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Expanding the Irrigated Areas in the MENA and Central Asia: Challenges or Opportunities?

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Abstract: Middle Eastern, North African countries (MENA), and Central Asian countries are considered the countries most facing water and food scarcity. The current water exploitation indicates that a few countries are overexploiting their water resources and using the fossil water available. This study reviews each country's renewable water resources volume and evaluates the resources available to expand the agricultural area. Different scenarios are considered, using both irrigated and rainfed farming options, for concluding the most sustainable farming method in each country. Different scenarios are considered using irrigated and rainfed farming options to recommend the most sustainable farming method for each country. Results show that the countries in the MENA and Central Asia can be divided into three main categories: (1) Countries whose expansion of agricultural area can only be applied by using fossil water resources (Bahrain, Egypt, Kuwait, Libya, Qatar, Saudi Arabia, Turkmenistan, United Arab Emirates, and Uzbekistan); (2) Countries where the agricultural area can be expanded to a certain limit, by sustainably using both irrigated and rainfed farming (Afghanistan, Algeria, Iran, Palestine, Jordan, Kazakhstan, Morocco, Oman, Syria, Tajikistan, Tunisia, and Yemen); (3) Countries that have enough renewable water resources to farm all their agricultural area (Lebanon, Iraq, Turkey, and Kyrgyzstan). However, the aim of this study and its results are only to assess the renewable water resources available to sustain the increased agricultural water demand by setting aside other agricultural factors that constrain the sector.

Keywords: sustainability; agriculture; FAO; water resources management; arid and semi-arid climatic zones

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1. Introduction

The world's population is overgrowing, introducing constant stress on water and agricultural resources [1]. The Millennium Development Goals launched in 2000 have set goals to decrease world poverty and hunger by 2015 [2]. Since then, much has been achieved; still, more effort must be made to ease the effects of population growth, especially in Africa and Asia. According to Hadebe et al., in the last 50 years, our water and calories intake increased three times, leading to overexploitation of the water resources, especially in arid climatic zones [3]. Still, increasing the farming yield can cover the food shortage by suitable agricultural water management means, increasing the farmed area, and improving the production per unit area. Since the mid-20th century, the total crop production area has hardly changed from about 1.5 billion hectares (ha) [4]. Still, food production has witnessed spectacular growth, exclusively employing improving agricultural productivity. Technology and research have developed crop varieties to take full advantage of the climate and soil fertilization. As most crop water demand is met by rainfall, irrigation applications in areas where the rainfall is insufficient will help meet the crop water requirements in the growing season. Irrigation restores the water loss for direct evaporation, crop evapotranspiration, and surface run-off.

Middle Eastern, Northern African, and Central Asian countries are likely the most affected areas with water limitations resources areas facing critical water resources issues, limiting the input to food security, and economic and social development [5–7]. Overall, 70 percent of these countries' areas are arid and semi-arid (less than 250 mm annual rainfall), and the rest receive a moderated rainfall volume of 300 to 600 mm [8]. However, water supply seems insufficient to follow the pace of economic growth and population, whereas the annual water supply per capita is expected to drop from 1000 to 600 cubic meters in the Middle East by 2025 [9]. Therefore, the exploitation of new water resources will become unjustifiable economically and technically due to the increasing number of contaminants in the surface and groundwater resources. These water shortages lead to crucial triggers for both internal and international conflicts. Many MENA and Central Asia countries have mobilized their water resources, especially in the second half of the 20th Century. These countries are entering a critical phase, as most countries are overexploiting their resources [10]. With the widespread pollution and salinity, building dams and extracting groundwater are becoming scarcer [11]. These conditions shift the attention to managing water resources in the most sustainable way, especially in the agricultural sector. As the agricultural sector is the leading water consumer, water conservation in agriculture is the main target for most management plans.

For that, and as most MENA and Central Asian countries face water scarcity and food insecurity, this study aims to review renewable water availability, which is the annual rechargeable water volumes due to the hydrological cycles, in these countries for agricultural expansion. The agricultural hectare water requirement for each country will be calculated based on local farming data to define the possible expansion of farmed areas in the MENA and Central Asian countries. The sustainability of this expansion will also be evaluated based on the available renewable water resources. It is essential to mention that this study only assesses the availability of renewable water resources to sustainably cover the increased agricultural water demand by setting aside the other agricultural factors that also constrain the sector.

2. Methodology

2.1. Current Situation and Data Used

This study consists of 25 countries forming the Middle East, Northern Africa, and Central Asia (Table 1). The data collected for renewable water resources, farmed area, available area to be farmed, crop yields, and agricultural GDP are the average of data collected by the Food and Agriculture Organization (F.A.O) for 30 years between 1990 and 2020. As all countries vary in their surface area and renewable water resources, and for comparison, the available renewable water resources in each country can be expressed as:

$$R_{WR} = \frac{T_{WR}}{A} \quad (1)$$

where R_{WR} is the renewable water resources volume in millimeters (mm), T_{WR} is the total renewable water resources in cubic kilometers (km^3), which is the summation of the renewable surface water resources (R_{SW}) and the renewable groundwater resources (R_{GW}), and A is the given country area. The current renewable water volume and other agricultural and economic variables in different MENA and Central Asian countries are detailed in Table 1.

Table 1. The current water and agricultural situation of MENA and Central Asian Countries. R_{SW}: renewable surface water resources, R_{GW}: renewable groundwater resources, R_{WR}: total renewable water resources volume, A_{WU}: annual total renewable water volume, A_L: agricultural land, A_{LP}: plausible agricultural land, R/I_{CY}: rainfed per irrigated crop yield, A_{GDP}: agricultural gross domestic product (GDP), I_{GVA}: irrigated gross value added in agricultural GDP [12,13]. In the region column, ME: Middle East, NA: Northern Africa, CA: Central Asia.

Country	Region	R_{SW} (km^3)	R_{GW} (km^3)	R_{WR} (mm)	A_{WU} (km^3)	A_L (1000 ha)	A_{LP} (1000 ha)	R/I_{CY}	A_{GDP} (%)	I_{GVA} (%)
Algeria	NA	10.15	1.52	4.90	2.7	41,456	41,432,000	2.2	12	20
Bahrain	ME	0.004	0.112	151.63	0.2	8.6	4365	1.77	0.3	92.4
Egypt	NA	56	2.3	57.72	54.3	3790	75,000	-	11.5	100
Iran	ME	105.8	49.3	94.11	64.6	45,954	27,847,000	2.5	9.5	73.4
Iraq	ME	88.58	3.28	210.17	39.6	9250	3,240,000	2.2	3	57.3
Palestine	ME	0.555	1.225	80.38	1.0	534	231,300	1.9	1.2	49.1
Jordan	ME	0.65	0.54	13.32	0.7	1056	751,800	1.77	5.5	54.4
Kuwait	ME	0.19	0.02	11.79	0.3	150	142,000	-	0.5	100
Lebanon	ME	3.803	3.2	670.02	0.9	658	476,000	1.85	3	66.1
Libya	NA	0.2	0.6	0.45	3.3	15,350	13,630,000	2.67	0.8	39.7
Morocco	NA	22	10	71.66	11.2	30,047	22,591,400	1.8	12.3	28.6
Oman	ME	1.05	1.3	7.59	1.2	1434	1,382,230	-	2.1	100
Qatar	ME	0.2	0.058	22.30	20.7	68	60,600	-	0.2	100
Saudi Arabia	ME	2.2	2.2	2.05	16.2	173,635	172,192,000	-	2.5	100
Syria	ME	12.63	6.174	101.54	14.8	4662	81,79,000	2.07	20.6	38.6
Tunisia	NA	3.42	1.595	30.65	2.2	9834	7,136,000	1.77	9.6	16.6
Turkey	ME	171.8	67.8	305.78	26.7	38,551	11,196,000	2.14	6	26
UAE	ME	0.15	0.12	3.23	2.5	383	126,832	-	0.78	100
Yemen	ME	5.3	1.5	6.31	2.7	23,433	22,198,812	2.34	19	59
Afghanistan	CA	55.68	10.65	101.60	19.9	37,910	30,009,000	2.1	24	44.5
Kazakhstan	CA	100.6	33.85	49.34	15.1	217,161	192,556,500	1.77	4.5	6.9
Kyrgyzstan	CA	21.15	13.69	174.29	7.1	10,611	9,190,300	1.77	12.5	84.1
Tajikistan	CA	18.91	6	174.07	10.4	4755	3852,700	-	21.2	90.3
Turkmenistan	CA	24.36	0.405	50.42	26.3	34,000	31,898,000	-	8.7	100
Uzbekistan	CA	42.07	8.8	113.30	54.3	25,598	20,926,700	1.77	30	90

2.2. Calculating the Irrigation and Rainfed Hectare Annual Water Demand

The irrigation water demand depends on precipitation volume, potential evapotranspiration, and soil moisture. As these factors may vary annually in each country, the irrigation water demand per hectare is assumed from the CropWat software, based on the 30 years average based on the FAO database. The irrigation consumptive water volume is expressed as

$$I_{CU(Mod)} = ET_C - P - D_S \tag{2}$$

where $I_{CU(Mod)}$ is the consumptive irrigation water used for the crop demand (mm), ET_C is the potential crop evapotranspiration (mm), P is the effective precipitation (mm), and D_S is the change in soil moisture between the start and end of the irrigation period (mm). In this study, $I_{CU(Mod)}$ is calculated by using the CropWat software provided by FAO. Another irrigation consumptive water requirement is calculated from the actual irrigated farmed area and the annual irrigation water consumption. The irrigated farmed area and the annual irrigation consumption data used are the average for each country in the period between 1990 and 2020 and are expressed as

$$I_{CU(Act)} = \frac{A_{WUI}}{A_{LI}} \tag{3}$$

where $I_{CU(Act)}$ is the actual irrigation water consumption per hectare (m^3/ha), A_{WUI} is the irrigation water consumption (m^3) in a given year, and A_{LI} is the irrigated agricultural area (ha) in the same year. I_{CU} used in the calculation is the average between $I_{CU(Mod)}$ and the $I_{CU(Act)}$.

Similarly, especially in droughts and low precipitation volume, farmers tend to irrigate the rainfed farmed areas to ease the severity of the crop evapotranspiration. This rainfed irrigation volume varies annually, so an average of the rainfed irrigation volume for 30 years between 1990 and 2020 is used. The rainfed irrigation volume is expressed as

$$R_{CU(Act)} = \frac{(A_{WU} - A_{WUI})}{(A_L - A_{LI})} \quad (4)$$

where $R_{CU(Act)}$ is the rainfed irrigation demand per hectare (m^3/ha) in a given year, A_{WU} is the total agricultural water consumption (m^3), A_{WUI} is the irrigation water consumption (m^3), A_L is the total farmed area (ha), A_{LI} is the irrigated farmed area in that year (ha).

2.3. Expanding the Farmed Area Scenarios and Classification

Expanding the plausible agricultural area can happen by either irrigation or rainfed farming or merging both methods. To assess the sustainability of each farming scenario, a new agricultural water demand (N_{AWD}) is calculated:

$$S_1: N_{AWD} = (I_{CU})(A_{LP}) + A_{WU} \quad (5)$$

$$S_2: N_{AWD} = (I_{CU})(A_{LP})(\%I) + (R_{CU})(A_{LP})(\%R) + A_{WU} \quad (6)$$

$$S_3: N_{AWD} = (R_{CU})(A_{LP}) + A_{WU} \quad (7)$$

where S_1 expands the plausible agricultural area using irrigation farming, S_2 uses a merge of irrigated and rainfed farming, and S_3 uses rainfed farming. Here, (%I) and (%R) are the current agricultural land irrigated or rainfed. The new water demand (N_{AWD}) when compared to the renewable surface (R_{SW}) and groundwater resource (G_{SW}), a classification of the sustainability of the resource usage can be developed (Table 2).

Table 2. Country classification based on the current and new water demand, compared to the renewable surface and groundwater resources [14].

	NAWD ≤ RSW and $N_{AWD} \leq R_{GW}$	New water demand is less than both renewable surface and groundwater resources. Expansion is sustainable.
	$N_{AWD} \leq R_{SW}$ and $N_{AWD} > R_{GW}$	New water demand is less than renewable surface water resources but larger than renewable groundwater resources. Expansion is partially sustainable.
	$N_{AWD} > R_{SW}$ and $N_{AWD} \leq R_{GW}$	New water demand is larger than renewable groundwater resources but larger than renewable surface resources. Expansion is partially sustainable.
Class IV	$N_{AWD} \leq (R_{SW} + R_{GW})$	New water demand is less than the summation of surface and groundwater resources. Expansion is partially sustainable.
	$N_{AWD} > (R_{SW} + R_{GW})$ and $C_{AWD} < (R_{SW} + R_{GW})$	New water demand is larger than the summation of the renewable surface and groundwater resources, but the current water demand is lower. Expansion is unsustainable.
Class VI	$C_{AWD} > (R_{SW} + R_{GW})$	Current water demand is higher than the summation of renewable surface and groundwater resources. Fossil water resources, which are the overexploited nonrenewable water resources, are currently used.

3. Results

The MENA and Central Asian countries have diverse renewable water resources and water resources exploitation. Regarding the total renewable water availability (Equation (1)), Lebanon (670 mm), Turkey (305 mm), and Iraq (210 mm) are considered to be the countries with the highest renewable water volume. In contrast, UAE (3 mm), Saudi Arabia (2 mm), and Libya (0.5 mm) are considered the countries with the lowest renewable water volume. By FAO definition, any country with renewable water volume less than 100 mm, is considered arid in these resources. This applies to Iran, Palestine, Morocco, Egypt, Turkmenistan, Kazakhstan, Tunisia, Qatar, Jordan, Kuwait, Oman, Yemen, Algeria, UAE, Saudi Arabia, and Libya. Still, renewable water resource aridity does not affect the sustainable exploitation of these resources.

Currently, Libya, Egypt, Saudi Arabia, Kuwait, Qatar, Bahrain, UAE, Turkmenistan, and Uzbekistan have a higher water exploitation rate than the water renewability rate (Figures 1 and 2). Except for Uzbekistan (renewability rate of 113 mm), all these countries are considered arid countries regarding their water resources renewability. For example, Egypt considered a wealthy country regarding its surface water (56 km^3 annually), still overexploits these resources in agricultural usage (61 km^3 annually). Other countries with severe water renewability aridity Algeria (4.9 mm), Yemen (6.3 mm), Oman (7.6 mm), and Jordan (13.3 mm) are managing to keep their agricultural water exploitation sustainable. Tunisia, Syria, and Palestine are still agricultural water usage are currently almost exploiting all their renewable water resources, both surface and groundwater combined. In the rest of the MENA and Central Asian countries, agricultural water exploitation is sustainable.

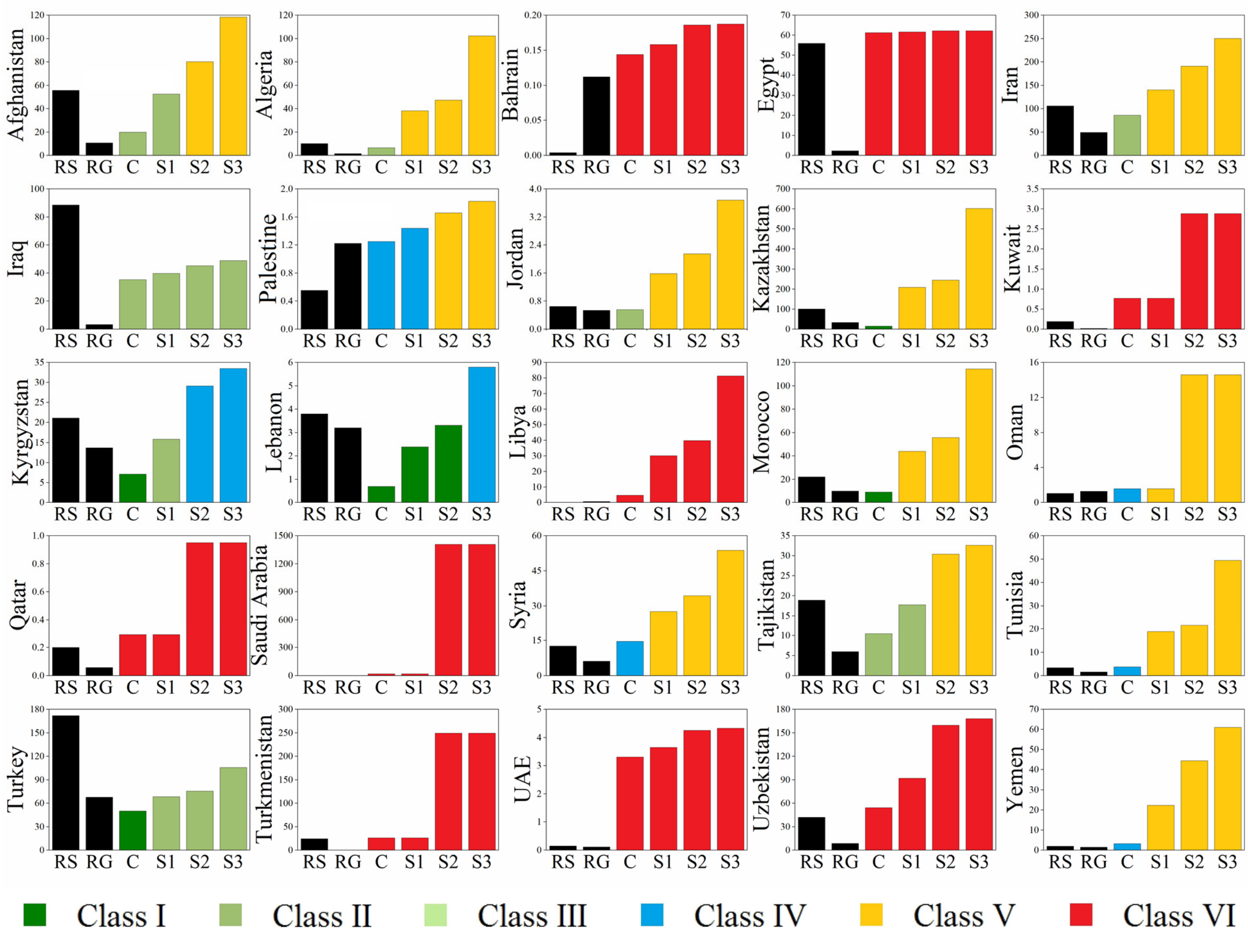

Figure 1. The current surface and groundwater renewability rate in MENA and Central Asian countries (km^3). The figure also shows the current agricultural water demand and the three farming scenarios water demand for each country. R_S: renewable surface water (km^3), R_G: renewable groundwater (km^3), C: current agricultural water consumption (km^3), S_1, S_2, and S_3 are scenarios 1, 2, and 3 water demand in (km^3), respectively.

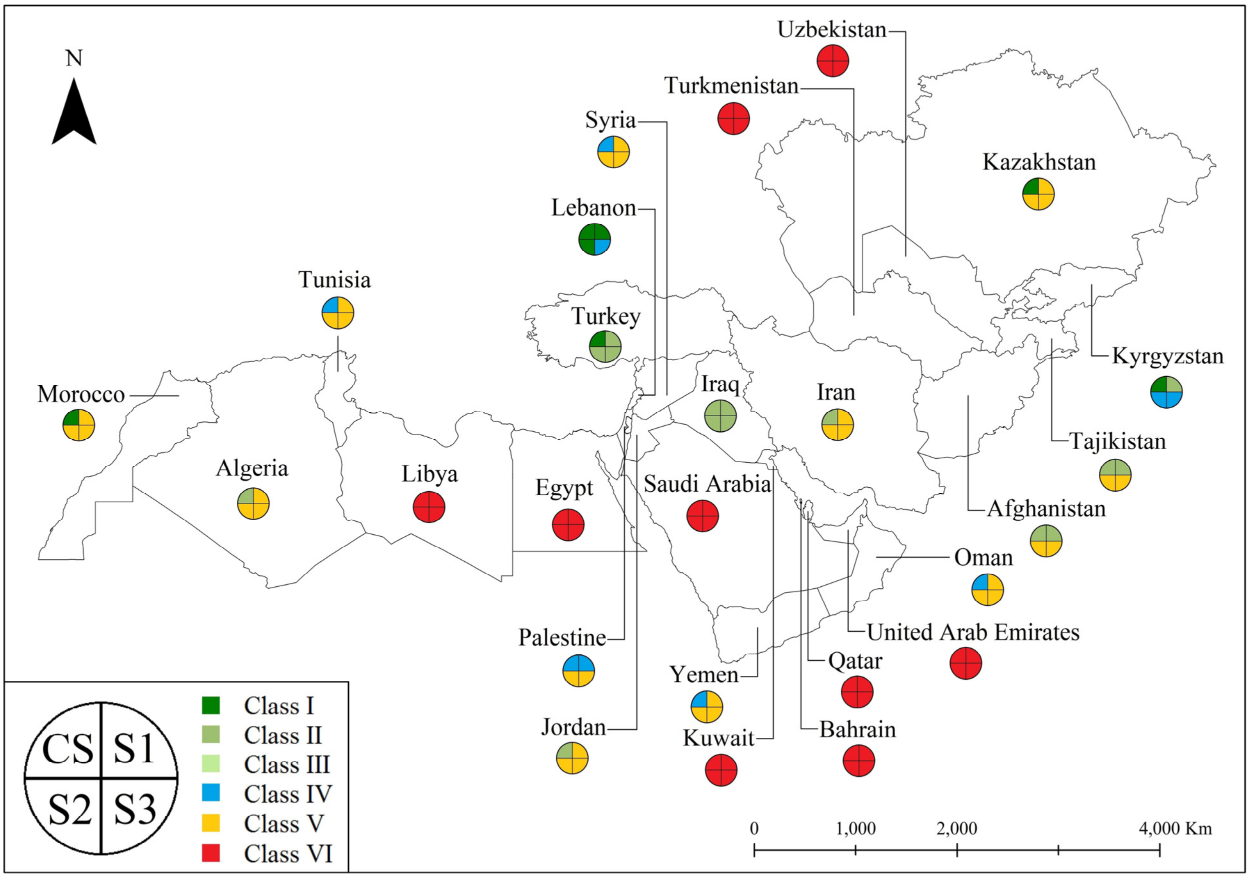

Figure 2. MENA and Central Asian countries, with their current renewable water exploitation rate. The figure also shows the three farming scenarios' water requirement classifications. CS is the current situation, S1, S2, and S3 are the classification for scenarios 1, 2, and 3 in each country, respectively.

Regarding expanding the agricultural area, only Lebanon (670 mm of renewable annual water resources), Turkey (306 mm), Iraq (210 mm), and Kyrgyzstan (174 mm) have the available renewable water resources for farming the plausible agricultural land. Lebanon is the only country that can balance between exploiting the surface water resource (364 mm) or its groundwater resources (307 mm). Afghanistan, Tajikistan, and Palestine can fully expand the plausible agricultural area using rainfed farming. These countries have the available water resources to expand the irrigated farmed areas but not entirely. Iran, Kazakhstan, Syria, Tunisia, Algeria, Morocco, Jordan, Yemen, and Oman can expand their farmed area by either irrigated or rainfed farming to some extent, but reaching total capacity will lead to unsustainable exploitation of the renewable water resources. Syria, Yemen, Oman, and Palestine are already using either surface or groundwater resources unsustainably. In the rest of the countries mentioned above, which are currently using their water resources unsustainably, any increase in the farmed areas will decrease the surface water volumes and groundwater tables, as these countries are currently using all their renewable resources and fossil water.

4. Discussion

The current water consumption rates in the MENA and Central Asian countries, and the agricultural expansion water demand, show that the countries of these regions belong to three categories and are more diverse in their renewable water resources than other regions [11,15]. These categories can be divided as countries that can maintain sustainable agricultural expansion (Lebanon, Turkey, Iraq, and Kyrgyzstan); countries that can maintain the sustainable agricultural expansion to some limit (Morocco, Algeria, Tunisia, Iran, Palestine, Yemen, Jordan, Syria, Kazakhstan, Tajikistan, Afghanistan, and

Oman); and countries that are already in the unsustainable water usage for agriculture, and are already using their fossil surface and groundwater resources (Libya, Egypt Saudi Arabia, Turkmenistan, Uzbekistan, Kuwait, Bahrain, Qatar, and UAE). The irrigation exploitation compared to renewable water resources is the highest globally (2450% in Kuwait, 2200% percent in UAE, 870% in Saudi Arabia, 512% in Libya, and 450% in Qatar compared to renewability rate) [13]. Thus, at least in these countries with high-water stress, where the water exploitation is higher than that renewability rate, any expansion in the irrigated areas must depend on strategies that maintain the sustainability of the water resources.

Countries that fall under the three main categories within the MENA and Central African region call for some governmental measures to sustain the currently available water resources while being open to innovative techniques for the agricultural sector. Governments should develop clear policies to protect the remaining water resources by looking into new opportunities to either encourage farmers to substitute crops with varieties that need less water consumption or by introducing new irrigation techniques such as: drip irrigation [15], wastewater reuse [16], deficit irrigation [17], or switching to another type of horticulture which is hydroponic. MENA and Central African countries should take advantage of their geographic position that can decrease the expenses of crops transportation logistically. They can sign agreements to facilitate the import/export of needed or exceed crops. In this way, they can fulfill their food security needs without stressing over the remaining and/or available water resources.

Since they are considered the backbone of any society, farmers should be sensitized to the impact of water depletion in the countries that fall under the third scenario. These farmers should be trained and oriented to be more open by switching to crops that require less water and reconsidering all the options before expanding their planting areas. They also should be trained to use new equipment, such as soil moisture sensors and irrigation planning software, in order to avoid excessive and unnecessary use of water, to increase water saving and to improve water consumption, crop yield, and water resources management in general. However, water depletion is an alarming fact that can negatively impact the agricultural sector and go beyond other sectors such as transportation, agri-food factories, tourism, industries, population growth, etc.

Services sectors such as coffee shops, restaurants, tourism, and hotels rely on water to operate, and due to water depletion, losses can be found in the national economies and GDP. Unemployment rates can increase in some countries. This can be explained by the fact that decreasing water resources could lead to some challenges in expanding agricultural activities, thus decreasing market labor demand. Poverty levels and consumers price indexes could rise sharply due to the increase in crop prices. Low-income consumers will become more sensitive as they spend a high share of their incomes on staple foods. Water depletion's outcomes can lead to some coping mechanisms that threaten ecosystems. Farmers tend to expand and switch from irrigated croplands to rainfed ones at the expanse or natural habitats and forests.

Water availability is crucial in expanding the farmed area in any given country, but other factors are still considered essential, especially when it comes to economic revenue [18,19]. In countries with a high contribution of agriculture to the GDP (Uzbekistan 30%, Afghanistan 24%, Tajikistan 21.2%, Syria 20.6%, and Yemen 19%) [13], the expansion of the farmed area can be justified by economic reasons, particularly when the irrigation Gross Value Added (GVA) is high (such as Uzbekistan 90%, Tajikistan 90%, and Yemen 60%) [13]. In those countries, the expansion of the farmed areas by irrigation directly and significantly contributes to the economy. In other countries (Bahrain, Egypt, Kuwait, Oman, Qatar, Saudi Arabia, UAE, and Turkmenistan), the irrigation GVA is 100% [13], as rainfed farming is not possible in these countries. In countries with lower irrigation GVA (Kazakhstan 6.9%, Tunisia 16.6%, Algeria 20%, and Turkey 26%) [13], it seems more reasonable to expand the rainfed farming in these countries, as the economic revenue is low when compared to the irrigation systems costs and the increase in water usage.

One of the main objectives of increasing the farmed area in any country is providing more products to suffice the local market needs. Increasing the production rate becomes a priority in any community if the unnourished population rate becomes high. The three countries with the highest unnourished percentage globally are MENA and Central Asia countries (Yemen 3%, Afghanistan 30%, and Iraq 27% of the population) [13]. These countries also have the highest rainfed/irrigation crop yields in MENA and Central Asia countries (Yemen 2.34, Iraq 2.2, and Afghanistan 2.1 rainfed/irrigation crop yield) [13]. The water availability results show that these countries have the available surface and groundwater resources to expand their irrigated farmed areas to a certain extent. Other remarkable countries with high rainfed/irrigation crop yield, with the plausibility of expanding the irrigated farmed area to a certain extent, are Iran (2.5), Algeria (2.2), and Turkey (2.14) [13].

Another objective of expanding the farmed area is reducing the number of agricultural imports. MENA and Central Asian countries' agricultural imports are considerably high and cover an important share of the total import costs. On average, the agricultural imports value in MENA countries covers 38% of the total imports value, while in Central Asian countries, it is 35% [20,21]. Countries with the highest agricultural import rate in MENA (Lebanon 58%, Syria 58% Jordan 44%, and Yemen 39%) [13] and Central Asia (Tajikistan 68% and Afghanistan 45 %) [13] all have renewable water sources to expand the farmed areas to a certain limit. Expanding the farmed area might not cover all the agricultural imports range; categorized cultivation can decrease the import dependency of certain crops. For example, nine out of the top twenty wheat importers worldwide belong to MENA and Central Asian countries [22]. Except for Egypt (the biggest importer of wheat worldwide), all (Turkey is 4th, Algeria is 6th, Morocco is 9th, and Yemen is 15th largest wheat importer) have sufficient renewable water resources to expand the farmed area to a certain extent.

When considering the expansion of the farmed areas, it is crucial to consider upgrading the irrigation infrastructure and the production cost per hectare, including the seeding, fertilizers, labor, fuel, and other costs. Except for the Persian Gulf region countries, with no surface water resources, the MENA and Central Asia countries have developed reliable irrigation dams and reservoirs [23]. Some countries in these areas are even considered to have large irrigation reservoir volumes (Turkey 965 dams, Iran 594, Algeria 147, and Tunisia 127) [13]. On average, the surface and groundwater resources exploitation in MENA and Central Asian countries is much lower than the world average [24]. On a global scale, water resource exploitation costs are 20 US dollars for 1000 m^3 of surface water and 30 US dollars for 1000 m^3 of groundwater [25]. Excluding Bahrain, Palestine, Oman, Qatar, Saudi Arabia, and UAE, the daily income of the MENA and Central Asia countries is considered low, with an average of 10 US dollars daily for MENA countries, and 15 US dollars for Central Asian countries [26]. These factors give the opportunities to expand the farmed areas at a relatively low cost. The livelihood of 30% of the MENA and Central Asia population is directly related to agricultural activities. Some countries have a significantly higher percentage (Afghanistan 62.2% of the population, Tajikistan 50.8%, and Morocco 37.8%) [13]. The expansions will have a direct social impact, as the unemployment rates are considered high in MENA and Central Asian countries. For example, the official unemployment rate reaches 15% in Jordan and Saudi Arabia, with only 4% of the population involved in agricultural activities in these countries [27]. The general average of unemployment is 12.5% of the population in MENA and Central Asian countries. The countries with a low percentage of the population involved in agricultural activities and with sufficient renewable water resources (Palestine 1.1%, Lebanon 3.2%, Jordan 3.7%, Oman 6.5%, Algeria 12.8%, and Tunisia 13.7%) [28], must consider the expansion of this crucial economic sector, especially since the agricultural imports and the unemployment rate are high.

5. Conclusions

Analyzing the renewable water resources availability in the MENA and Central Asian countries has shown the diversity in these countries' renewable water resources availability and the plausible water exploitation range in each country. Expanding the farmed areas in any given country or society is subjected to various factors and setting objectives on both the short and long ranges. Regardless, in this study, we have shown that the fundamentals of expanding the farmed area, at least regarding the water resources, land, and workforce availability, are plausible in almost all countries. Still, setting such plans on the country level depends on each country's economic and social situation. For countries like Yemen, Afghanistan, and Iraq, which have all the mentioned factors for expanding the farmed areas and are facing food insecurity, increasing the agricultural investments is a must. In countries like Lebanon, Syria, Jordan, and Tajikistan, where the agricultural imports cover most of the country's imports, agricultural investments will reduce the import costs, allowing more investments in other sectors. Countries with significant scarcity in specific crop types, like Egypt, Turkey, Algeria, and Morocco, benefit from specialized farming. In countries with a high unemployment rate, like Saudi Arabia and Jordan, agricultural investments will create more job opportunities, decreasing unemployment. Even in the Persian Gulf countries, where the economy is oil-oriented, long-term investments in other economic sectors will immunize and decrease import dependency. Future research should focus on greater water productivity and increasing yield per m^3 water consumed in irrigation. It is also important to understand what motivates farmers to adopt new technologies and practices. Farmers must be educated about crop, land, and water management in different circumstances, especially farmers with access to poor water quality who risk decreasing yield rates and increasing soil salinity. Irrigation water use must be directly related to crop value, e.g., vegetables are a good irrigation investment because of higher quality and price.

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