Climate Change



Reduction of the vulnerability of the Egyptian cropping pattern to climate change stress

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The objective of this study was to quantify the effect of climate change in 2030 on the prevailing cropping pattern, with respect to its water requirements and cultivated areas. Furthermore, testing the effect of suggested procedures, namely using water saving techniques and implementing intercropping systems on reducing the negative effects of climate change on the cultivated area of the cropping pattern in 2030 was also done. Data on the area of 16 important crops cultivated in 2014/15 were collected. Water requirements of these crops were calculated. Climate scenario RCP6.0 resulted from MIROC5 climate model was used to calculate water requirements of the cropping pattern in 2030. The results indicated that using the suggested procedures could increase the cultivated area of the current cropping pattern by 28%. The results also showed that, in 2030, the cultivated area is expected to be reduced by 10%, as a result of increasing the water requirements of the crops. Furthermore, implementing the suggested procedures in 2030 could result in an increase in the cultivated area by 29%, compared to the area under traditional cultivation. Thus, it is recommended to use the suggested procedures to reduce the losses in the cultivated area in 2030.

INTRODUCTION

Cropping pattern is the yearly sequence and spatial arrangement of crops, or of crops and fallow on a given area. It indicates the proportion of area under different crops at a point of time (Madari & Shekadar, 2015). Cropping pattern is evolved based on climate, water availability and soil for efficient use of available natural resources (Valipour, 2014). The cropping pattern in Egypt depends on five main crops, namely wheat, maize, clover, cotton, and sugarcane. Wheat and maize for flour production, clover for feed; cotton for fiber and edible oil and sugarcane for sugar production. Other crops exist in the Egyptian cropping pattern, such as cereals, legumes, fibers, forages, vegetables and fruit crops. The current cropping pattern of Egypt is known to have food gaps as a result of the steady increase in the population, in addition to the lack of land and water resources (Hafez et al., 2011). As reported by Field Crops Research Institute; agricultural Research Center, Egypt have production-consumption gap in wheat and maize, where the gap is 49 and 47%, respectively (Ouda & Zohry, 2017; 2017a). There is a gap in legume crops, especially faba been, where expansion in sugar beet cultivated area was done using the cultivated area of faba bean resulted in 73% production-consumption gap (Zohry & Ouda 2017b). There is a gap in the production of oil crops, about 97%, where the cultivated area of sunflower and soybean became very low.

Two-crop sequence cultivation, a winter crop then a summer crop, is the common field practice by the Egyptian farmers. Within a cropping

pattern, different crop systems could be implemented, such as intercropping systems (Rajesh Khavse and Chaudhary, 2019). An intercropping system is define as two or more crops share the same piece of land for a part, or for all, of their growing season (Eskandari et al., 2009). To ensure the optimum productivity in an intercropping system, the peak periods of growth of the two crops should not coincide, so that one quick maturing crop completes its life cycle before the main period of growth of the other crop starts (Parsons, 2003). In Egypt, several crops are good candidates to the main crop in an intercropping system. Sugar beet is one of them, where two intercropping systems were successfully implemented in Egypt: wheat intercropped with sugar beet (Abou-Elela, 2012) and faba bean intercropped with sugar beet (Abd El-Zaher & Gendy, 2014). Tomato, either winter or summer crop, is another good candidate for implementing intercropping system. The secondary crop in this systems modified the micro-climate for tomato, increase tomato yield (Fernandez-Munoz et al., 1995), increase water use efficiency (Pressman et al., 1997), reduced pests and diseases (Hao, 2013) and mitigating heat stress (Abdel, 2006). Additionally, sugarcane offers another unique potential for intercropping (Nazir et al., 2002), where, the secondary crop will not need extra irrigation water as it will use the applied water to sugarcane to fulfill its required irrigation water. Furthermore, implementing sugarcane intercropping systems provides extra income for farmers during the early growth stage of sugarcane (El-Gergawi et al., 2000). Fruit trees are also provide good environment for intercropping, especially young evergreen fruit tree (1-3 years old) or deciduous fruit trees. Both wheat and faba bean could be intercropped with sugarcane and under fruit trees (Zohry & Ouda, 2016). These intercropping systems, if implemented could increase food production and reduce food gaps.

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Additionally, in the old clay and new sandy soils of Egypt, irrigation application efficiency is low, which endure large water losses to the ground water. Using water saving techniques in the old clay soils and new sandy lands could be beneficial in many ways. Changing tradition method of cultivation in the old lands, from basins or on narrow furrows, to raised beds cultivation proved to reduce the applied water to crops under surface irrigation by 20-25% (Abou elenein et al., 2009, Karrou et al., 2012). Sing et al. (2010) found lower water consumption and higher wheat yield under raised beds planting than under conventional flatbeds planting due to decrease in the applied irrigation amounts. Moreover, raised beds cultivation showed reduction in seed mortality rates, and improve in soil quality (Limon-Ortega et al., 2002), which led to enhanced root growth, and higher yield (Dey et al., 2015).

In the new sandy lands, irrigation scheduling and fertigation could attain irrigation water saving. Irrigation scheduling helped in applying water in the exact time for the plant needs and result in irrigation water saving, compared to farmer practice (Taha, 2012; Mathukia et al. 2018). Furthermore, applying fertigation (application of fertilizer via irrigation water) resulted in increasing water and fertilizer use efficiency, compared to farmer practice (broadcast fertilizer on the soil then apply irrigation water) (Ibrahim et al., 2012). A saving by 23% in irrigation water was found in maize grown under drip irrigation, when irrigation scheduling and fertigation were implemented (Ouda et al, 2014). Irrigation scheduling and fertigation can attain irrigation water saving by 10% in wheat. Taha (2012) indicated that irrigation scheduling and fertigation attained irrigation water saving by 10% in wheat, compared to farmer practice. The obtained irrigation water as a result of using water saving techniques could be used in cultivating new areas under modern irrigation systems, namely sprinkler and drip systems to increase the cultivated area and food production (Emmanuel Mavhura et al. 2017; Siddartha Mandal and Binoy Chhetri, 2019).

Climate change is one of the overwhelming environmental threats that are defined as a long-term alteration in the global weather patterns, including temperature, precipitation, soil moisture, sea level, and storm activity (IPCC, 2007). The Intergovernmental Panel on Climate Change (IPCC, 2001) stated that 'water and its availability and quality, will be the main pressures on, and issues for, societies and the environment under climate change'. Accordingly, it is expected that climate change will induce disruption in food production systems in both irrigated areas and rain fed (IPCC 2013; Mandale et al. 2019). Climate change may significantly alter water availability as a result of changing temperatures and precipitation (IPCC, 2001; Ajay Kumar Singh and Pritee Sharma, 2018). Furthermore, climate change is expected to increase potential evapotranspiration due to higher temperature, solar radiation and wind speed (Abtew & Melesse, 2013), which will affect the hydrological system and water resources (Shahid, 2011; Gezu Tadesse and Moges Dereje, 2018). Ouda & Zohry (2017) indicated that, in 2030 and under climate change effect, water requirements for the cultivated crops will increase, which will result in reduction in the cultivated area and consequently in food production.

Modification in the management of the cropping pattern of Egypt should be done to face the negative effects of climate change. Water saving techniques and implementing intercropping systems could be used as adaptation strategies under climate change (Gichangi and Gatheru, 2018), where the increase in water productivity by the water saving techniques, as well as the increase in land productivity by implementing intercropping systems will compensate the loss in the productive lands under climate change. Thus, the objective of this study was to quantify the effect of climate change in 2030 on the prevailing

cropping pattern, with respect to its water requirements and cultivated areas. Furthermore, testing the effect of using water saving techniques and implementing intercropping systems on reducing the negative effects of climate change on cultivated area of the cropping pattern in 2030 was also done.

MATERIALS AND METHODS

Current cropping pattern

Data on the total cultivated area of the most important winter and summer crops grown in the governorates of the Nile Delta and Valley were collected from the Central Administration for Agricultural Economics; Ministry of Agriculture and Land Reclamation in Egypt in 2014/15. The cultivated area included the old and new lands. The old lands are represented by the area surrounding the Nile River and its soil is clayey in texture. It is irrigated with surface irrigation with low application efficiency, namely 60%. The new lands are located on the edges of the old lands in most governorates. It is characterized by having sandy soil and it is under modern irrigation systems (sprinkler or drip system) with higher application efficiency, namely 70 and 80%.

Calculation of water requirements for the current cropping pattern

The Basic Irrigation Scheduling model (BISm, Snyder et al., 2004) was used to calculate water requirements for the studied crops in the cropping pattern using weather data for the same studied year. The BISm model calculates evapotranspiration (ETo) using the Penman-Monteith equation (Monteith, 1965) as presented in the United Nations FAO Irrigation and Drainage Paper (FAO 56) by Allen et al., (1998). The model calculates crop coefficients and water consumptive use. The model schedule irrigation and calculate water requirements. Thus, the model was used to calculate water requirements for the studied crops in the current cropping pattern.

Suggested management practices n the current Egyptian cropping pattern

Two suggestions were quantified, namely using water saving techniques in both old and new lands and implementing intercropping systems. Changing cultivation method from basins or narrow farrows to raised bedsin the old lands, as well as using irrigation scheduling and fertigation in the new lands were suggested to be used tosave some of the applied irrigation water. Thus, these saved amounts of water could be used in cultivating new areas and increase the production of the cropping pattern.

Furthermore, implementing intercropping systems, where either wheat, maize, faba bean, soybean or sunflower could be intercropped with other crops in the old and new lands could increase its cultivated area through sharing the cultivated area of other crops. These intercropping systems are considered as tactics to increase the cultivated area of one crop (secondary crop) through sharing the cultivated area of the main crop. Furthermore, the two intercropped crops are using the applied water to the main crop. Under this situation, the cropped area of the secondary crop will increase by the area it will occupy from the cultivated area of the main crop (Ouda & Zohry, 2016).

Calculation of water requirements of the projected cropping pattern in 2030

Climate change scenario RCP6.0 resulted from MIROC5 climate change model was used to calculate the projected water requirements for the studied crops in the cropping pattern in 2030. The MIROC5 climate change model is available from the following web site:

http://www.ccafs.cgiar.org/marksimgcm#.Ujh1gj-GfMY. The model is one of the CMIP5 Genral Circulation Models developed by Atmosphere and Ocean Research Institute (The University of Tokyo), National Institute for Environmental Studies, and Japan Agency for Marine-Earth Science and Technology. The model has a horizontal resolution equal to 1.40° x 1.40°. BISm model was used to calulate the water requirements of the cropping pattern.

Calculation procedure

- We assumed that changing the cultivation method for all the crops cultivated in the current cropping pattern in the old lands to raised beds cultivation will result in 15% saving in the applied irrigation water to them.
- 2. We assumed that sugarcane will be irrigated using gated pipes and fruit trees will be irrigated using drip system to attain 15% saving in the applied irrigation water to both sugarcane and fruit trees.
- 3. We assumed that implementing irrigation scheduling and fertigation in the new lands could result in water saving by15%.
- 4. We assumed that these amounts of water will be used in cultivating new lands. Thus, we calculated these areas and added it to the area of the current cropping pattern.
- 5. We suggested to implement intercropping systems to increase the cultivated area of wheat, maize, faba bean, soybean, and sunflower, without using extra irrigation water. The purpose of doing that is to create additional area to cultivate these crop through sharing other crops in their cultivated area.
- 6. To quantify the effect of implementing intercropping systems on the current cropping pattern, we used data previously published in the literature (Table 1).
- We used the values of the potential added area of these five crops presented in Table (1) and added it to its area of the current cropping pattern.
- 8. We also assumed that, in 2030 under climate change, similar cropping pattern to the one existed in 2015 will be cultivated.
- We assumed that the allocated water to the cropping pattern in 2030 will be the same as its counterpart value of the current cropping pattern, as a result of limited water resources in Egypt.
- 10. The increase in the water requirements of the studied crops were calculated, as well as the reduction in the cultivated area. Then, we calculated the cultivated area under climate change
- 11. We followed the above procedure in calculating the added area under climate change using water saving techniques and intercropping systems.

RESULTS AND DISCUSSION

Effect of using water saving techniques on the current cropping pattern

Table (2) presented the cultivated area of the current cropping pattern and its water requirements. The table showed that the total cultivated area of winter and summer crops in the studied year of 2014/15 was 6,296,944 hectares and it required 62,323,656,063 m³ of irrigation water. The table also presented the potential cultivated area as a result of using water saving techniques in the old and the new lands. The results indicated that 9,348,548,409 m³ of irrigation water could be saved. This amount of water was invested in irrigating new lands equal to 944,542 hectares, which could increase the total cultivated area to 7,241,488 hectares (Table 2).

Furthermore, implementing intercropping systems could be a good solution to reduce production-consumption gaps for wheat, faba bean,

maize, soybean, and sunflower. Table (3) indicated that an increase by 23 and 9% in the cultivated area of wheat and maize respectively could be attained by implementing intercropping systems, compared to its values presented in Table (2) under current cropping pattern. A very high increase in the cultivated area of faba bean, soybean and sunflower equal to 611,878 and 1267%, respectively could occur, compared to its value in Table (2) under current cropping pattern. These high values resulted from the intercropping faba bean, soybean, and sunflower on crops cultivated in large areas, such as sugar beet, maize, and tomato, respectively. These huge increases can diminish the existed production-consumption gaps in these three crops.

Under this situation, the potential national cultivated area can be increase to reach 7,100,386 hectares. Table (3) also showed that the potential total cultivated area could be increased to reach 8,044,928 hectares, with 28% increase, if water saving techniques and intercropping systems were implemented compared to its value in Table (2) under current cropping pattern.

Similar results were obtained by Zohry & Ouda (2018), where they indicated that implementing intercropping systems, raised beds cultivation, and cultivation of three crops per year increase the total cultivated area by 35%.

The projected cropping pattern under climate change

Table (4) showed that the lowest percentage of increase in the crop water requirements of winter crops could be found for faba bean and the highest percentage of increase could be found for onion. With respect to summer crops, percentage of increase in crop water requirements will be higher than its counterpart in winter crops, with the highest value will be exist for tomato. Similar results were obtained by Zohry & Ouda (2018), with respect to the expected increase in the water requirements of these crops under climate change. Furthermore, Morsy & Ouda (2018) indicated that an increase in water consumptive use for several crops in 2030 in Egypt will occur. An expected increase in the water requirements of crops was also found in Al-Jouf region in Saudi Arabia, where Chowdhury et al., (2016) concluded that water requirements for the cultivated crops are expected to increase in 2050. Therefore, these expected increases in water demand for agriculture should be met by implementing water conservation practices instead of flooding methods.

On the contrary, reduction in the cultivated area in Egypt is expected to occur under the effect of climate change due to the unavailability of extra water resources to fulfill the higher water demand for irrigation and fixed amount of allocated water to agriculture. Thus, it can be noticed from Table (4) that the highest reduction in the cultivated area can be occur for winter and summer tomato. Furthermore, the total cultivated area of winter and summer crops will be reduced by 10%, compared to its value in Table (2). Similar assessment was done by Ouda & Zohry (2018), which revealed that 16% decrease in the cultivated area of Egypt is expected under climate change.

Reduction in the losses of productive lands under climate change

Although there is an expected losses in the cultivated area in 2030, using the suggested water saving techniques could still save a portion of the applied irrigation water to be used in cultivated new lands. Table (5) indicated that, in 2030, the potential added area will be lower than its counterpart values in 2015 by 11% (Table 2). Furthermore, implementing both water saving techniques and intercropping systems could result in an increase in the cultivated area by 29%, compared to traditional cultivation under climate change (Table 4). Furthermore, the cultivated area in 2030 will be lower by 10% (Table 5), compared to its

Table 1 Potential increase in the cultivated area of five crops using different intercropping systems

Intercropping system	Main crop	Reference	Potential added area (ha)	Reference
	Tomato	Abd El-Zaher et al., (2013)		
Wheat intercropped	Sugar beet	Abou-Elela (2012)	305,735	Ouda & Zohry (2016)
with	Cotton	Zohry (2005)	303,733	
WILLI	Sugarcane	Ahmed et al., (2013)		
	Fruit trees	Ouda & Zohry (2016)		
	Soybean	Sherif and Gendy (2012)		
Maize intercropped	Cowpea	Hamd-Alla et al., (2014)		Zohry & Ouda (2016a)
with	Tomato	Mohamed et al., (2013)	79,887	
	Peanut	Abd El-Zaher et al., (2007)		
	Potato	Ibrahim (2006)		
	Tomato	Ibrahim et al., (2010)		
Faba bean	Sugar beet	Abd El-Zaher and Gendy (2014)	210,306	Zohry & Ouda
intercropped with	Sugarcane	Farghly, (1997)	210,300	(2016b)
	Fruit trees	Zohry and Ouda (2016b)		
Soybean	Sorghum	Abou-Keriasha et al (1997)		
intercropped with	Sugarcane	Eweida et al., (1996)	124,068	Zohry & Ouda (2019)
intercropped with	Fruit trees	Zohry & Ouda (2019)		
Sunflower	Tomato	Abdel (2006)		
intercropped with	Sugarcane	El-Gergawi et al., (2000)	83,444	Zohry & Ouda (2019)
intercropped with	Fruit trees	Zohry & Ouda (2019)		

Table 2 The total cultivated area under the current cropping pattern in 2014/15 and its potential counterpart value under using water saving techniques

	Current cropping pattern		Potential cropping pattern under water saving techniques		
	Cultivated area (ha)	Water requirements (m³)	Saved water amount (m³)	Add area (ha)	Total cultivated area (ha)
Winter crops					•
Wheat	1,354,844	8,825,826,373	1,323,873,956	203,227	1,558,071
Faba bean	34,418	178,997,045	26,849,557	5,163	39,581
Clover	624,741	5,948,296,442	892,244,466	93,711	718,452
Onion	148,173	1,244,936,988	186,740,548	22,226	170,399
Tomato	70,173	347,661,962	52,149,294	10,526	80,699
Potato	102,285	339,729,364	50,959,405	15,343	117,628
Sugar beet	231,193	1,955,202,088	293,280,313	34,679	265,872
Others	680,278	2,858,335,063	428,750,259	102,042	782,320
Total	3,246,104	21,698,985,326	3,254,847,799	486,916	3,733,021
Summer crops					
Cotton	100,349	1,264,924,487	189,738,673	15,052	115,401
Rice	506,249	5,896,134,782	884,420,217	75,937	582,186
Maize	938,329	9,259,942,383	1,388,991,357	140,749	1,079,078
Soybean	14,130	147,263,643	22,089,546	2,120	16,250
Sunflower	6,585	48,883,220	7,332,483	988	7,573
Potato	53,110	385,322,673	57,798,401	7,967	61,077
Tomato	89,825	824,943,808	123,741,571	13,474	103,299
Cowpea	516	1,032,000	154,800	77	593
Sugarcane	134,656	4,271,214,589	640,682,188	20,198	154,854
Fruit trees	524,763	9,789,068,856	1,468,360,328	78,714	603,477
Others	682,329	8,735,940,296	1,310,391,044	102,349	784,678
Total	3,050,840	40,624,670,737	6,093,700,611	457,626	3,508,467
Grand total	6,296,944	62,323,656,063	9,348,548,409	944,542	7,241,488

Table 3 The potential total cultivated area of the current cropping pattern, using water saving techniques and implementing intercropping systems

	Potential total area under surface irrigation and	Potential total area under water saving techniques and
	intercropping systems (ha)	intercropping systems (ha)
Winter crops	11 9 2	11 9 /
Wheat	1,660,579	1,863,806
Faba bean	244,724	249,887
Clover	624,741	718,452
Onion	148,173	170,399
Tomato	70,173	80,699
Potato	102,285	117,628
Sugar beet	231,193	265,872
Others	680,278	782,320
Total	3,762,146	4,249,062
Summer crops		
Cotton	100,349	115,401
Rice	506,249	582,186
Maize	1,018,216	1,158,965
Soybean	138,198	140,318
Sunflower	90,029	91,017

Potato	53,110	61,077	
Tomato	89,825	103,299	
Cowpea	516	593	
Sugarcane	134,656	154,854	
Fruit trees	524,763	603,477	
Others	682,329	784,678	
Total	3,338,240	3,795,866	
Grand total	7,100,386	8,044,928	

Table 4 Expected percentage of increase in the water requirements of the current cropping pattern, expected percentage of reduction in its cultivated area and expected total cultivated area in 2030.

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	Expected increase in water requirements (%)	Expected reduction in the cultivated area (%)	Expected cultivated area (ha)
Winter crops	1 1 2 2 1 (1 2)	()	
Wheat	7	5	1,260,005
Faba bean	4	6	33,041
Clover	9	8	568,514
Onion	13	9	128,911
Tomato	8	11	64,559
Potato	6	5	96,148
Sugar beet	8	6	212,698
Others	10	9	612,250
Total			2,976,126
Summer crops			
Cotton	17	12	83,290
Rice	12	16	445,499
Maize	19	15	760,046
Soybean	16	15	11,869
Sunflower	17	17	5,466
Potato	16	17	44,612
Tomato	20	18	71,860
Cowpea	17	14	428
Sugarcane	16	21	113,111
Fruit trees	11	12	467,039
Others	7	5	634,566
Total	-	-	2,637,787
Grand total	-	-	5,613,913

Table 5 The potential total cultivated area for the projected cropping pattern, using water saving techniques and implementing intercropping systems in 2030.

	Projected cropping pattern in 2030			
	Under water	saving techniques	Under intercropping systems	Potential total
	Potential	Potential total	Potential cultivated	cultivated area (actual
	add area	area (actual +	area (actual + added)	+ added) (ha)
	(ha)	added) (ha)	(ha)	
Winter crops				
Wheat	189,001	1,449,006	1,577,550	1,766,551
Faba bean	4,956	37,997	230,041	234,997
Clover	85,277	653,791	574,762	660,039
Onion	19,337	148,247	134,837	154,174
Tomato	9,684	74,243	62,454	72,138
Potato	14,422	110,570	97,171	111,593
Sugar beet	31,905	244,602	217,321	249,226
Others	91,838	704,088	619,053	710,891
Total	446,419	3,422,545	3,513,189	3,959,608
Summer crops				
Cotton	12,493	95,783	88,307	100,801
Rice	66.825	512,324	105 010	492,074
	00,020	312,324	425,249	492,074
Maize	114,007	874,053	865,484	979,491
Maize Soybean	,	· · · · · · · · · · · · · · · · · · ·		
	114,007	874,053	865,484	979,491
Soybean	114,007 1,780	874,053 13,650	865,484 117,468	979,491 119,249
Soybean Sunflower	114,007 1,780 820	874,053 13,650 6,285	865,484 117,468 74,724	979,491 119,249 75,544
Soybean Sunflower Potato	114,007 1,780 820 6,692	874,053 13,650 6,285 51,304	865,484 117,468 74,724 44,081	979,491 119,249 75,544 50,773
Soybean Sunflower Potato Tomato	114,007 1,780 820 6,692 10,779	874,053 13,650 6,285 51,304 82,639	865,484 117,468 74,724 44,081 73,657	979,491 119,249 75,544 50,773 84,436
Soybean Sunflower Potato Tomato Cowpea	114,007 1,780 820 6,692 10,779 64	874,053 13,650 6,285 51,304 82,639 493	865,484 117,468 74,724 44,081 73,657 444	979,491 119,249 75,544 50,773 84,436 508
Soybean Sunflower Potato Tomato Cowpea Sugarcane	114,007 1,780 820 6,692 10,779 64 16,967	874,053 13,650 6,285 51,304 82,639 493 130,078	865,484 117,468 74,724 44,081 73,657 444 106,378	979,491 119,249 75,544 50,773 84,436 508 123,345
Soybean Sunflower Potato Tomato Cowpea Sugarcane Fruit trees	114,007 1,780 820 6,692 10,779 64 16,967 70,056	874,053 13,650 6,285 51,304 82,639 493 130,078 537,095	865,484 117,468 74,724 44,081 73,657 444 106,378 461,791	979,491 119,249 75,544 50,773 84,436 508 123,345 531,847

value of the current cropping pattern under implementing water saving techniques and intercropping systems (Table 3).

CONCLUSION

This study quantified the effect of procedures to be done to increase the cultivated area of the current cropping pattern through implementing techniques to save some of the applied water to the cultivated crops and use these amounts of water to cultivate new areas. Furthermore, the effect of another technique on increasing the cropped area of the current cropping pattern, namely using intercropping systems was quantified. The results indicated that both water saving techniques and intercropping systems could increase the cultivated area of the cropping pattern. Our results also indicated that these procedures could be successful in increasing the area of the cultivated crops in the expected cropping pattern in 2030. Furthermore, these procedures could be helpful in reducing the losses in the cultivated area, as a result of increasing water requirements of the cultivated areas and limited water resources in 2030. Thus, it is recommended to use the suggested water saving techniques and intercropping systems to increase the cultivated area of the current cropping pattern and to reduce the losses in the cultivated area in 2030 under climate change.

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