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Challenges for Sustainable Rural Water Management in Sulaimani Governorate in Kurdistan Region of Iraq: A Review Study

TAHIR Twana[1&2], Rezhen HARUN[1]

[1]Department of Agribusiness and Rural Development, College of Agricultural Engineering Sciences, University of Sulaimani
[2]Department of Environmental Engineering, College of Engineering, Komar University of Science and Technology
* Corresponding author e-mail: twana.tahir@univsul.edu.iq

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Abstract

Rural communities face significant challenges, mostly because of globalization, demographic change, and rural-to-urban migration. Rural farmers make up a large portion of the population in every developing country, including The Kurdistan Region of Iraq (KRI). When rural farmers lack access to knowledge, general services, early warning systems (drought, pests, diseases, etc.), improved seedlings, fertilizer, agricultural equipment, credit, market prices, and information that would help them achieve the maximum agricultural yield, they are not only left in the dark but are forced to seek formal employment in urban areas. In KRI, over 90% of water is used for irrigation, and more than a quarter of irrigation withdrawals are deemed unsustainable. Climate changes all have an impact on water availability. Significant agricultural output is reliant on surface water, groundwater, or a mix of the two for irrigation. Over the last 20 years, a growing body of literature has examined the lack of agricultural water policy and a competent agricultural extension program has resulted in many difficulties in terms of water scarcity and the migration of rural people to urban areas in Sulaimani Governorate.

Keywords: rural water management, sustainable development, resilience of water management, climate change.

1. Introduction

Water differentiates our planet from all those we are aware of. While the worldwide quantity of accessible freshwater is sufficient to fulfill all present and future water needs, its geographical and temporal distributions are insufficient.

Our freshwater supplies are insufficient in many areas to fulfill domestic, economic growth, and environmental demands. In such areas, a lack of enough clean water to fulfill human drinking water and sanitation demands is a significant limitation on human health and productivity, as well as economic growth and the preservation of a clean environment and healthy ecosystems [16].

The human right to water entitles everyone to sufficient, safe, acceptable, physically accessible, and cheap water for personal and household uses," according to UN Resolution 64/292. The pledge to "leave no one behind" necessitates a focus on rural areas, which are frequently overlooked [7].

Water supplies in rural areas have typically been overshadowed by those in urban areas. Water for all is currently a requirement of the Sustainab le Development Goals.

Developed nations must evaluate the detrimental effects of industrialization and natural resource use on the environment to discover a method to mitigate them. On the other hand, the lack of funding to maintain natural resources such as water, forests, and others from depletion results in ongoing damage to these resources. Lack of functioning and active institutions prevents economic growth at the country level from meeting international laws and criteria [3].

Water was officially recognized as a precious resource by the international community two decades ago, with the 1992 Dublin Statements declaring that water resources are not limitless and are "vulnerable." As water scarcity worsens as a result of climate change, the need for strong water resource policies will grow. Water scarcity is expected to affect 57% of the world's population [58].

Recognizing that water has long been an economic good help to explain in practical terms the economic instruments that may be used to affect the resources ecologically, socially, and commercially efficient usage. The intricacy of water as an economic good has not been well appraised, even among economists. The greatest amount a customer would be prepared to pay to utilize water is the worth of water to them. Water value is thus dependent on crop value; for low-value crops, it is uniformly very low [55].

Providing humanity with safe drinking water has been a big concern for all countries across the world. Local, regional, and global efforts increased the number of people with access to at least basic drinking water services to 89% of the world's population between 2000 and 2015 [45].

Water is now seen as an economic good, although it has many qualities with other resources, such as life and politics. Its shortage becomes a worldwide problem. The hydrological cycle makes water one of the few renewable resources on the planet. Water ownership and management for agricultural, irrigation, industrial, and human usage are becoming increasingly contentious [1].

Based on the report of Food and Agriculture Organization (FAO) in 2017, 1kg of grain requires between 1 and 3 tons of water to grow. It takes up to 15 tons of water to produce one kilogram of beef. Besides that, a person's daily diet requires between 2000 and 5000 liters of water. According to the United Nations Department of Economic and Social Affairs, the world population will reach 8.4 to 8.6 billion people by 2030, and 9.5 to 13.3 billion by 2100, when it is likely that numbers will stabilize and begin to decline. Also, worldwide water withdrawal expanded 1.7 times faster than population over the previous century, raising concerns about water sustainability as demand for agricultural, industrial, and household usage continue to rise [20].

Water shortage will worsen in regions where water withdrawals are unsustainable, limiting agricultural productivity, endangering ecosystems, and affecting the incomes and livelihoods of many rural and urban inhabitants. As water scarcity worsens as a result of climate change, the need for strong water resource policies will grow [9]. By 2050, it is anticipated that 57% of the world's population would face water scarcity for at least one month of the year. Green, blue, gray, and virtual water are the four different kinds of water [11]. Water trade could be beneficial to countries that are experiencing water shortages [4].

Drinking and irrigation water universalization in rural communities is a huge challenge for developing countries, where rural areas generally have low water service coverage and receive little attention from authorities [5]. Agriculture's fundamental problem is to produce enough food to feed a growing population, but this is complicated by ever-increasing competition for water and land, climate change, droughts and anthropogenic water scarcity, and less-participatory water governance. In such a setting, novel concerns in agricultural water management and practices must be addressed at both the field and system or basin scales, primarily in irrigation to address water shortages, environmental friendliness, and rural society welfare [35].

Food production will be sufficient to feed a worldwide population of 9–10 billion in 2050, according to FAO and the World Water Council [20, 66], with proper investment and policy reforms, however, food and nutritional insecurity will remain in many places. Countries in water-scarce regions will be forced to develop food security plans that include the structural food supply shortfall as well as trading arrangements that safeguard against food price volatility. Because substantial portions of the population in emerging countries will tend to increase their standards of living, more strains on the water for food production may arise. When compared to bread, eating more beef needs a lot more water [13]. Agriculture confronts a triple challenge in the present context of changing global agricultural markets: it must boost the production of safe and nutritious food to meet the rising demand caused by popu lation growth.

Agriculture must create employment and incomes, as well as contribute to poverty reduction and rural economic development. Agriculture has a critical role in the long-term management of natural resources, as well as the adaptation and mitigation of climate change, which is already hurting the livelihoods of many people, particularly the most vulnerable [68].

Water-agriculture-food nexus innovation focuses on several key issues and goals, including: (a) developing integrated approaches to water and food policies and practices; (b) improving water management in agriculture; (c) adapting agricultural systems to increase water use and productivity in the face of water scarcity and climate change, and (d) ensuring long-term management and sustainability [8].

There is no universally applicable or usable worldwide formula for reducing water losses. To decrease the losses, a variety of approaches can be utilized. This is dependent on many elements, the most significant of which are the Water Authority's technical circumstances and economic potential, as well as the desired magnitude of the loss reduction. The challenge of overcoming water losses is the most pressing issue that all countries, without exception, are confronting [4].

Agriculture is severely hampered by unreliable rainfall, frequent dry periods, irrigation water constraints, and water disputes. This puts food security in these nations at risk, and it tends to increase reliance on food aid. Financing irrigation development to improve rain-fed yields through the use of supplemental irrigation is part of global efforts to reduce food assistance reliance.

However, improving water production through water conservation has lately been discovered to be a more tempting alternative than constructing additional irrigation infrastructure. The expense of developing new irrigation systems is significant on a financial, social, and environmental level [48].

Under the surface irrigation method, crops rely on irrigation to satisfy their water requirements. Irrigation is the practice of adding water to the soil in various ways to meet the water needs of crops by reaching optimum soil moisture and therefore increasing agricultural yield. Climate conditions, soil texture, and the quantity and quality of accessible water resources, which are represented by rain, water bodies, and wells, all have an impact on irrigation volume and intervals.

These aspects are crucial in recognizing water consumption. Table 1 showed the crop's net water consumption, less any losses due to system irrigation. To determine the overall water demand including field losses, it is necessary to include surface irrigation with 55% efficiency [49].

Table 1. Total water requirement of the crop (with field losses)

Crops	Net (mm/season)	Total (mm/season)
Wheat	417	758
Barley	314	571
Maize	993	1805
cucumber	605	1100
Eggplant	707	1285
Kidney beans	363	660
Potato Soring	693	1260
Sesame	767	1395
Sunflower	841	1529
Sweet pepper	941	1711
Tomato	901	1638
Watermelon	567	1031
Berseem	568	1041
Broad bean	375	682
Cauliflower	333	605
Potato autumn	282	513
Citrus	1154	2098
Grape	1138	2069
Olives	1178	2142
Palm	1661	3020

2. Sustainable Agricultural Water Management

The notion of sustainable development was born when an international committee concluded that humanity's existing course was unsustainable due to haphazard industrial operations, the bulk of which was done at the expense of the environment. Before Brundtland introduced of the phrase in 1987, many other people including some authors from classical theories addressed the term development and its connection to economic progress [41].

In the modern world, sustainability is divided into three categories: environmental, social, and economic sustainability. Human progress and action during the previous decades have contributed significantly to climate change and natural disasters, as well as the harmful consequences of conflicts and political and socio-economic instability [41].

Sustainability was defined as "the ability to maintain something, outcome, or process across time" and executing actions that do not place a strain on the resources on which the capacity is based [10]. However, Shiva (2010) pointed out that a broad definition of sustainability is harmful since it ignores environmental boundaries and plant carrying capacity, as well as the necessity to balance human activities with natural sustainability [59].

Within the triangular model of sustainability, theinstitutional application of the Integrated Water Resources Management (IWRM) paradigm comprises three components (Fig. 1) [40].

1. Enabling environment: strong governance, appropriate legislation, and so on;
2. Management instruments: water allocation modeling, economic tools, and so on.
3. Institutional functions include capacity building, action levels, and so on.

Figure 1. Sustainability triangle and IWRM implementation approach (adapted from G WP, 2000) [23]

This implies that IWRM's scope should be broadened to include areas outside hydrological limits (i.e., river basins). The answer to the "water box" problem should be found outside the "water box" through a political decision-making process including governmental, civil society, commercial, and economic players [67]. The challenges of sustainable development, particularly in the area of water management, are grave. While the world's population continues to grow, so does the amount of water used by various sectors. In the last century, half of the world's wetlands have vanished. Water use is expected to rise by about 50% in the next thirty years. And half of the world's population will be in desperate need of significant changes in water management. A sustainable strategy may be one that can cope with climatic variability (in the near future) and is flexible enough to respond to any sort of change brought on by climate change, socioeconomic progress, or changing viewpoints [24].

In many nations, national food security has evolved into a unique agricultural strategy centered on boosting food production through irrigated agriculture (i.e., increased Blue Water usage) and improved crops (i.e., enhanced technology). UN and international organizations support this program, which aims to improve food and social security (alleviate hunger and eradicate poverty). This strategy has the effect of allocating more water for agriculture in water resource systems. As a result, the current global water problem is primarily a food catastrophe [22]. As a result, water security will become increasingly crucial in the future. This is because physical water shortage is caused in part by human behavior and is influenced by natural events such as droughts

Water scarcity is usually assessed in terms of renewable water supply per capita per year [19]. The United Nations Development Program (UNDP) was using human development index in the social water stress index. This is based on the necessity for water to maintain home, agricultural, and industrial operations, as well as the need for the environment to survive. The social water stress index is a variant of the Falkenmark Indicator that incorporates a society's "adaptive capability" to examine how economic, technical, and other factors influence a region's total freshwater availability status. Ohlsson (2000) was the one who came up with the idea [51].

Furthermore, water poverty index was created to determine whether people are water secure in their homes and communities. It tries to reflect the physical availability of water, as well as the degree to which that water serves humanity and the preservation of ecological integrity. The five elements of this index are [60]:

1.Access to water.

2.Water quantity, quality, and variability.

3.Water uses for domestic, food, and productive purposes.

4.Capacity for water management; and

5.Environmental aspects.

Climate change has varying effects on people and communities within countries, with the most vulnerable populations bearing the brunt of the consequences. As a result, resilience measures must be integrated within a larger sustainable development framework that empowers marginalized groups and improves people's asset positions and access to essential services [62].

Water is a unique economic good with no replacement, thus its distribution is a social rather than a market issue. As a result, water should not be priced solely based on market forces; rather, the price of water should include the full economic cost of providing the water service and, second, send a clear message to users that water is a scarce resource that provides valuable ecosystem services and should be conserved [10].

There are two types of sustainability advocates: those who believe in weak sustainability and those who believe in strong sustainability. Natural capital can be substituted for other forms of capital in the quest for economic growth in the weak form of sustainability, whereas strong sustainability prioritizes the maintenance or enhancement of present levels of natural capital in the pursuit of economic growth [50].

Opponents of weak sustainability claim that it encourages a "take-make-waste" economic model in which natural resources are taken from the environment, converted into goods and services, and enormous volumes of trash are then returned to the environment, creating irreparable environmental harm. Natural capital, according to strong sustainability proponents, cannot be substituted for other forms of capital for three reasons: first, natural capital depreciation is irreversible or takes a long time to recover; second, it is impossible to replace a depleted resource with a new one; and third, ecosystems can collapse suddenly [50].

3. The Resilience of Agricultural Water Management

The Water Services Regulation Authority (Ofwat, 2015) defines resilience as "the capacity to cope with, recover from, and anticipate trends and unpredictability to sustain services for people and safeguard the natural environment, now and in the future. As stated by (Ofwat)'the systems, agents, and institutions are aspects can be contained of the societal resilience [53]. Despite certain failures or operational disturbances, resilient systems guarantee that their functionality is preserved and may be quickly restored through system connections. Factors that contribute to system resilience include flexibility and diversity of the system, redundancy of the system and safe failure (ability of the system to absorb the sudden disturbance [10]. Resilience planning aims to build iterative, inclusive, and integrated processes to reduce the uncertainty and complexity of climate change. Agents of resilience include responsiveness and capacity of the community to identify the problems, anticipate, plan, and prepare for a disruptive event to respond quickly. Also, the resourcefulness of a community can be measured by having access to financial assets (wealth or access to credit), physical assets (house, possessions), natural assets (land), social assets (family), and human assets (health and skills) [10]. Water resources management, as an environmental pillar of strong sustainability, strives to maintain the quality and quantity of water required for both human and natural existence. The environmental pillar recognizes the need of safeguarding ecosystem services that benefit both humans and nature. Falling groundwater levels and decreased surface water flows can cause wells to dry up, increasing the distances that must be traveled to obtain water and increasing pollution at water sources. As a result, drilling rigs that would otherwise be utilized to expand access may be repurposed to renew or replace out-of-service wells, delaying access expansion [64].

Perhaps Virtual Water 'trading,' is one of the alternatives, as defined by Allan (1997), is the water used in the manufacture of commodities, such as agricultural products. For example, 1000 liters of water are required to create a kilo of grain. As a result, 'trading' food commodities is comparable to 'trading' Virtual Water. Despite considerable debate and criticism concerning the term's economic and linguistic legitimacy, Virtual Water can help nations with water scarcity solve blind water policy assumption gaps [7].

3.1 Agricultural Water Management/ Iraqi Scenario. According to Worldometer's elaboration of the most recent United Nations data, Iraq's current population is 41,193,497 as of Sunday, August 1, 2021, with a yearly growth rate of 2.32% in 2020. It is expected to reach nearly 50,193,756 million people by the end of 2030. The ratio of urban verse rural population in Iraq was shown in Fig. 2 which is around 73% and 27% respectively [32].

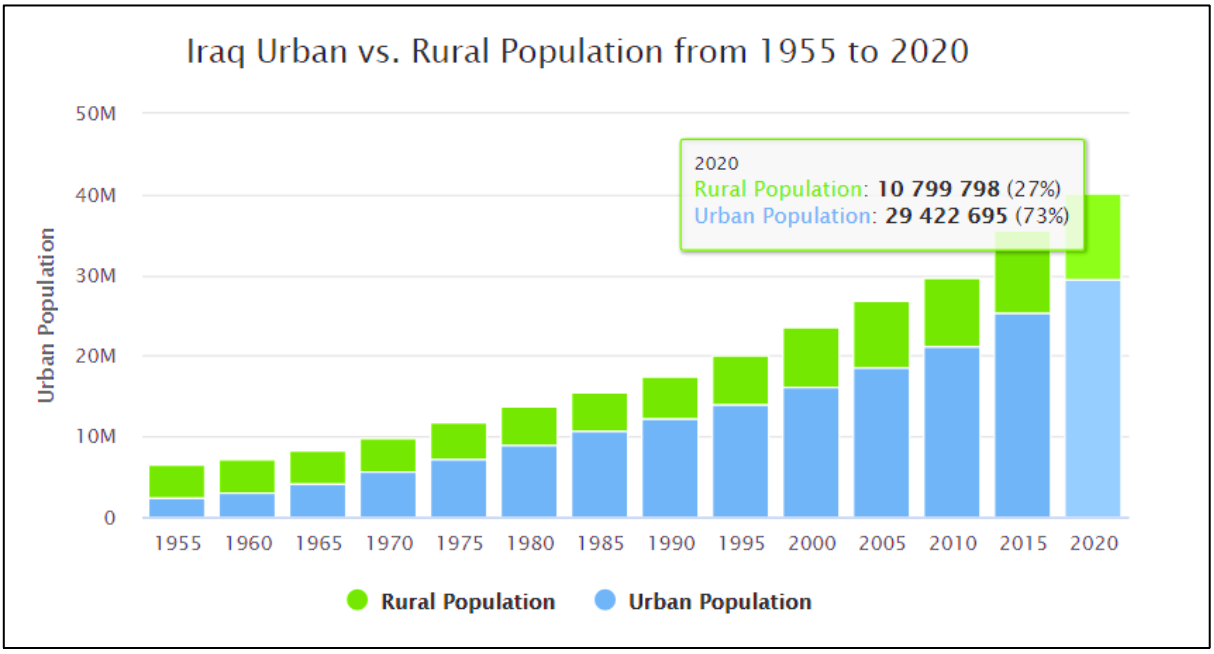

Figure 2. Iraqi Urban vs. Rural Population from 1955 to 2020 (adapted from www.Worldometers.info) [32]

According to the United Nations, Iraq is the world's fifth-most vulnerable country to the effects of climate change, including water and food shortages. Iraq, which is located in a water-stressed region with few water resources of its own, fa ces substantial and interconnected political, economic, environmental, and security concerns. Climate change's effects, such as rising temperatures, decreasing precipitation, increasing water scarcity and salinization, and increasing the frequency of sand and dust storms, will exacerbate these problems and have major consequences for Iraq's future [31].

Water development in Iraq has been driven more by hydraulic engineering than by water economics, which has resulted in a slew of issues with current water usage and management. Iraq's centralized, command-and-control institutional systems have resulted in poor customer accountability, a lack of a pricing strategy, a reliance on government funding, and a lack of focus on service standards.

As a result, the infrastructure has deteriorated, and poverty has increased [27].

The decrease of the Tigris and Euphrates rivers, on which Iraq's water security and agriculture are dependent, both of which originate beyond Iraq's borders in Turkey and over which Iraq has no power or influence, is at the heart of these issues [46].

Water emergencies involving shared waterways necessitate immediate international intervention. Unfortunately, Iraq was engulfed in a series of conflicts from 1980 to 2003, preventing the country from developing its institutions. Rapid population growths in the transboundary nations along the Tigris and Euphrates rivers, as well as strong agricultural needs, are hastening water extraction [68].

There are four strategies to mitigate the risks of climate change's impact and improve and stabilize rain-fed crop output, according to the Kurdistan region of Iraq (KRI) study for evaluating agricultural sectors (2019):

1. Increase the number of water-harvesting projects to improve water productivity and management.

2. Enhance agricultural techniques and inputs, such as crop types that are appropriate for rain-fed environments and other inputs.

3. Promote supplementary irrigation as a cost-effective and yield-stabilizing technique. During dry spells, supplemental irrigation is an effective way to mitigate the negative effects of soil moisture stress on the production of rain-fed crops.

4. Establishment of new irrigation projects, where it is feasible to cover a section of rain-fed land and convert it to irrigate agricultural land, as well as the potential of resuming planned and halted irrigation projects owing to the financial crisis.

In Iraq, Internal political conflict and unrest policy are considered as the main factors that the water crisis is deepened due to not having enough financial investments in the field of water resources.

Also, the government had to put water security in the priority of its list to have a sustainable and long-term plan for transboundary water body management. Abbas et al. (2017) stated that rainfall has declined from about 177mm in 1980 to 156 in 2017. He also points out that the declining trend is expected to continue over the next decades [1, 6].

Fifty percent of Iraq's accessible surface water comes from upstream rivers in Turkey and Iran via the Kurdistan Region, which has a direct impact on downstream rivers.

As a result, for these transboundary rivers, an integrated water resource management (IWRM) approach is necessary. The map in Fig. 3 depicts the locations of transboundary river basins in Iraq across the Kurdistan area, as well as the water balance (inflow and outflow) [23].

Many water projects have been ongoing in Iraq's neighboring nations in recent decades. The Turkish GAP project (Güneydo gu Anadolu Proje), which means "South-eastern Anatolia Project," was one of the most important. The GAP is a significant and comprehensive water management project set up by the Regional Development Administration in Turkey's southern region (RDA). It cost $32 billion to build and was completed between 1975 and 2017. The project consisted of 13 separate projects, involving the building of 22 dams and 19 hydropower plants with a total capacity of 27 gigawatts (GW). The irrigated area of Turkey is projected to be 1.8 million hectares or 9.7% of the total land area. Although Iraq and its neighbors have signed agreements and protocols regulating the sharing of transboundary water bodies, none of them are currently in force owing to political disputes. Iraqi institutions came apart when coalition forces invaded Iraq in 2003, and Iranian influence and domination over political choices in later phases of the battle prevented Iraq from obtaining its water rights [23]. Iraq obtains 70.92 billion m^3 of water per year and uses 60.43 billion m^3 of it. The yearly reductions in Tigris and Euphrates waters are 0.1335 billion m^3 and 0.245 billion m^3, respectively. As a result, by 2020, the average annual demand for incoming water from the Tigris and Euphrates rivers was expected to rise to 42.884 billion m^3 and 29.225 billion m^3, respectively, for a total of 72.069 billion m^3, implyi ng an estimated deficit of 8.609 billion m^3 [36]. Irrigated agriculture consumes more than 80% of the Tigris and Euphrates Rivers and their tributaries' total water supplies. Large sections of agricultural land are affected by salt and waterlogging, notably in central and southern Iraq, where salinity is the most serious problem confronting Iraq's irrigated agriculture.

It has gotten worse in recent years as a result of outdated irrigation infrastructure and the government's inability to finish numerous projects, particularly land reclamation initiatives (Fig. 4) [39, 34].

The Green Climate Fund approved funding some of the projects like Adaptation planning support for Iraq through UNEP in 2019 and Readiness and Preparatory Support for Iraq (with UNDP) in 2017.

Iraq has also filed a proposal to the Adaptation Fund for Building Agricultural Sector Resilience to Climate Change (with International Fund for Agricultural Development (IFAD) as the implementing organization) [2].

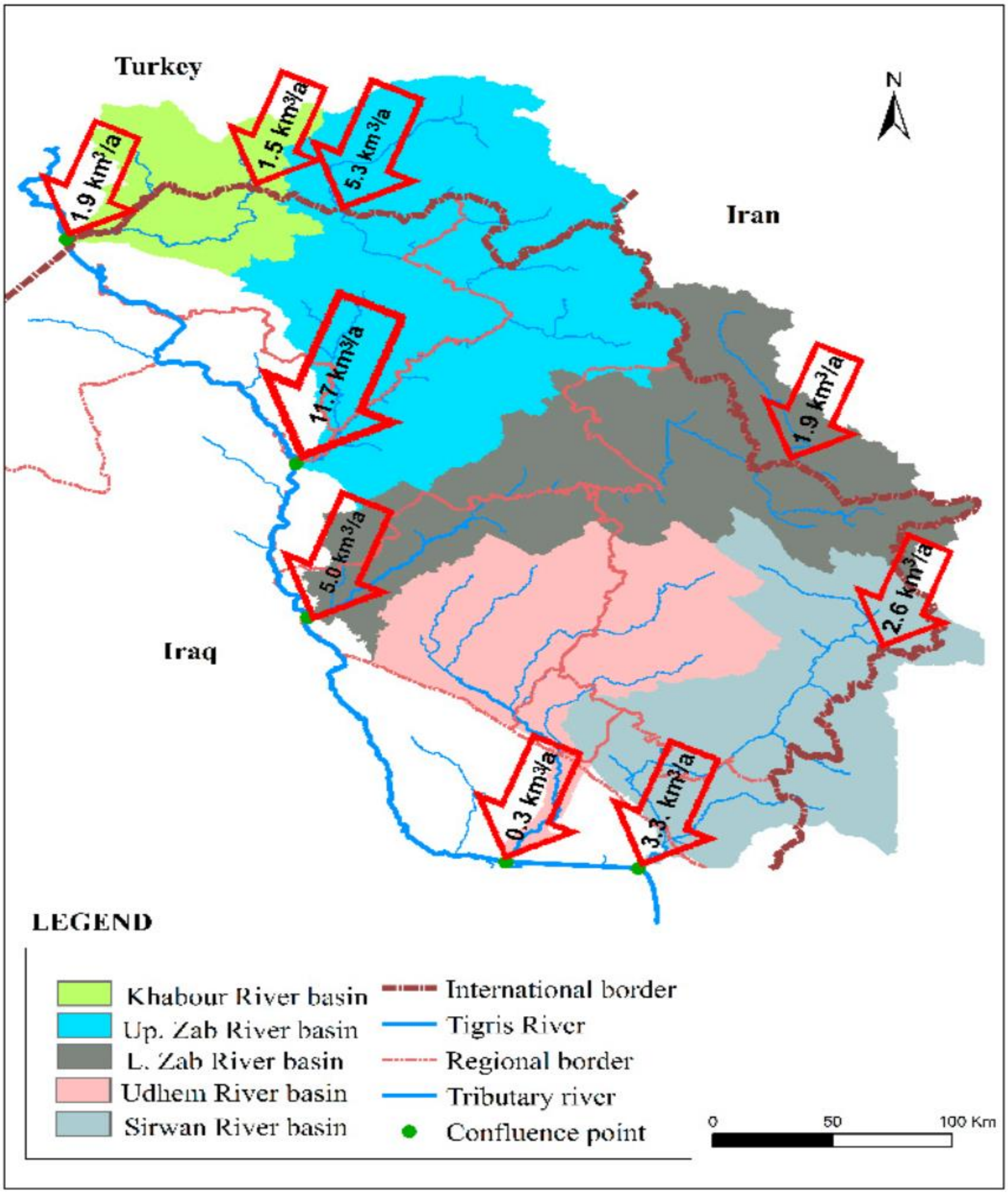

Figure 3. Location of river basins in Kurdistan (Iraq), and the inflow and outflow water balance of the Kurdistan Region
(Source: Yousuf et al., 2018) [68]

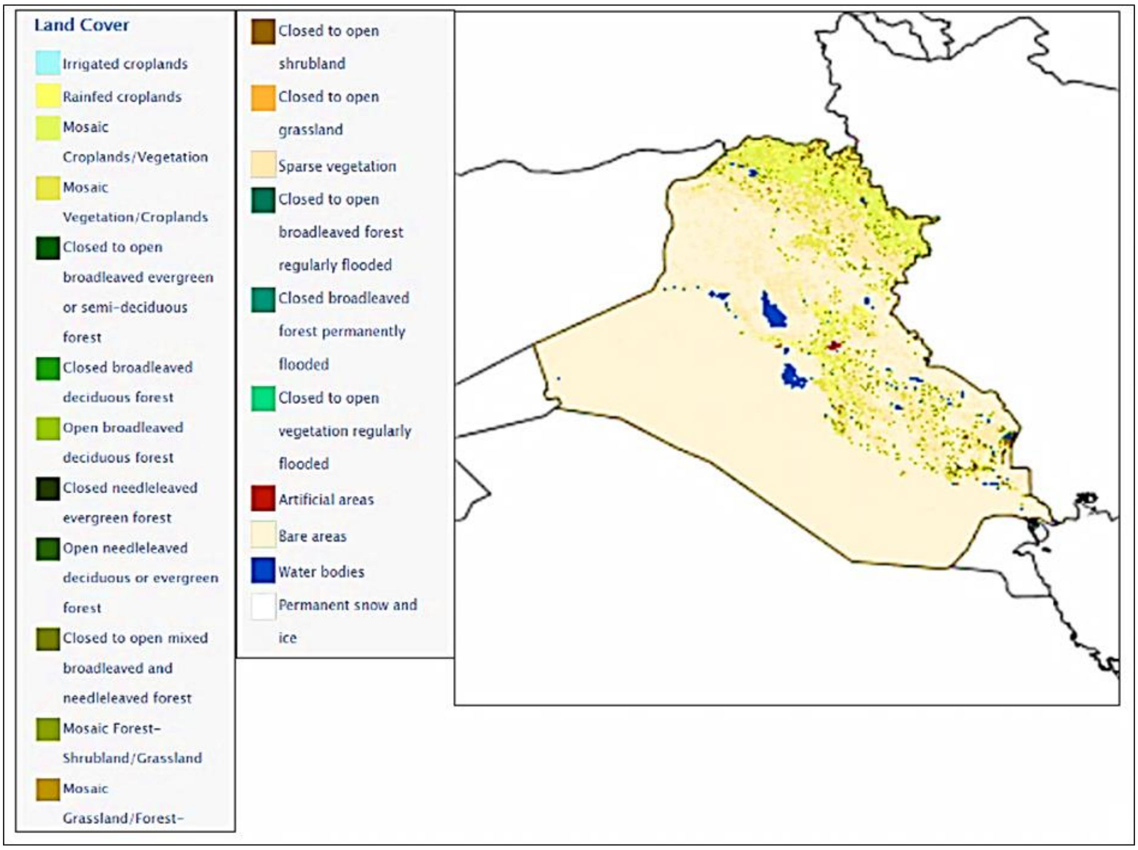

Figure 4. Iraqi Land cover map
(Adapted from http://www.fao.org/countryprofiles/maps/en/?iso3=IRQ) [34]

3.2 Agricultural Water Management/ Kurdistan Region Scenario. The Kurdistan Region of Iraq (KRI) is an autonomous region in northern Iraq recognized under the Iraqi constitution. The Kurdistan Regional Government (KRG) oversees the area, with Erbil as its capital. Kurdistan's institutions have legislative and executive power in numerous areas, including education and health policy, policing and security, natural resource management, infrastructure development, and regional budget, according to Iraq's federal constitution. The KRG, the Kurdistan Region Presidency, and the Kurdistan Parliament are its principal institutions [31].

From 2009 to 2017, the population of Kurdistan grew at an incredible rate. Flash waves of Syrian refugees in 2010 and a high rate of entering Iraqi internally displaced persons (IDPs) under the effect of uncertain security owing to an ISIS offensive in 2014 were the primary factors driving population increase. The population grew by 28% as a result of these events. Furthermore, migration from rural to urban areas was fueled by the need for better job opportunities [68]. Based on the data from Kurdistan Region-Statistics Office (2021), the KRI population was 6.8 million and it is projected to reach 7.5 million by 2030 (Fig. 5) [42]. It was also shown the urban population in 2020 was around 5,022,603 while the rural one was 1,148,480 people [43]. Many agricultural regions in the Kurdistan Region have suffered because of decades of violence. However, up to the pre-financial crisis in 2014, the agriculture industry in KRI has seen significant growth in previous years. The industry faced several issues as a result of the financial crisis, including a lack of agricultural equipment and field machinery, a need for fertilizer and high-quality seed supplies, and a lack of investment. The improvement in several elements of agriculture has led to the sector being seen as a key to the economy's restoration and having the ability to play a significant role in helping the local economy's growth [18].

There is no regulation regulating the location of the property in terms of a basin or specific watershed, thus the interaction with water management is not considered. It only examines the irrigation mechanism, but there is no direct link between the land, crops, and basin, making it difficult to promote an integrated management system capable of expanding the irrigation sector. This absence of regulation, which integrates land and water management, produces disequilibrium and restricts the agricultural sector's economic expansion [54]. Despite the development of the public sector as a way of fostering clientelistic relationships, agriculture still employs around 20% of Iraq's workforce. However, in the KRI region, this ratio is astonishingly low, with agriculture accounting for only 6% of total employment (Fig. 6) [37, 14]

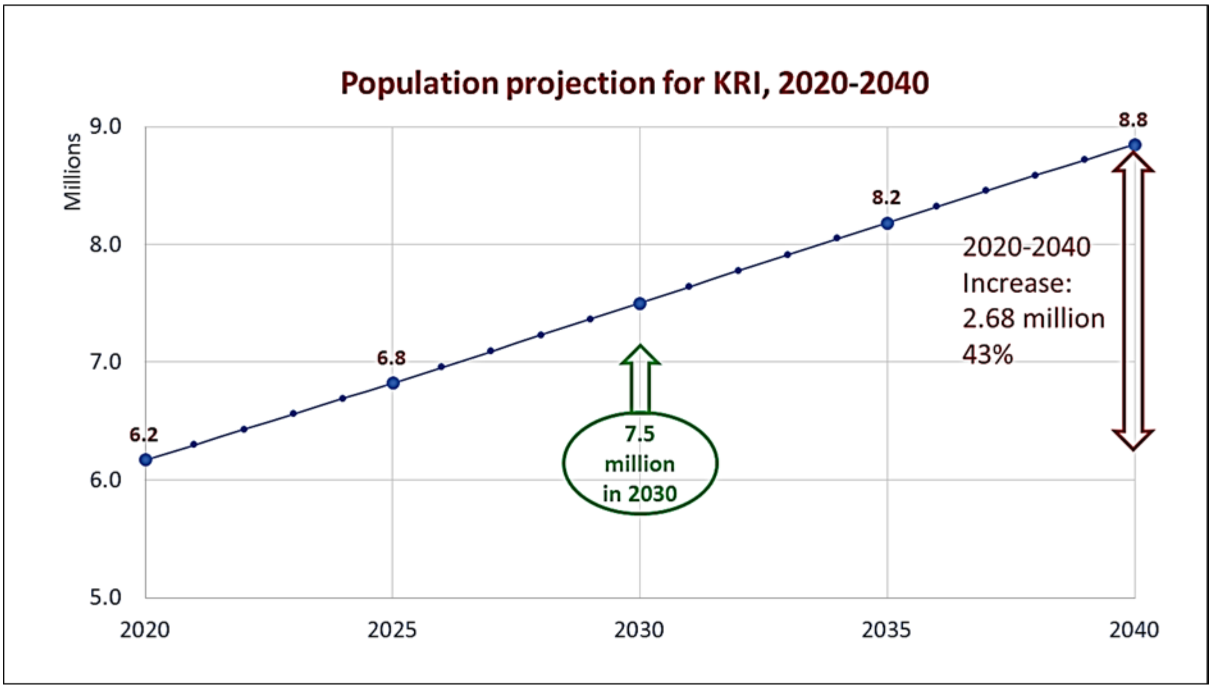

Figure 5. Population projection in KRI for year 2020 to 2040
(Source: Kurdistan Region-Statistics Office, 2021) [42]

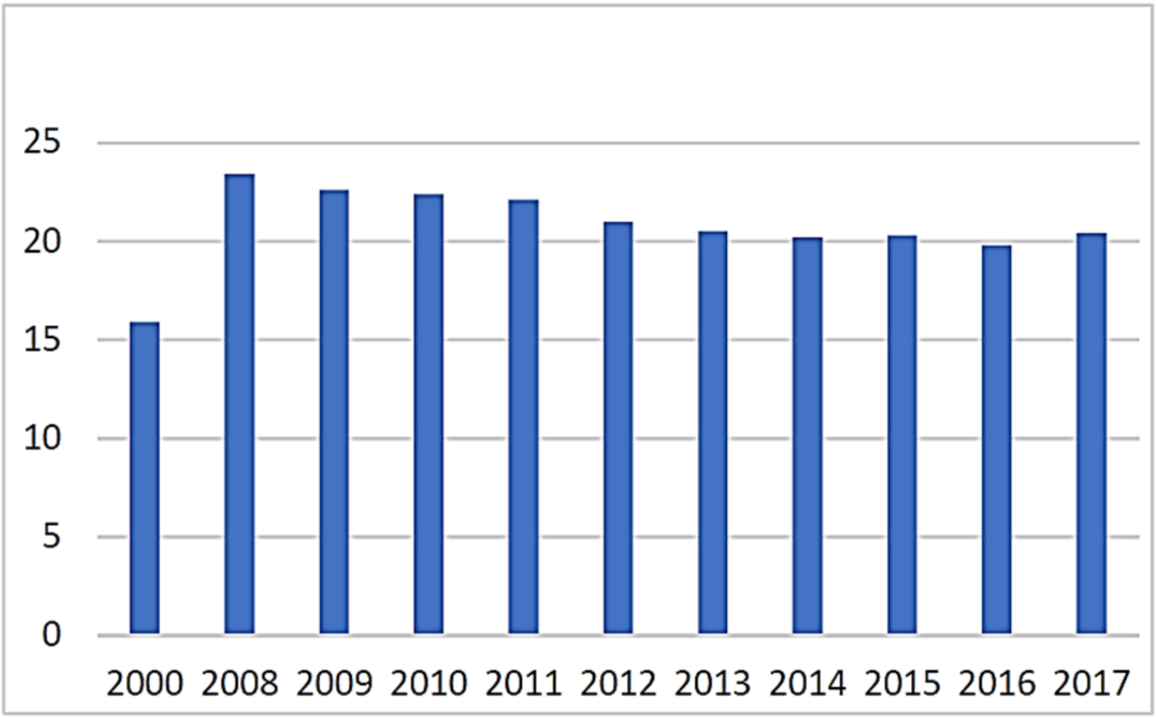

Figure 6. Employment in agriculture in Iraq, including KRI, 2000–2017 (% of total employment)
(Source: DataBank. The World Bank, 2018) [66]

Pesticides, fertilizers, agricultural runoff, and irrigation all have a negative impact on the environment in Kurdistan Region, which includes the human food chain. As a result, it is critical to examine the negative impacts of any irrigation project before proceeding with its execution. Poor water quality under an irrigation project may make the water unsuitable for other users, damage aquatic animals, and promote aquatic weed growth, which obstructs rivers and has health, navigation, and ecological repercussions due to high nutrient content [54].

Soils in KRI are calcareous, originating from various strata of limestone and dolomite. "There are also scattered areas of blue Marle, red mud, and chalky soils from the Kolosh, Gercus, and Shiranish formations, although soil variability is influenced by parent material, slope, runoff, soil depth, and maturity." Heavy precipitation and eroded rock debris are influeced by rich and fertile soils which are changed by the higher plant cover [63]. In places where precipitation levels are low throughout the growing season, irrigation is an essential agricultural activity. A recent study by FAO international Consultants in 2019 revealed that 73% of farmers polled stated they would be prepared to pay for a better water supply to assist them to irrigate their crops.

Farmers' most important suggestions include the building of new irrigation projects and the digging of wells. Farmers replied positively to the issue of whether a local group might assist them in managing water in their region, with 83% saying yes and 16% saying no specifically, assisting them with water-saving and waste reduction methods, as well as the construction of modern irrigation systems [54]. KRI region is falling under the Kirkuk agro-ecological zone having semi-arid and sub-tropical climate experiencing 200-600 mm rainfall annually. Summer is hot and dry, with the warmest months being July and August (43°C), with some heat waves bringing temperatures up to 48°C (Fig. 7).

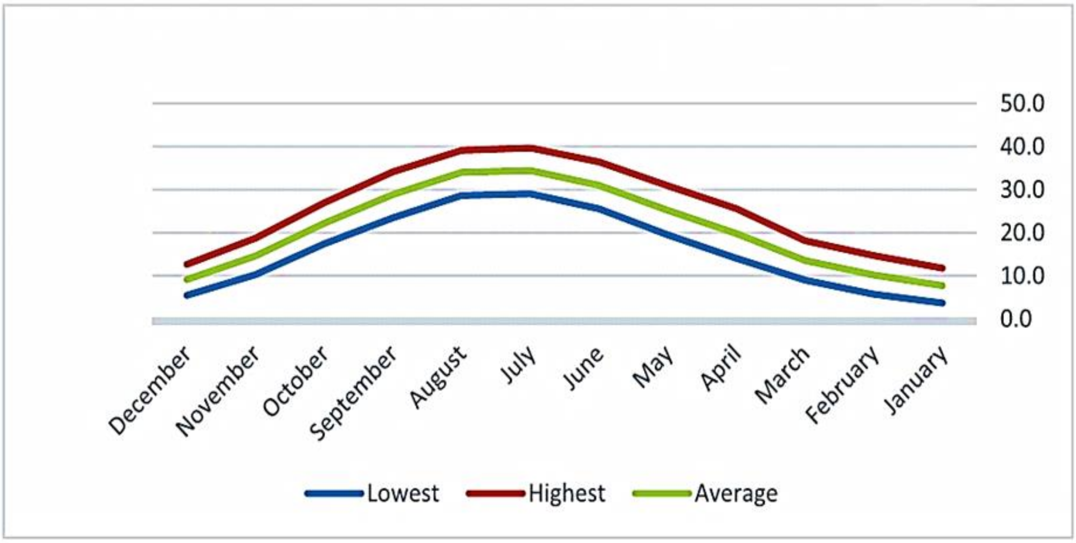

Figure 7. The average temperature in KRI between 2012-2017
(Source: Review of the Agricultural Sector in the KRI, 2019) [65]

The average difference rate of temperature in KRI between the years 2012-2020 was around 2.52°C (Fig. 8). The winter is chilly and wet, with mean low temperatures in January and February ranging from 1 to 2°C. The quantity and timing of rainfall, on the other hand, is very unpredictable, particularly in places with less than 400 mm of mean annual rainfall. The soils are non-saline clay and loam kinds.

The primary rain-fed farming areas are the plains and valleys [53, 65]. The average annual precipitation in Erbil, Halabja, Dohuk, and Sulaimani go vernorates was 386, 496, 556, and 654 mm, respectively, from 2012 to 2020 (Fig. 9). During the previous seven years, the highest precipitation was 791 mm in Sulaimani/2013 and the lowest was 266 mm in Erbil/2017, according to certain literature, while precipitation varies between 300 and 1000 mm, with interannual fluctuations of 100 mm to 1300 mm. The annual rainfall in the highlands is higher, reaching 1000 mm in certain places. Rain-fed agricultural production is in danger due to large variations in rainfall volume and distribution.

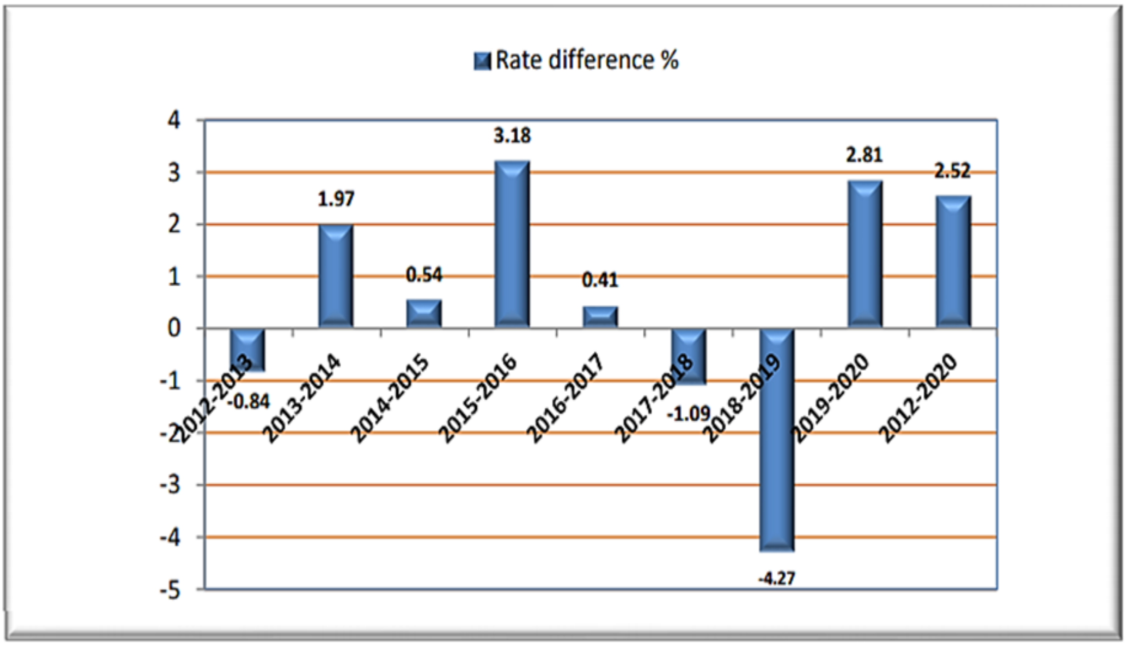

Figure 8.The average rate of difference of temperature in Kurdistan Region 2012-2020 (adapted from Kurdistan Region Statistics Office/ Weather statistics in Kurdistan Region s governorates, 2021) [43]

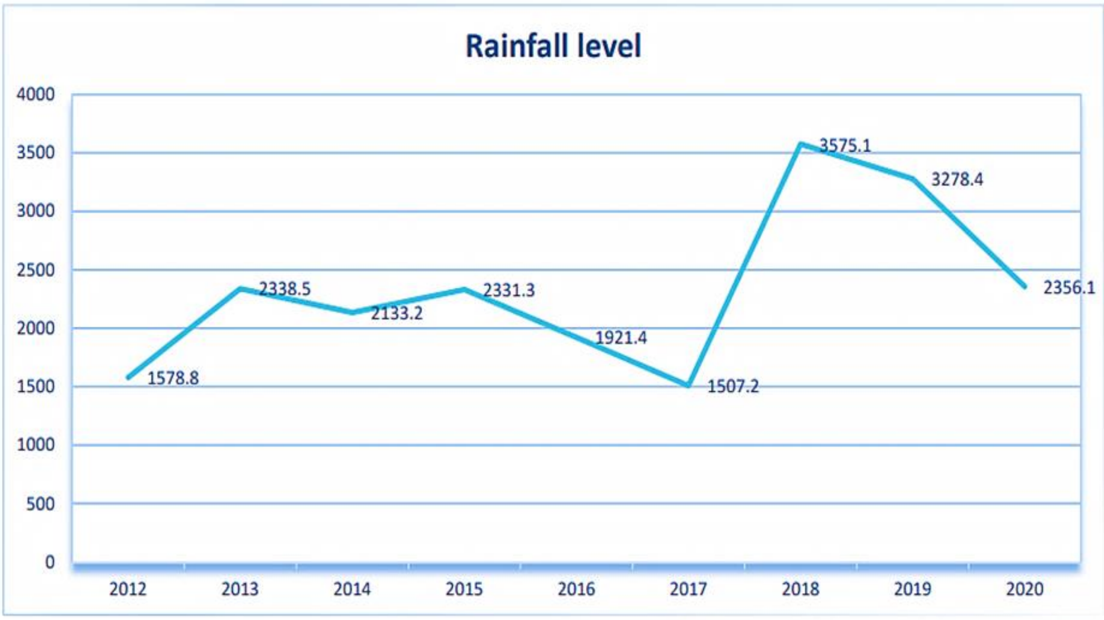

Figure 9. Rainfall level in Kurdistan region for the years 2012-2020/mm (adapted from Kurdistan Region Statistics Office/ Weather statistics in Kurdistan Region's governorates, 2021) [43]

Besides that, another study in the Sulaimani Governorate looked at the influence of land use on water quality. According to the Water Quality Index (WQI), the runoff water from the investigated region is inappropriate for household use, but all runoff water samples from the analyzed land uses are suitable for irrigation, according to the Irrigation Water Quality Index (IWQI) [39].

According to the survey conducted by the Ministry of Planning in KRI for the year 2015-2017 showed that the total rain-fed land in KRG is 4,833,466 donum, accounting for 79% of total cultivat ed areas, while irrigated land is 1,309,710 donum, accounting for just 21% of total cultivated areas. The rain-fed region includes 50% assured rain-fed territory, 35% semi-guaranteed area, and 15% non-guaranteed area. The agriculture workforce in the Kurdistan Region accounts for roughly 3.1% of the overall population, with 68,704 winter crop farmers and 23,160 summer crop farmers [8].

In the recent report suggested that demand-side management methods should be prioritized and exploited by the KRI. Aside from water pricing systems and irrigation costs, residents should be encouraged to adopt water conservation measures through awareness campaigns and instructional initiatives. Water abuse is a major source of waste and pollution, particularly in metropolitan settings [33]. The average annual surface water flows from the Kurdistan Region into Iraqi territory are estimated to be 22.4 billion m^3, or 1064 m^3/s.

The discrepancy between the inflow and outflow data suggests that the Kurdistan Region provides surface water to Iraq via the rivers indicated above, accounting for almost half of the total quantity of surface water input into Kurdistan [68].

In rural areas around the world, community participation and Public-Private Partnership (PPP) in water supply systems have become the most common strategy for administering water supply systems. Water is a major stumbling block to agricultural output and poverty reduction in rural areas. Due to a combination of factors including highly variable and erratic precipitation, poor development of hydraulic infrastructure, management, and markets, non-conducive land and water governance, and a lack of access to water for domestic and productive uses, rural people in developing countries remain vulnerable [52].

When dealing with water shortages, it's important to keep in mind issues like access to water, as well as the fact that environmental services and ecosystem processes can't be viewed as the leftovers of all water users. As a result, a complex collection of location-specific technological hurdles and societal expectations influence how people deal with water scarcity. It has also been emphasized that in some sections of developing countries, not only community engagement has been able to alleviate the problem of unsustainable water services. Other factors cited for the low levels of sustainability include a lack of financial resources, ineffective monitoring and evaluation mechanisms, a lack of technical assistance and institutional capacity, and other difficulties that affect communities include a lack of demand, affordability or acceptability, ownership, and restricted community management systems [66].

4. Environmental law related to Water Management in KRI

In her book Environmental Principles and Policy, Sharon Beder outlines six principles for environmental policies. These ideas, she claims, "were evolved over the last half-century and enjoy the broadest support worldwide."

They have made their way into ‘international treaties and national legislation,' to varying degrees. Beder claims that these principles may be used to "analyze all environmental policies" that a government adopts, as she does in her book. The first three principles are "unique to environmental issues," while the latter three "have broader societal implications" [57].

Law No. 4 of 2006 was the first legislation by the Kurdistan Regional Parliament that contains a reference to the environment. According to Article 4 paragraph 5, the investor must be dedicated to a clean environment as well as public safety and health. Inside the law No. 8 of 2008, three articles of the law are allocated to the protection and improvement of water resources; Article 22 of the law states that all types of pollutants are prohibited from being thrown into water sources if they are not treated; Article 23 states that regional standards will be applied when dealing with surface water and groundwater; and Article 34 states that the Ministry of Environment will identify, and protect, water resources [44, 56].

Also, inside the law No. 1 of 2015 on Water well drilling, Article 4 is about agricultural water wells. It stipulates that only when the surface water does not serve anymore, when it is not available anymore, wells can then be drilled.

He also added when the Environmental law of KRI is compared to Beder’s six principles for environmental policies, the gap for meeting such principles inside the law can be seen as follow [56]:

1. There is no agricultural water management policy.
2. Sustainability slightly appears in developing and investing in water resources.
3. There is no mention of the polluter pays principle in this statute.

4. Law No. 1 of 2007 (Article 2 Paragraph 6), which was approved for the then Ministry of Agriculture. The law directs the Ministry to provide agriculture with modified seeds and artificial fertilizers, but it ignores the issue of agricultural runoff and how it should be handled before entering rivers or mixing with groundwater.

5. Precautionary measures are mentioned very briefly (to protect water from dirt), and involvement is completely neglected.

5. Rural Community in KRI

A population of individual farm systems with broadly similar resource bases, enterprise patterns, household livelihoods and restrictions, and for whom similar development strategies and interventions would be appropriate" is how a farming system is defined. Besides that, Culture is an essential element of a sustainable community. The environmental conditions are affected by the culture, which is, in turn, shaped by the environment. The values of science, the arts, politics, economics, and the determination to change the existing consumption patterns can be sized by contemporary development and globalization for a better quality of life [17,38].

The KRI's most important internal surface or groundwater resources originate from renewable precipitation resources: snowfall and rain. Over 80% of the region's necessities are now imported, and the region's open border has made it a market for frequently inferior or polluted commodities. The Kurdistan Region's inability to generate its food puts it at a disadvantage when bargaining with neighbors who feed it [42].

Because their livelihoods are inextricably linked to these resources, communities have an interest in protecting the natural resources in their surroundings. As a result, local communities are in the greatest position to manage natural resources. People who live closest to natural resources have the most to lose from their degradation, and so would be the most inclined to effectively conserve them if given the right tools and incentives [61].

Another study focused on the rural community problems in the Kurdistan Region as they develop mostly as a result of changing lifestyles, population shifts, and rural migration. A survey of more than 200 farmers in the Kurdistan Region was undertaken, with a focus on socioeconomic factors to forecast the challenges faced by farmers in the region like (household, migration, climate change, and rural policy). The result showed that because of a shortage of basic services such as drinking water, schools, hospitals, and roads, 10.59% of farmers have been migrating for a long time. Those who remain in rural communities face numerous obstacles during agricultural activities, the majority of which are caused by a lack of water (fertilizers, pests, equipment, and fund) [25].

In Kurdistan's rural areas, the ratio of people under 30 years old is about 70%. It was also added that the Kurdistan region's rural community is suffering from a lack of education. Around (28.45%) are illiterate, and 27.66% have only completed elementary school, implying that they have just rudimentary reading and writing skills [25].

The region's agricultural land, "both rain-fed and irrigated," covers 1,535,000 hectares, or around 36% of the region's total geographical area. Rain-fed lands cover about 1,368,000 hectares, or around 31% of the region's total land area. Irrigated land accounts for around 11% of all cultivated land and 4% of the region's overall area. Also, based on climatic condition, KRG can be divided to secure rain-fed line (more than 600mm/year) and semi and un-secured rain-fed line (less than 600mm/year) [28].

Decades of violence, damaging national policies, international sanctions, and two decades of isolation have wreaked havoc on the KRG's agricultural sector. Individual opinions about willingness to pay for water irrigation in the KRG's rural areas are diverse. Farmers' decisions on when and which crops to produce, how much water to apply, and which irrigation technologies to use, according to Marques et al. (2005), determine irrigation water demands. When water is scarce, farmers seek to optimize water allocation among competing crops and irrigation technologies to maximize production and farm revenue [47].

KRI during the two decades when water scarcity first arose, no amount of water management in the region would prevent agricultural land, particularly un-irrigated land, from becoming dry. Despite other challenges, droughts already hit the Kurdistan region hard in recent years, wreaking havoc on a population already reeling from earlier droughts that ravaged a broader geographic area and had devastating consequences for people's livelihoods [26].

The Kurdistan administration can end the agony of the "rural peasant" with a good rural development policy. Farmers can sell their property and go on to other endeavors, while others can expand their farms. Farmers can, on the other hand, establish value-adding operations on their farms and increase their revenue as a result. Urban employees can migrate to the countryside and commute into towns if they have equal access to services in the countryside. The financial viability of rural communities would be enhanced by such workers. "Delivery of information inputs to farmers for better farming practices" is how the agricultural extension is described. Agricultural extension is an important part of the agricultural sector's growth since it serves as a link between farmers and agricultural research institutions. Its job is to identify the difficulties that farmers' face, transfer those problems to scientific research to develop acceptable answers, and then transmit newly discovered technology from research institutes. Another responsibility is to make advice to farmers on how to enhance the quality and quantity of their crops. Research findings will go wasted if this action is not carried out (Table 2).

Table 2. Agricultural Extension Activities in Sulaimani Governorate 2013-2018 (Source: Review of the Agricultural Sector in the KRI, 2019) [54]

No.	Type of Activities	No. of activities					
		2013	2014	2015	2016	20 17	First half of 2018
1	Field visit	108 2	850	839	785	266	208
2	Farmer Meetings	99	22	15	2	1	5
3	Training for farmers	41	14	29	4	2	2
4	Training for employees	0	0	16	4	2	1
5	Field demonstration for wheat	9	0	0	0	0	0
6	Field demonstration	0	8	29	3	0	0
7	Field day	0	0	11	0	0	0
8	Wheat cleaning training	2	0	0	0	0	0
9	Agricultural exhibition	0	2	4	1	0	0
10	Workshop	3	4	10	3	1	0
11	Seminar	9	17	33	19	0	5
12	Animal numbering	42	0	0	0	0	0
13	Telephone communication with farmers	18	0	0	99	39	36
14	Summer trainings for students (College andinstitution of Agriculture)	3	0	0	0	0	0
15	Agricultural programs in radio	0	0	1	0	6	0
	Total	1308	917	987	920	317	257

Agricultural extension program, on the other hand, plays an important role in improving farmer awareness and knowledge, as well as encouraging them to expand their usage of greenhouses. It also aids in the resolutio n of marketing issues, which are the primary impediment to greenhouse production continuing owing to high prices.

In KRI, there is a high demand for veggies, but the production supply cannot meet it. As a result, imports from neighboring countries are required, resulting in the construction of greenhouses to enhance domestic vegetable crop output and satisfy market demands in order to achieve self-sufficiency and export.

4. Conclusions

Rural communities in KRI continue to face water shortages and the harmful effects of climate change due to a lack of agricultural water policy. Lack of a defined land-ownership policy, sufficient funding to support agricultural initiatives, a lack of modern irrigation technology, and a lack of institutional-rural community links for exchanging scientific findings and putting them into practice on the ground have resulted in the current unsustainable scenario. Also, it caused in a slew of unsustainable agricultural water outcomes for the region's present and future generations. The governorate of Sulaimani, which includes Garmiyan, has the most cultivated land in KRI. As a result, any effective policymaking on how to utilize resilience aspects in agricultural water management will ensure the current and future water sustainability of the KRI.

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