crop varieties having tolerant to the dry environments should be developed, 3- Areas practicing innovative irrigation technologies resulting better water savings should be enlarged, 4- Training activities for farmers about irrigation water management in field conditions should be

increased, 5- Deficit irrigation should be applied for some crops e.g. 25% deficit irrigation can be recommended for some field crops such as sugar beet, corn, sunflower, potato and so on, 6- Fresh water from neighbor basins can be brought to water shortage farmlands, and 7- Rainwater harvesting techniques could be viable solution for improvement of rainwater effectiveness for crop production.

V. CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

REFERENCES

[1] P. Hayaloğlu. 2018. "The effects of climate change on agriculture sector and economic growth ". GÜSBEED, 9 (25): 51-62.

[2] U. Şahin, and L. Kurnaz. 2014. "İklim Değişikliği ve Kuraklık". Istanbul Policy Center, IPC, Sabancı University, STIFTUNG MERCATOR GİRİŞİMİ, 36 ps (In Turkish).

[3] H.N. Bayraç, and E. Doğan. 2016. "Impacts of climate change on agriculture sector in Turkey". Eskişehir Osmangazi Üniversitesi IIBF Dergisi, 11 (1): 23-48.

[4] Ö. L. Şen. 2013. "A Holistic View of Climate Change and Its Impacts in Turkey". Istanbul Policy Center, IPC, Sabancı University, STIFTUNG MERCATOR GİRİŞİMİ (In Turkish).

[5] N. Yavuz, N. Çiftci, and D. Yavuz. 2019. "Effects of different irrigation interval and plant-pan coefficient applications on yield and quality parameters of oil sunflower grown in semi-arid climate conditions". Arabian Journal of Geosciences. https//doi.org/10.1007/s12517-019-4867-1.

[6] D. Yavuz, N. Yavuz, M. Seymen, and Ö. Türkmen. 2015a. "Evapotranspiration, crop coefficient and seed yield of drip irrigated pumpkin under semi-arid conditions". Scientia Horticulturae, 197: 33-40.

[7] D. Yavuz, M. Seymen, N. Yavuz, and Ö. Türkmen. 2015b. "Effects of irrigation interval and quantity on the yield and quality of confectionary pumpkin grown under field conditions". Agricultural Water Management, 159: 290-298.

[8] B. Acar. 2020a. "Water-yield relationships of lettuce plants for different irrigation strategies". Mechanization in agriculture & Conserving of the resources, 66 (5): 177-180.

[9] WWW. 2010. "Türkiye'nin Yarınları Projesi", 32 ps (InTurkish).

[10] I.K. Tunçok, and O.C. Bozkurt. 2015. "4. Bütüncül Havza Yönetimi: Konya Kapalı Havzası Uygulaması". 4. Su Yapıları Sempozyumu, 19-20-21 Kasım 2015: 479-488 (In Turkish).

[11] O.M. Akınnagbe, and I.J. Irohibe. 2014. "Agricultural adaptation strategies to climate change impacts in Africa: In Review". Bangladesh J. Agril. Res., 39 (3): 407-418.

[12] M. Seymen, D. Yavuz, A. Dursun, E.S. Kurtar, and Ö. Türkmen. 2019. "Identification of drought-tolerant pumpkin (*Cucurbita pepo* L.) genotypes associated with certain fruit characteristics, seed yield, and quality". Agricultural Water Management, 221: 150-159.

[13] N. Boomathi. 2020. "Farmers' satisfaction towards drip irrigation system with special reference to Erode district, Tamil Nadu". Research Explorer, VIII (27): 1-6.

[14] B. Acar, and B. Sevinçer. 2020. "Water distribution uniformity of sprinkler irrigation systems for different design and environmental conditions". International Journal of Agriculture and Economic Development, 8 (2): 8-16.

[15] B. Acar. 2020b. "Efficacy of drip irrigation systems for some vegetables: assessments of yield and water productivity". International Journal of Agriculture and Economic Development, 8 (2): 1-7.

[16] H. Dehghanisanij, T. Oweis, and A.S. Qureshi. 2006. "Agricultural water use and management in arid and semiarid areas: current situation and measures for improvement". Annals of Arid Zone, 45 (2): 1-24.

[17] B. Acar, R. Topak, D. Yavuz, and M.A. Kalender. 2014. "Is drip irrigation technique sustainable solution in agriculture for semi-arid regions? A case study of Middle Anatolian Region, Turkey". International Journal of Agriculture and Economic Development, 2 (2): 1-8.

[18] N. Yavuz, M. Seymen, D. Yavuz, B. Acar, and Ö. Türkmen. 2017. "Deficit irrigation affect on yield performance of pumpkin in semi-arid Middle Anatolian Region of Turkey". International Journal of Agriculture and Economic Development, 5 (2): 1-10.

[19] A. Clift-Hill, and J.N. Aliwa. 2019. "Adopting deficit irrigation as a strategy to enhance food security in Botswana". Botswana Journal of Agriculture and Applied Sciences, 13 (1-Special): 43-50.

[20] P.S. Khapte, P. Kumar, U. Burman, and P. Kumar. 2019. "Deficit irrigation in tomato: agronomical and physio-biochemical implications". Scientia Horticulturae, 248: 256-264.

[21] E.H. Çakmak. 2010. "Agricultural Water Pricing: Turkey". Middle East Technical University, Ankara, Turkey, OECD, 28 ps.

[22] L.B. Roy. 2019. "Irrigation water pricing in Sone command area". Water Resource Management & Climate Change, Adrian An ENVIS Newsletter, 2 (1&2): 8-12.