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DRAINAGE PRACTICES IN TURKEY

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Abstract
There is a need for drainage systems in all lands worldwide weather or not the lands were opened for irrigation. Drainage practices play a significant role both in the preservation of soil and water resources and in the protection of environment and ecology. Therefore, irrigation projects should definitely be constructed together with drainage facilities. The lands with drainage problems turned into marshlands in time and humans abandoned these lands. History of drainage systems goes back to very early civilizations. However, the first modern sub-surface drainage systems were founded at the beginning of the 19th century. Excess water in plant root regions has been discharged in different countries and regions with different materials placed over the impervious layer. Today with developed technology, both surface and sub-surface drainage systems can be constructed easily and economically. The critical point is to have proper surveys and designs. The first drainage Project of Turkey was constructed at the end of 1960s in Tarsus plain over 3 thousand hectare land area. By the year 2015, about 170 thousand land areas were drained from different regions and plains of Turkey. Drainage system construction works are ongoing over 10 thousand land area in different plains and regions and tenders were completed for drainage projects of 50 thousand land area. The nationwide master plans indicated a need for drainage systems for about 2.5 million land area. In this study, yesterday, today and tomorrow of drainage practices in Turkey were assessed and information and recommendations were provided for efficient drainage systems.

Keywords: agriculture, drainage system, Turkey.

1. INTRODUCTION

Excess water should be discharged from the places wherever it is used. A portion of the water used in agricultural practical practices evaporates from the soil surface and another portion is released into the atmosphere through transpiration from plant vegetative parts. The remaining portion percolates into the soil profile and accumulates over the water table in places with poor natural drainage conditions. This accumulated water is also quite saline. The great product diversity and improved yield and quality provided through irrigations in time are not sustainable under poor drainage conditions. Reversing the case to the initial state is a costly and labour-intense process and it takes a quite long time. Sustainable agricultural production will only be possible with sufficient drainage conditions.

Ever extending urban spaces, traditional agricultural practices and environmental concerns are the leading problems for the sustainability of human life on earth. Competition for deficit water

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resources is another great concern for sustainable agriculture. Cultivated lands are also continuously decreasing. Therefore, desired productivity levels in agricultural production can be achieved through design, operation and maintenance of both irrigation and drainage systems and proper determination/calculation of plant water consumptions. Current problems mostly result from unsustainable used of surface and groundwater resources, improper and insufficient water resources planning. In this case, responsible engineers, planners and managers do not investigate sufficiently the effects of irrigation and drainage problems on water resources and they usually develop technology, design and management without any investigations, measurements and assessments.
The expected benefits from agricultural investments can be obtained through modernization of irrigation and drainage systems, development of environment-friendly management practices and identification of financial and socio-economic trends. An integrated management approach is required in irrigation and drainage systems to improve food production, to preserve water resources, prevent groundwaters and soil salinity and to protect the environment (Malek Mohammadi, 1998; Dudley, 1999). Besides all, there is also a need for water control and regulation tools, remote sensing and geographical information systems, decision-support systems and models, site researches and assessment techniques and advanced researches on various issues. To solve the relevant problems, solutions should be proposed and developed for the following issues (Schultz and Wrachien, 2002);

- Proper pricing for implementation of new technologies,
- Integrated planning and management of irrigation and drainage systems,
- Identification of the constraints for the proper performance of irrigation and drainage systems,
- Plant water consumption and calculation methods,
- Plant water requirement estimations,
- Technological requirements for design, construction and modernization of irrigation and drainage systems,
- Strategy development to improve irrigation and drainage system efficiency,
- Measures to be taken for environmental impacts and sustainability of irrigation and drainage systems,
- Strengthening relevant organizations, proper financial supports, capacity development, education and training.

There is a need for drainage systems in all lands worldwide weather or not the lands were opened for irrigation. Such a need is quite significant with regard to soil and water resources preservation, environmental and ecological protection. Especially in places where irrigations are not developed sufficiently and places with poor drainage conditions, excessive irrigation water raises water table levels and creates serious salinity problems. In such cases, sufficient amount of water able to irrigate large areas either charges the groundwater or creates environmental pollution through runoff under low infiltration conditions. Therefore, irrigation projects should always be designed with drainage systems. The lands with drainage problems turned into marshlands in time and humans abandoned these lands. History of drainage systems goes back to very early civilizations. However, the first modern sub-surface drainage systems were founded at the beginning of the 19th century. Excess water in plant root regions has been discharged in different countries and regions with different materials placed over the impervious layer. Today with developed technology, both surface and sub-surface drainage systems can be constructed easily and economically. The critical point is to have proper surveys and designs.

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2. MATERIALS AND METHODS

The land is necessary for sustainable agricultural development, essential ecosystem functions and food security. More than 1.5 billion hectares – about 12% of the world's land area – are used for crop production. Although large amounts of land are potentially suitable for agriculture, much of it is covered by forests, protected for environmental reasons or is part of urban areas. According to FAO statistics by the year 2013, worldwide 255.2 million hectare land areas are irrigated. Of these areas, 191.2 million hectares is irrigated with surface water, 116.2 million hectares are irrigated with groundwaters and 0.3 million hectares is irrigated with nonconventional water resources. Agricultural lands have already reached to their ultimate sizes in Southern Asia, Western Asia and Northern Africa (FAO, 2015).

The total surface area of Turkey is 783 577 km^2 and 28.05 million hectares of this area are covered by agricultural lands. By the end of the year 2015, the total irrigable land area is 8.5 million hectares and 5.9 million hectares (69.4%) of it is currently being irrigated. By the year 2023, the remaining 2.6 million hectares of total irrigable 8.5 million hectares are planned to be irrigated (Anonymous, 2016a).

The soils of Turkey vary considerably infertility. The soils of the Central Anatolian Plateau reflect the semi-arid steppe condition of the region. Here low rainfall coupled with sparse plant cover of short grasses has resulted in the formation of limestone as the parent material. The character of the terrain handicaps the development of deep natural soils in this highland area and therefore most of the soils are thin and easily erodible. Overgrazing and deforestation of the sloping lands have led to an intensification of soil erosion problem. More productive soils, comprising of clay and lime underlay by deep sand-silt and clay strata are found in the coastal and lowland regions of Turkey. These areas cover nearly one-seventh of the total cropland of Turkey. The capabilities of these alluvial soils for crop production range from low, due to frequent flooding or low natural fertility, to very high. They have greater potential for increased agricultural production than any other group of soils. Dominant salts accumulated in the soils are chlorides (NaCl, $CaCl_2$, $MgCl_2$), sulphates (Na_2SO_4, $MgSO_4$), nitrates ($NaNO_3$, KNO_3), carbonates and bicarbonates (Na_2CO_3, $NaHCO_3$), and boron salts in certain areas. Sodium salts occur most frequently, but calcium and magnesium compounds are common, too (Sener, 1986).

Turkey has, in general, a semi-arid climate with extreme temperatures. Almost the whole Anatolian plateau has hot, dry, dusty summers and cold, windy, damp winters, but in the Eastern Anatolian region the summers are cool and short and the winters are severe and long. The Mediterranean climate with short, wet winters and long, warm, sunny summers, prevails in the southern and western part of the country.

Mean precipitation in Turkey is 574 mm/year amounting to 450 billion m^3/year. A volume of 269 billion m^3/year water evaporates from water bodies and soils to the atmosphere. Including 41 billion m^3/year net discharging into groundwater (covering safe yield extraction, unregistered extraction, emptying into the seas, and transboundary), the gross (surface and groundwater) renewable water potential of Turkey is estimated as 234 billion m^3/year. However, under current technical and economic constraints, annual exploitable potential has been calculated as 112 billion m^3/year of net water volume, as 94 billion m^3/year from surface water resources, as 18 billion m^3/year from groundwater safe yield (Anonymous, 2017). Meteorological data show that over 90% of Turkey has not enough soil water during the crop growing season, and for good agricultural production, irrigation is essential in most parts of the country.

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3. RESULTS AND DISCUSSIONS

Excess water in the crop root zone soil is harmful to plant growth. Crop yields are drastically reduced on poorly drained soils, and, in cases of prolonged waterlogging, plants eventually die due to a lack of oxygen in the root zone. Sources of excess soil water that result in high water tables include: high precipitation in humid regions; surplus irrigation water and canal seepage in the irrigated lands; and artesian pressure. Waterlogging in irrigated regions may result in excess soil salinity, i.e., the accumulation of salts in the plant root zone. Artificial drainage is essential on poorly drained agricultural fields to provide optimum air and salt environments in the root zone. Drainage is regarded as an important water management practice, and as a component of efficient crop production systems. World food supply and the productivity of existing agricultural lands can only be maintained and enhanced if drainage improvements are undertaken on cropland currently affected by the excess water and high water tables.

In Turley, the first modern irrigation project was constructed between the years 1907-1914 during the Ottoman period as Konya Cumra Irrigation. With this project, 57000 ha land area in Konya plain were irrigated with the water received from Beysehir Lake (Anonymous, 2016b). Following the foundation of the Republic of Turkey, the first irrigation project was constructed in 1934 as Antalya Kırkgozler-Uzunkuyu Irrigation. In this project, 1500 ha land area was opened to irrigation. Then, Aksu-Solak Irrigation was realized. Water received from Aksu River conveyed with 10 km canal and 1000 ha land of Solak Village opened to irrigation in 1934. After that, between the years 1934-1936, Capalı-Karakuyu marshlands located at North of Isparta-Keciborlu were dried off to prevent mosquito problems and to gain agricultural land (Buyukyildirim, 2008).

After that, the planning of water resource development on River Seyhan started in 1939. In the 1940s, a diversion dam, flood control barriers, and two main conveyance channels were constructed from which 18500 ha could be irrigated. In 1956, Seyhan Dam was completed and the hydroelectric power plant started its operation with an installed capacity of 54 megawatts, an average annual power generation of 350 Gwh. Seyhan Dam and its reservoir also serve for flood control for 24500 ha of agricultural land and the city of Adana, and the area surrounding the reservoir is used for recreation. The available volume of surface water from the river Seyhan, dammed in Seyhan reservoir, is sufficient to irrigate the project area of 175000 ha, and water quality is suitable for irrigation purposes.

The first survey study for problematic soils was conducted by Caglar (1934) to identify arid lands of Turkey and spread and general characteristics of these lands were determined with this study. The first survey study to identify the saline and alkaline lands of Turkey was performed by Oakes (1954). With this study, 2312380 ha land area, including poorly drained, saline, alkaline lands, holomorphic and hydromorphic soil, were identified as non-available for agricultural purposes (Bahceci, 2002). In 1978, Provincial Soil Resources inventory was prepared According to this inventory, the total land area with different salinity and alkalinity levels were identified as 1517695 ha, of which 837405 ha is classified under II, III and IVth class, 93513 ha Vth class and 586777 ha VI and VIIth class. Of II, III, IV and Vth class lands, 60% was slightly saline, 19% was saline, 0.4% was alkaline, 12% was slightly saline-alkaline and 8% was saline-alkaline. Considering these values, it was observed that 2% of the total surface area of Turkey, 6% of total irrigable lands (25.75 million ha) and about 5.4% total agricultural lands (28.05 million ha) was covered with those problematic lands. Including 1 257 115 ha wet soils, total problematic lands of Turkey was identified as 2775115 ha. Such an amount corresponds about 3.6% of the total surface area of Turkey, 9.9% of total agricultural lands and 10.8% of total irrigable lands of Turkey.

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The improvement works for saline and alkaline soils were initiated in 1946 by the Ministry of Agriculture and State Hydraulic Works (DSI) with the foundation of Irrigated Agriculture Experiment Stations. The very first works for the improvement of saline and alkaline lands were initiated by Soil and Water Resources Research Institute in Tarsus. Initially, paddy and meadow plant culture was practised over these lands.

Although very simple individual surface and subsurface drainage systems have been found in Anatolia since Roman and Ottoman time, only extensive and planned work on this subject has been started since 1950 on a project basis. In those years and a few years ago, some big irrigation projects such as Seyhan, Cumra, Menemen and Alpu were completed and irrigated agriculture was started in these rather flat alluvial and hydromorphic alluvial soils. As soon as irrigation started crop yields doubled. But the following years irrigated agriculture brought new problems to the farmers such as high water tables, salinity and alkalinity. On the other hand, new dams and irrigation schemes came under construction whereby sufficient drainage had to be provided. In the 1960's intensive land reclamation and drainage program was initiated by the government with the assistance of international organizations, such as the International Development Agency (IDA), European Investment Bank (EIB) and International Bank for Reconstruction and Development (IBRD). As a result of this programme, surface and subsurface drainage works have been started in 21 big irrigation projects (Table 1).

Table 1 The most important land development and drainage projects in Turkey (It was created using Seren, 1986).

Name of the Project	Total Area (ha)	Land Levelling Area (ha)	Subsurface Drainage		Surface Drainage (ha)	Land Reclamation (ha)
			Area (ha)	Lateral Length (m/ha)		
Seyhan (Adana)	181 300	139 100	47 300	100	139 100	
Gediz (Manisa)	110 495	69 620	45 400	100	69 620	32 350
Akr;ay (Nazilli)	18 050	13 150	3 517	100		1 863
Berdan I, II (Tarsus)	27 706	17 520	11160	100	5 265	3 374
Uluirmak (Nigde)	21 095	17 750	11 860	75		4 415
Kiipriicay (Antalya)	24 215	18 000	7 526	87	18 000	840
Igdir (Kars)	67 473	66 000	36 093	125	66 000	36 093
Ercis (Van)	2 300	1 600	1000	100		
Kazova (Tokat)	22 950	15 000	3 860	100	15 000	2 100
Alpu (Eskisehir)	23 200	17 940	9 300	100		
M. Kemalpasa (Bursa)	16 250	13 200	6 861	75		
Silifke (Mersin)	6 005	3 300	2 350	100	3 300	
Cumra (Konya)	5 800	4 500	1 000	125		2 500
Nusaybin (Mardin)	8 600	6 500	1 800	100		
Sarimsakli (Kayseri)	12 405	8 900	1 350	100	8 900	
Ceyhan (Adana)	107 996	97 200	6 050	138	97 200	2000
Carsamba (Samsun)	50 000	20 000	33 173	125	20 000	
Bafra (Samsun)	30 000	15 000	10 122	125	15 000	10000
Kartalkaya (K.Maras)	23 368	18 527	2 100	100	6 000	
Erzincan	10 520	10 099	5 000	100	2 000	8 000
Bigadiç (Balikesir)	3 403	2 492	2 500	115	1 500	
Southeastern Anatolia Project (GAP)		2 430 000	61 000			90 250
Total	773 131	2 875 398	310 322		466 885	193 785

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Surface and subsurface drainage works are mostly completed in these projects. However, in the coastal plains, the lowlands below 2 m elevation which require pumping for drain water disposal are for an economic reason still in a future drainage project phase. Besides those 21 big projects, there have been many separate drainage projects all over the country. According to the 1986 statistics of Koy Hizmetleri (Rural Affairs) General Directorate, land development, installation of surface and subsurface drainage systems and application of soil amendment was carried out by this organization in 1985 on 752470 ha. Subsurface drainage was installed on 427220 ha. Approximately 20000 ha has been proposed for subsurface drainage installation in 1986 (Sener, 1986). By the end of 2015, drainage works were completed in 170000 land area in different regions and plains. About 10000 ha are under construction and tenders were completed for drainage works of another 50000 ha. According to data of General Directorate of Agricultural Reforms, besides the current drainage works, there is a need for drainage in 984943 ha land area in 57 provinces by the end of the year 2015. The provinces with the greatest need for drainage were identified as Konya with 120594 ha, Samsun with 83331 ha, Sakarya with 74177 ha, Antalya with 62528 ha and Bursa with 51599 ha. The size of land requiring both drainage and soil reclamation was identified as 1373181 ha. Similarly, the provinces with the greatest need for both drainage and reclamation were also identified as Konya (266435 ha), Nigde (156843 ha), Adana (109762 ha), Mus (90000) and Kayseri (73707 ha). The total land area nationwide with drainage and soil reclamation problems was identified as 2 358 124 ha.

The world's net cultivated area has grown by 12% over the last 50 years, mostly at the expense of forest, wetland and grassland habitats. At the same time, the global irrigated area has doubled. The distribution of these land and water assets is unequal among countries. Although only a small proportion of the world's land and water is used for crop production, most of the easily accessible and (thus economic) resources are under cultivation or have other ecologically and economically valuable uses. Thus the scope for further expansion of cultivated land is limited. Only parts of South America and sub-Saharan Africa still offer scope for some expansion. At the same time, competition for water resources has also been growing to the extent that today more than 40% of the world's rural population is now living in water-scarce regions. The global land area is 13.2 billion ha. Of this, 12% (1.6 billion ha) is currently in use for cultivation of crops, 28% (3.7 billion ha) is under forest, and 35% (4.6 billion ha) comprises grasslands and woodland ecosystems. Low-income countries cover about 22% of the land area (FAO, 2011).

In many irrigation projects, crop yields are reduced due to waterlogging and salinization of the land. In some cases, there is a total loss of production and therefore the land is abandoned. Waterlogging may also cause human health problems, particularly malaria, because of ponded water. Of the estimated 235 million ha of irrigated land in the world, 10 to 15% has been affected by waterlogging and salinization. Two important causes of waterlogging and salinization are: (a) excessive application of irrigation water; and (b) lack of adequate drainage. Thus the provision of adequate drainage is a solution to the waterlogging and salinization problems of irrigated lands. However, it must be pointed out that improving drainage should not be a substitute for reducing excessive application and that improved drainage should not be implemented without first assessing whether waterlogging may be reduced by optimizing the application. Countries do not have sufficient information on their drainage problems. Existing information is incomplete, inadequate and not reliable (Yildirim, 2013).

In the last years, the importance of land drainage to the farming sector has been so high. For commodity prices remaining low, the focus now needs to be on controlling input costs and

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maximising yield and quality. Good land drainage can facilitate which increase yield potential, reduce variable costs, reduce machinery costs, increase timeliness, increase land values, save of irrigation water, sustainable farming, protection of environmental and protection of public health, the existing structures, roads and other facilities in the land are protected.
According to 2013 data of FAO; there is an area in the world from Area equipped for irrigation drained (39218800 ha), Non-irrigated cultivated area drained (10447600 ha), Total cultivated area drained (87310530 ha), % of area equipped for full control surface irrigation drained (41.22%), % of the total cultivated area drained (15.25%), Area salinized by irrigation (37038920 ha) and % of area equipped for full control irrigation salinized (20.81%) are presented.
The World Bank/ICID (1989) assumed that in developing countries waterlogging and salinity are encountered at a significant level in about 15 million hectares of irrigated land in arid and semi-arid zones. Present data of the Drainage Working Group of the International Commission on Irrigation and Drainage (ICID) show that over 50% of the world's irrigated land has developed drainage problems (AbdelDayem 2000). In developing countries, the lack of drainage or poor drainage performance has become a critical development constraint. Besides, poorly drained fields and inadequately maintained drains favour vector-borne diseases, and create poor sanitary conditions.
Agricultural land drainage is almost completed in developed countries. However, it is not at the desired level in other countries. Drains are mainly basin drainage. How much of the published data directly agricultural drainage and how many basin drainages are not clearly shown. According to FAO statistics of 2016, Egypt 3024000 ha, India 5800000 ha, Iran 1508000, Israel 100000 ha, Mexico 5203000 ha, Pakistan 5100000 ha, Pakistan 15140000, Republic of Korea 1039000 ha, Romania 3100000 ha, and Russian Federation 5027000 ha land drainage has been completed.

4. CONCLUSIONS
The drainage systems constructed in Turkey commonly designed for precipitated regions. However, the drainage of irrigated or arid lands is quite different from the drainage of precipitated regions. Improper and wrong projects are usually implemented to remove the excess water from the root zones of the plants. Such projects commonly create water deficits. Such water deficits exert a greater pressure of freshwater resources, and then farmers are forced to use improper waters in irrigations. Also, both construction costs, operation and maintenance costs are increasing with these improper projects. Therefore, the design of drainage systems should be carried out with accurate and updated data for each region separately.
In Turkey, especially within the scope of Southeastern Anatolia Project (GAP), 145 000 ha land area opened to irrigation in Harran Plain in 1995, but 5 years after the operation of irrigation systems, water table reached to the soil surface in low elevation sections of the plain. The first drainage project of Turkey was implemented in the 1960s in Tarsus plain over 3 000 ha land area. By the end of 2015, drainage works were completed in 170 000 land area in different regions and plains. About 10000 ha are under construction and tenders were completed for drainage works of another 50000 ha. The total land area nationwide with drainage and soil reclamation problems was identified as 2358124 ha.
Drainage systems are large investments in terms of cost whether they are small-scale or basin-based. Costs vary depending on country and region conditions. Changing conditions also make it necessary to change the drainage systems. Nowadays, where water becomes scarce, installing and operating controlled drainage systems instead of classical drainage systems will be a good choice. Especially, when the groundwater quality is suitable, a great saving can be made from irrigation

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water. Also, approximately 25% of savings can be achieved from other inputs, primarily fertilizers. The use of technological smart solutions, as well as controlled drainage systems in production, is very important in ensuring sustainability. At the same time, it is also possible to increase yield and quality, while reducing production costs.

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