



RAINWATER HARVESTING: AN EFFECTIVE SYSTEM FOR ACHIEVING FOOD SECURITY

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ABSTRACT

Rainwater harvesting (RWH) considering as a technique system is being exploited of the variance topographic nature of the earth's surface, such as the use of valleys, depressions and oases, or through the berms or small dams from stone or cisterns building, to collect then reserve and store rainwater and floods during winter periods in various ways that differs in the purpose of collecting them depending on their rainfall rates and reuse when needed, whether for drinking, supplementary agricultural irrigation or to feed groundwater. Iraq in general and Nineveh Governorate in particular have been experiencing severe environmental conditions in the past two years, (2020/2021) & (2021/2022), and the most important of which is the rainfall lowing and the increasing demographic growth offset by significant water consumption, so as to ensure continued food production, increased irrigation projects have become urgent. Iraq is one of the countries that suffers from water scarcity in general and the amount of rainfall ranges (99.8 billion cubic meters/year) fluctuating and irregular distribution, so it requires investing this quantity and managing its use rationally by the system of rainwater harvesting. Northern of Iraq, including Nineveh Governorate is characterize by cereal winter crops production by depends mainly on rain fall to produce winter crops such as Wheat and Barley by rainfed agriculture method with rain requirements of more than (400mm/year), the rate of rainfall for a period (1970-2011) reached (170.3 mm/year). The rainy season in Nineveh Governorate extends from November to the end of May with fluctuating falls and small amounts that do not meet the needs of agricultural crops. This current study was prepared to activate the potential for harvesting rainwater for agricultural uses in the rain-fed areas prevailing in Nineveh Governorate. The agricultural system in semi-dry areas, including Nineveh Governorate, suffers from drought due to lack of rain and lack of yield in winter crops, including wheat and barley, which attracts the attention of researchers and stakeholders in finding a strategic solution to this problem, which lies in the activation of rainwater harvesting techniques, which is an integrated system for water management in rain lands in semi-dry areas to meet the lack of water need for agricultural crops. This system includes facilitating the flow of rainwater through canyons according to the decline of the land towards depressions, valleys and water basins prepared for this purpose to conduct supplementary irrigation with sprinkler irrigation techniques to activate the productivity of agricultural crops, improve the performance capacity of rainfed farming systems, sustain green cover, reduce biodiversity extinction and address the problem of environmental drought to achieve agricultural sustainability.

Keywords: Rainwater, drought, food security, supplementary irrigation, Nineveh Governorate.

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INTRODUCTION

The rainwater harvesting techniques (RWH) is an old idea that is outdated over time, as it was used by Ur residents city of Iraq around 4,500 BC, but the concept of rainwater harvesting has only recently received serious attention as rainwater harvesting is using in worldwide for various purposes especially in agricultural projects. Due to the increasing pressure on available water resources, despite the scarcity of water and the relentless pursuit of food security, especial attention has emerged to this concept by execute further scientific studies and researches on the topography of the nature of the Earth, the state of the atmosphere, the preparation of maps, designs and land surveying the use of remote sensing program and data of techniques of the world space agencies each of NOAA and NASA, to obtain information about the global ecosystem for the purpose of implementing rainwater harvesting technique projects .Water resources covers three quarters of the earth's surface, but its valid water are limited not more than (2%), and the main source of all types of water is rainfall, where there is daily the rainwater falling on the surface of the earth and lost in various ways including evaporation, runoff and percolating towards the ground without benefiting from it, where the technique of rainwater harvesting is the best way to invest this water for various uses, especially agricultural, by taking advantage of the natural valleys by establishing basins and water baffles to keep the valleys filled by water and benefiting from it in supplementary irrigation procedures for agricultural crops, which are the source of food energy for humans. In most semi-dry regions of the world. So, conducted the highlighted to the growing gap between water supply and demand in sustainable agricultural development practices, thereby undermining food security. In such cases, non-traditional water resource practices such as agricultural rainwater harvesting can be used to address the scarcity of agricultural irrigation water. Therefore, it became clear to highlight the role and importance of rainfall in providing the water need for agricultural projects by preparing studies to know the annual precipitation of rainwater all over the world and the possibility of rainwater harvesting for agricultural purposes and identifying sites of an appropriate topographic nature. Which can exploit the ground depressions and valleys to store water [1, 2].This technology is developed through mapping under the GIS media, while estimating the efficiency of water supply coverage to meet the needs of agricultural crops, the application of appropriate (RWH) techniques in such agricultural areas is a sustainable option for water management to achieve agricultural sustainability, thereby improving food security. Rainwater is an alternative source of surface and groundwater resources, where investment has become often necessary to meet the demand for water under the current deteriorating environmental conditions, especially in semi-dry areas. Recently, rainwater has been identified as a supplementary source of winter agricultural crop irrigation and clean drinking water that rainwater harvesting is a potential global solution to cover the ever-increasing demand for water while reducing the negative environmental impacts of depletion of water resources and floods. In fact, the replenishment of all surface and groundwater resources is done through rainfall of various kinds (rain, dew, fog, hail, snow, sleet and ice pellets) with precipitation being the main source of the hydrological cycle in nature. Thus, rainwater harvesting systems involving rainwater collection, storage and careful use of modern irrigation techniques are suitable solutions for water supply as long as rainwater falling to the ground in addition to its direct use[3].One of the most distinguished countries in recent times in

rainwater harvesting applications (RWH) is the state of India, where it follows innovative methods different from traditional methods of rainwater harvesting in terms of context, using modern advanced sciences in soil sciences, earth sciences and water sciences; following modern techniques in the study of land characteristics and hydraulic systems; and following sophisticated management methods such as hydrological and hydraulic modeling, and relying on technological techniques in water management, distribution and use. In particular, artificial intelligence in the robotics system, and the amount of water used in the use of civil engineering and hydrology technology. In terms of purpose, modern water harvesting systems are used as resource management solutions. The preparation and implementation of many engineering designs for harvesting surface and groundwater by artificial feeding methods ensures strategic storage of water, and the implementation includes also studying the activities and effects of water harvesting systems in local hydrological systems in terms of achieving efficient water storage and the level of balance of the basin storage with falling rain and economic feasibility according to a long-term perspective and in the manner of ensuring the safety of the ecosystem. The provision of scientific data on environmental, hydrological, topographical, meteorological, remote sensing maps and space maps by NASA and NOAA global agencies with the economic feasibility of rainwater harvesting systems contributes to the accuracy and success of implementation and the effectiveness, performance and efficiency of the desired results [4]. Water scarcity is one of the causes of food insecurity and widespread hunger and social poverty due to low incomes. Water is the main factor in changing the basic conditions of the existence and development of poor areas and residential stability. Because of the topographical variation of land from mountains, plateaus, valleys, plains and slopes, it will be difficult to build a large water convey project that will be economically useless. The RWH contributes to the process of modifying the agricultural system affected by drought, thereby enhancing the provision of income to the product. Previous experience shows that rainwater harvesting is an innovative approach to integrated and sustainable water development for areas with low agricultural production due to lack of rainfall [5]. RWH techniques in Iraq are considered great importance because of their role in the development of water and agricultural resources, given the harsh climatic conditions in Iraq, almost dry, low rainfall fluctuation from year to year, as well as rising temperatures, which lead to increased evaporation, although more than half of Iraq's area is desert land suffering from water scarcity, so it requires the application of water harvesting techniques in Iraq by various means, including construction of small dams and reservoirs on valleys throughout Iraq, especially in dry, semi-dry and semi-desert areas. This requires overcoming the difficulties and obstacles facing water harvesting technology, including natural, regulatory, administrative and funding constraints. Nineveh Governorate has a network of valleys from the far north to the far south of Mosul, which helps to provide a reservoir sufficient for winter crops to need irrigation water if invested [6]. Iraq has limited water resources and will be under severe water demand in the coming years due to the sources of the Tigris and Euphrates rivers are under the control of neighboring countries. Therefore, Iraq must consider natural and non-conventional water resources to overcome this problem. Rainwater harvesting is one of the solutions in filling the water need for agricultural fields in Nineveh Governorate, so it requires studying rainwater in terms of quantities and distribution in different areas of the province. The data indicated that rainfall in the province fluctuated from year to year, with an annual average of (200-300 mm). The average annual amount of rainwater used effectively for agricultural purposes is estimated at about (1 billion cubic meters), but this amount is irregular and insufficient compared to the size of the agricultural areas in the province [7]. Therefore, it is necessary to establish and implement rainwater collection and storage stations in various agricultural sites side by side the agricultural fields, the stored rain can be used for agricultural irrigation, as well as the development of sustainable watersheds in appropriate locations in rainfed areas. In addition to cost-effective support to facilitate owning special technological techniques, including modern irrigation systems. The method of water harvesting is considered ancient, as its use dates back to more than a thousand years in various dry lands around the world. However, the techniques of these systems have undergone great development over time, especially in matters related to irrigation, in addition to the development of water conservation techniques to provide Irrigation water for humans and animals.

MATERIALS AND METHODS

The current study was carried out at the Northern Technical University- Technical Institute/ Mosul in the department of water resources. Nineveh Governorate is considering the first city in following the system of rainfed agriculture for production of winter crops on Iraq level , which is the source of the main food energy of humans, especially wheat and barley crops, which are grown under dry farming conditions by ensure the production with precipitation ranging (400-500 mm/year), but the amounts rain falling in recent years do not cover the needs of the crops above due to global drought . The study has been prepared to address water scarcity and meet the water need of agricultural crops and prevent their failing by rainwater harvesting technology to ensure agricultural production and food security, where the Nineveh Governorate occupies an area of (37.323 km²) from the total area of Iraq, which is (435.052 km²), which constitutes (8.6%), its geographical location between the latitudes (36° 21' 34" N, 43° 9' 10" E), the Governorate is located in the Northwest part of Iraq. To achieve the objective of the study, the analytical inductive approach was used for factors associated with the technique of rainwater harvesting (RWH) and in particular the environmental characteristics prevailing in the region, including rainfall and its relationship by food security in addition to climatic factors such as precipitation rates, maximum , minimum temperatures, relative humidity and geographical characteristics, including the prevailing topographic nature and spatial and temporal analysis of the agricultural areas that make up the bread basket of Iraq, which are each of the following districts ; Mosul, Al-Baaj, Sinjar, Tel Afar, Hamdaniya, Tel -kaif, Sheekhan, Makhmur, and Al-Hadar , which include (22) sub-districts as in figure (1). With the method of scientific analysis in the analysis of the prevailing drought phenomenon of lack of rain and the accompanying decline in agricultural production year after year and the development of solutions to ensure the water need for winter crops. The following formation shows the global drought indicator depending up on dominant climate characters. [Table-1]

Table-1: The global drought indicator depending up on dominant climate characters

Dominant climate characters	Drought indicator
Dry	Less than 5
Semi-dry	5 - 9.9
Semi-humid	10 - 19.9
Humid	20 - 29.9
very humid	More than 30

RESULT

Recently the global ecosystem is suffering from degradation it is followed the subsequent cycles of drought on the Planet , and the continuation of environmental crises that constitute a transboundary phenomenon, which requires adapting to it and finding strategic solutions to these global challenges, in addition to the increasing global demographic growth with high water consumption and extreme forcing on available water resources, with the difficulty of exploiting them in some cases due to high cost and low groundwater levels, all these are alarming factors, that requires to finding serious solutions , this lies in the investment of rainwater harvesting techniques, which have recently received great attention in arid and semi-arid areas, including Iraq, especially Nineveh Governorate. Due to climate instability and changes in the ecosystem throughout Iraq, including drought, low rainfall, widespread desertification and thermal warming, these factors are an warning in finding an alternative to the phenomenon of drought, as harvesting

rainwater is the best solution to take advantage of the rainfall that occurs profusely for short periods and runs uselessly randomly and unregulated on valleys and depressions ,which, a large part of it is lost by drifting, filtration and evaporation without investment [8]. Figure (1)shows Administrative map of Nineveh Governorate and Figure (2) indicates to the climate zones in Iraq.



Figure-1: Administrative map of Nineveh Governorate

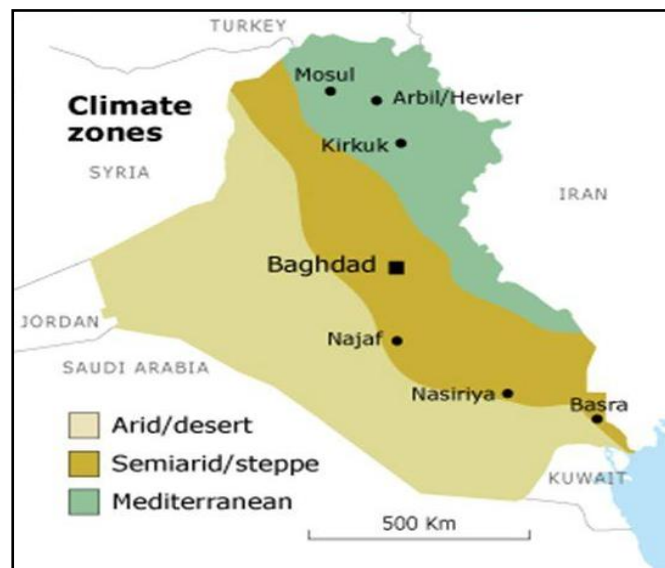


Figure-2: Climate zones in Iraq.

In Iraq and specially form in Nineveh Governorate considers rain water harvesting system is of great importance because it has a role in the development of agricultural system and water resources and the provision of water for various uses, due to the drought cases that Iraq suffers, the lack of rainfall and atmospherically fluctuation between the years, as well as the high temperatures that lead to high evaporation operations, knowing that about half of the area of Iraq is desert land suffering from water scarcity , that is possible to applying water harvesting technology in Iraq by various means, such as the construction of dams and reservoirs in certain special sites for the purpose of feeding basins . The water harvesting technology in Iraq faces

some obstacles and problems, including natural, regulatory, administrative and funding constraints, where the average rainfall for a period of (40) years ranges from (1970 to 2011) in (mm/year) at Mosul district (354), Sinjar (355.1), Tel Afar (288.6), Al-Baaj (218.8), Rabi'a (350.6), Tel-Abtah (208.6) and Makhmour (266.5), and the average amount of precipitation for the whole Governorate ranges from (99.8 billion cubic meters/year), but it does not meet the need of winter crops [9,10]. Our study aims to invest rainwater in economically feasible, environmentally safe and socially effective ways in the agricultural system and to benefit from water at its in first rainfall before it drifts and to exploit it in the method of supplementary irrigation by agricultural production, pastoral farming and feed production, in addition to sustaining vegetation, preserving biodiversity, protecting the genetic assets of plants in their natural habitats, rehabilitating degraded natural environments, rational use of terrestrial resources and groundwater feeding. RWH is calling also a water conservation system (W.C.S) which is basically aims to prevention run-off rainwater in agricultural areas by collecting & storing and retaining it in basins. This is conducting in arid and semi-arid areas which characterize by rainfall of more than 200 mm / year in areas that suffer from drought as well as semi-desert according to the surface water catchment area for rainwater harvesting on the site and emphasizing the adoption of soil service operations by methods Sustainable agriculture, including the method of conservation agriculture (zero tillage), a minimum tillage practice in which the crop is sown directly into soil not tilled after harvesting of the previous crop [11]. Rainwater reservation designs consist several forms :as small earth dams, rivulets, oases, stone basins, concrete dams, or cisterns and wells, that is conducted to collecting the rainwater from the territories, mountains, plateaus and hills in according to the slope system of the earth with control of runoff and directing the water towards the grooves then to watersheds prepared for this purpose, which are in different lengths between (30-200 m), so that irrigation of the cultivated are is according to the efficiency of the storage of rainwater that covering of the water need of the agricultural crop to achieving homogeneity of plant growth and completion of its life cycle equally, Figures (3,4) represents models basins for harvesting rainwater.

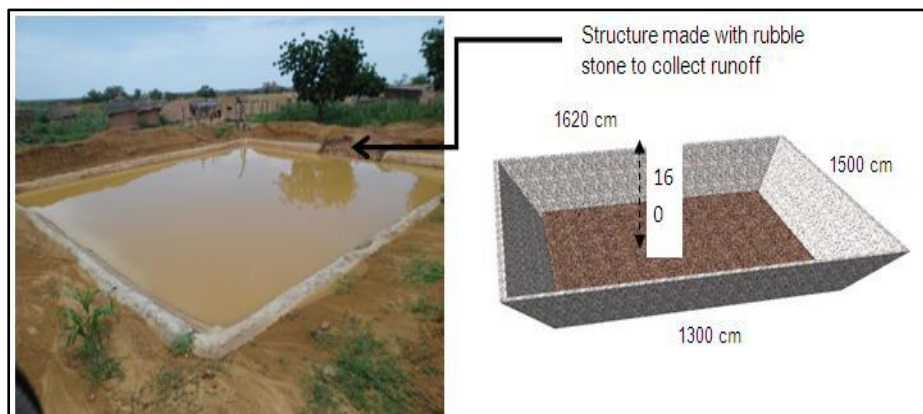


Figure 3: Rainwater harvesting basin between the plateaus.



Figure 4: Rainwater harvesting basin (left) and its dimensions (right).

The adoption of this system plays a role in the continuity of soil moisture renewal, increased crop production and the maintenance of land from desertification, which requires the formulation of a strategy for the implementation of rainwater harvesting and inclusion in national policies in the areas of water, agriculture, land sustainability, livestock, rural development, urban and environmental development, and the activation and formalization of policies and the drafting of regulations and legislation while providing an environment conducive to (RWH) work with the development of standard design frameworks for RWH systems and preparation effective monitoring systems to assess their performance. It also requires the implementation of demonstration projects and research on the efficiency of rainwater harvesting in productive projects, integrating rainwater harvesting with all production projects to achieve agricultural sustainability, and supporting producers and rural communities to develop rainwater harvesting techniques. In today's world, a variety of rainwater harvesting systems are used to ensure the growth of crops, grasses and trees in areas where rainfall is scarce or the distribution of rainfall in agricultural areas is irregular, where many systems are applied under a variety of conditions and on a wider range of agricultural crops [12, 13, 14]. The rainwater harvesting system (RWH) is generally seen as a promising and effective alternative water resource in terms of agricultural uses and its economic, environmental and technological benefits for water uses. The application of (RWH) technology reduces water waste and loss when rain falls and reduces the harmful effects of floods, recharge of groundwater, water storage for agriculture and livestock needs, and the provision of alternative water sources. Nineveh Governorate is the breadbasket of Iraq bread contains an agricultural area estimated (37323 km²) suitable for agriculture in most of its area and average in other areas somewhat, but the specific factor for agricultural production in it is the lack of rainfall and fluctuation and irregular distribution of rainfall, which is a cause of drought and the lack of agricultural yield. The solution to the problem lies in the process of collecting rainwater on the surface of the earth before penetrating into the soil and reaching the level of groundwater, conducting it towards land regression then store it in watersheds similar to lakes but at a lower level, and then exploiting it in the uses of agricultural irrigation and other traditional uses. The importance of harvesting water also contributes to the provision of drinking water in rural areas by treating and desalinating rainwater as part of low-cost water purification and purification projects. Groundwater levels are enhanced by groundwater re-feeding. Collecting them also contributes to reducing flood damage and preventing salts from piling up in the soil to make agricultural soils consistently viable, not lumbering and salty. One of the results of water harvesting is to support and strengthen dry environments with water harvesting systems to make productive agricultural activity possible despite the scarcity of other water resources, so water harvesting provides opportunities in the distribution of water attracted by rainfall to develop various agricultural projects so that it contributes to the production of larger quantities of crops in the rainfed zones for raises production levels in dry areas to ensure stable agricultural production without the migration of the producer to the land. One way to harvest water is to follow mechanical methods that require the allocation of low land and have a slope of different directions and processing and preparation by cleaning it from plant waste, softening it and pressing its soil with heavy rollers (soil compactor roller) to reduce its permeability and without losing storage water or by covering it with metal or plastic sheeting, or using chemical methods to reduce water permeability of soil such as paraffin wax or cover its land with black plastic cover, or follow the method of cistern and wells to according of the type of use [15,16]. For the importance of this affair, the Department of Water Resources Directorate in Nineveh Governorate participated in the water harvest workshop organized by the Department of Research and Development in Nineveh Governorate and the participation of all relevant departments, including the Directorate of Agriculture of Nineveh, the Directorate of Environment and the Presidency of Mosul University by its specialized centers in this field and through the electronic platform for six days. In addition to studying environmental problems through research and recommendations to build water harvest dams on the valleys to invest rainwater to develop and grow wheat and barley crops and develop green cover, natural pastures and biodiversity by addressing drought, drought is a serious environmental challenge that threatens Iraq because of its significant effects on agricultural production and food security, including risks to the basics of life year after year, the water crisis

worsens in Iraq as rainfall rates decline and expand drought, until Iraq became the "fifth" country in the world most affected by climate change, according to the UN report. This is to exacerbate the disaster with high temperatures, low levels of rain and drought, which deprives the winter crops from natural irrigation water, so wheat production is expected to decline by (17%) in Nineveh Governorate as a result of the drought, as these indicators reflect the worsening crisis that is ravaging Iraq due to drought, desertification and the decline in the groundwater level, and the decline in agricultural production and other agricultural products related to animal production products because of its impact on food security. Nineveh Governorate has been known as breadbasket of Iraq in ensuring foods for centuries, but in recent years, with high levels of drought, desertification, high warming and lack of support for the agricultural sector and rainwater scarcity, the province's production of wheat and barley crops has declined, that In 2020, the province produced (927,000 tons) of wheat, achieving self-sufficiency, but in 2021, the amount fell to (89,000 tons) due to drought and lack of rainfall. According to UNEP, in 2015, every Iraqi had a share of (2,100 cubic meters) of available water per year, but by 2025 it is expected that the amount will be reduced to (1,750 cubic meters) due to drought, threatening the long-term stability of agriculture and other productive activities in the country, as well as threatening the health of the population [17,18]. Droughts, high heat waves, water stress, floods, desertification, salinity, loss of agricultural land, mass migrations and others are detrimental to food security. In addition to influencing the key sectors that form the basis of development in the country due to water scarcity, it has become absolutely necessary to take strict measures to address the water file internally and externally and to enhance the flexibility of Iraqi society to adapt to climate change.

Iraq has strategic dams such as the Mosul dam, which a few years ago threatened Iraq with sinking, which was a huge water reservoir, but today the water has dwindled, reflecting Iraq's water crisis, which is added to its other complex environmental crises. The whole world is going through a water crisis, including Iraq, and the best way to secure and store water is in the rainy season by building several small dams to store water in agricultural areas, the idea of building large dams in light of climate change and lack of rain has become impractical, so what is the benefit of the dam of large water-free in the light of drought?, where the idea of small dams has become practical and provides benefit to different areas this in addition to the ability to store them and make the most of them faster, in addition to the cost of building them is cheap. It must be an internal work to organize and manage the water available to Iraq, and the idea of harvesting water must be addressed by the construction of small dams to harvest rainwater in villages and areas far from city centers, that rain, ice pellets, and snow in northern Iraq will be more frequent in December and February, which contributes to the continuation of river and stream drains to reach their maximum levels, and the aquifers and springs are renewed, and the accumulation of snow on mountain tops at high altitudes melts and disappears slowly at the beginning of the spring and summer seasons where the land turns from winter green to yellow in summer due to water scarcity, so it is necessary in Iraq to work a scientific strategy initiated by active managing for a sustainable and planned water storage approach to establish new strategic dams near to agricultural land or basins to harvest and store these water if not stored or not managed causing torrential and landslides and soil degradation, then laying a strategy design for integrated and sustainable management of Iraq's water resources, the importance of RWH is reflecting on increase the irrigated area and then the crop yield in the regions when combined with an effective system like supplemental irrigation. Rain-fed areas requires effective technique in terms of saving significant runoff water for irrigation purposes and this might be achieved by rain-water harvesting (RWH) technique. The small dams are considered as the best solution to conserve water especially in arid and semi-arid regions. That require to design a small dams series to conserve rainfall water [19, 20]. The severity of the simultaneous environmental drought and the decline in the level of the Tigris and Euphrates rivers after Turkey completed its huge impregnable dam on its territory, so the exploration and search for an alternative has become an inevitable and promising strategy to solve the problem of drought and achieve food security. The geometric designs for the creation of small double padded storage basins by establishing a horizontal basin in dimensions for example (10m long×5mwidth×3m depth) and inside (at the

center) there is another vertical basin which must not reach the level of groundwater of certain dimensions for example(1m length × 1m width× 30m depth),note that the three dimensions designed according to the slope of the earth and in the lowest area location avoiding waste of agricultural areas by creating storage basins. Therefore, the interest in this study was to emphasize the importance of activating and applying rainwater harvesting techniques in Nineveh Governorate with environmental and economic feasibility as the province constitutes the basket of bread of Iraq, which has been suffering over the past two years(2020/2021-2021/2022) from a severe shortage of rainfall to meet the need for winter grain crops and to achieve the production, and figure (5) shows the hydrological cycle of water, Table(2) Indicates to global classification of regions in precipitation.

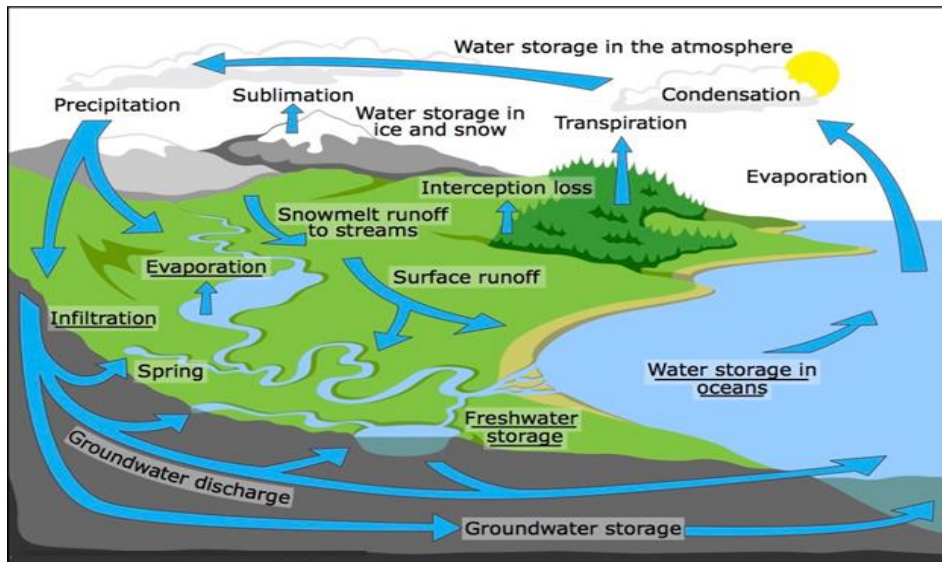


Figure-5: indicators to hydrological cycle of water

Table-2: Global classification of regions due to precipitation

Region	Annual rate of precipitation(mm)
Desert	0-100
Semi- Desert	100-250
Arid	250-500
Semi-Arid	500-750
Semi-Humid	900-1500
Humid	More than2000

CONCLUSION

We conclude from this study that the phenomenon of drought has become a global problem in dry, semi-dry and semi-wet areas that threaten water and food security in general. Iraq suffers

from it severely, especially Nineveh Governorate, which is characterized by the rainfed agriculture, where it is located within the semi-dry region in the environmental and geographical classification, it suffers from a lack of rainfall in recent years severely due to ecological degradation of by the result of irrational human activities and through our study we can concluding & recommending the following:

1. Most of the rainfall in the Nineveh Governorate occurs in winter from November until May fluctuating between one location and another and from year to year in addition of the irregular rainfalls.
2. Most of the precipitation is a picture of water only, and there is no snowfall and ice pellets except rare cases.
3. Rainfall increases as we head to the south of Nineveh Governorate towards the north and northeast.
4. The climate conditions of Nineveh Governorate are affected by the Mediterranean climate by the movement of medium & lows atmospherically depression not high to carry a little water vapors, which makes rainfall weak.
5. The climate in Nineveh Governorate is cold, humid in winter and hot dry in summer and is characterized by a low rainfall rate which range (200-300 mm/year).without covering the needs of grain winter crops.
6. We recommend activating the rainwater harvesting system in the districts of Nineveh Governorate (Mosul, Al-Baaj, Sinjar, Tel Afar, Hamdaniya, Tel kaif, Sheekhan and Makhmur), which all suffers from drought, where rainfall does not adequate to the sustain of agricultural production, although the Governorate was the main source of grain production in the past, but the region of Al-Hadar is characterized by limited rainfall and suffer from severe drought not suitable for rainfed agriculture but only potable to establish natural pastures because its rainfall is below (100 mm/year).
7. Rehabilitation of the degraded agricultural land, which begins to enters era desertification, such as the areas of Sinjar district, Tel-Abtah district and the district of Al-Baaj, where requires not to leave it to become a haven for desert creeping, but require to activate the RWH system to narrowing the creep of desertification.
8. We recommend using the designs of small double storage basins lined as horizontal basins of certain dimensions and in them (at the center) another vertical basin so that it does not reach the level of groundwater (don't exceed 150mm in depth) to meet the efficiency of the water need for the agricultural crop, and its design is according to the slope of the land and in the lowest area of location and with limited areas, so not to waste agricultural spaces by creating large storage basins.

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