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Review

Hundred percent renewable wastewater treatment plant: techno-economic assessment using a ret screen, case study Syria

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ABSTRACT

In regions prone to droughts, such as Syria, water shortages and urbanization increase the need for water to meet domestic, industrial, commercial, and agricultural demands. According to research, the leaching of toxic substances from the treatment of sewage water stations is likely to influence the quality of groundwater. In some locations, the overexploitation of surface water and groundwater resources has outpaced natural recharge rates, resulting in water scarcity and high demand for safe drinking water. Alternately, climate change has a significant impact on Syria's water situation, resulting in protracted drought in several sections of the nation. Water scarcity has been exacerbated by civil unrest and armed conflict in several areas of Syria, particularly in areas controlled by anti-Assad Syrian rebel groups. Previous studies established that groundwater and surface water pollution is a widespread problem across the entirety of Syria. The high levels of pollution resulting from concentrated agricultural and industrial activities pose a threat to drinking water sources. In addition, industrial waste, which might contain nitrate, phosphate, and heavy metals, contributes to a substantial amount of pollution. This project seeks to increase the use of wind and solar energy as a means of powering water treatment plants in Syria, where water is contaminated with heavy metals and other toxins.

1. Introduction

The UN defines climate change as long-term temperature and weather shifts. Solar cycle variations may cause these movements. Since the 1800s, human actions like non-renewable energy sources like coal, oil, and gas have caused climate change. Climate change is influencing water access worldwide, creating droughts and floods. In many locations, increased evaporation will reduce the water supply. Summer deficiencies will result in reduced soil moisture and severe agricultural dryness. Climate change will cause increasingly severe droughts, affecting water management. In most Middle Eastern nations, social and climatic factors contribute to serious water problems [1]. Similar to the rest of the region, Syria has considerable natural hydrologic fluctuations. Climate change has exacerbated Syria's drought. In the last century, multiple droughts have caused serious water scarcity and economic challenges. Syria experienced six catastrophic droughts between 1900 and 2005, with winter precipitation falling to one-third of average levels. The sixth drought extended over two seasons as opposed to one season

for the previous five [2]. Syria endured a multi-season, multiyear drought from 2006 to 2011 that caused agricultural losses, economic instabilities, and mass migration (Worth 2010). During the civil war, some observers suggested that drought causes, including agricultural loss, water shortages, and water mismanagement, contributed to social breakdown and bloodshed [3]. Climate change has affected the water supply in Syria. The Tabqua Dam on Syria's largest river, the Euphrates, dropped six meters in 2020. According to data from the United Nations, the Euphrates was so low that pumping stations could no longer support the river's water. Five million people in the region lacked access to adequate water in 2021, and a third of the 200 pumps along the Euphrates were impacted by low water levels. Less rain has made it take longer for groundwater to fill up, which boreholes and wells rely on (REACH Report 2021). Alok's restricted capacity prohibits piped drinking water to around 500,000 people elsewhere in the country. As a result, homes must rely on unstable water sources, such as private boreholes or hoarded water. Conflict and upheaval threaten Syria's water resources. During fighting near Aleppo in 2012, a major water pipeline was broken, and the city of 3 million people had water shortages in September [4]. Anti-Assad Syrian arm groups took the Tishrin hydropower dam on the Euphrates River in late November 2012. The dam is essential to the regime and provides electricity to several areas in Syria. In February 2013, anti-Assad forces overran the Tabqa/ al-Thawrah dam, which provides the majority of Aleppo's energy [4]. In countries with limited water resources, focusing on water systems underscores the strategic importance of water supply, hydroelectric power, and flood management.

In any country, the electric power sector contributes considerably to social, economic development, improving lives and enhancing welfare. This sector relied on traditional energy sources like burning fossil fuels to produce electricity. This technique emits gas; hence it's considered environmentally damaging. These gases' releases into the atmosphere have caused climate change or global warming. Despite efforts at all levels by environmentalists and world leaders to minimize dependence on oil by elevating discussions on renewable energy as an alternative, fossil fuels contributed 73.5 percent of global power generation in 2017, with renewables providing 26.5%. To address these issues, the global community must implement renewable energy. Biomass, solar, wind, and other renewable energy sources are among the most prevalent and successful methods for promoting sustainable development in the electric power industry [5]. During this research, we discovered that one of the major impediments to renewable energy technology (RET) adaptation is the lack of public awareness. World leaders are now discussing renewable energy at nearly all international forums as a means of creating awareness of the need for a cleaner energy source. China, The United States of America, and Brazil are currently leading the drive for renewable energy technology. If this is the case for politically and economically stable countries, then it is applicable for war-torn countries like Syria to embrace renewable energy as a power source in the post-crisis redevelopment process of the country's electric power sectors. Post-conflict reconstruction of this sector requires inventive solutions using renewable energy technology (RET) that meet the country's technical and economic norms. Wind, solar, and hydropower could be used to power water distillation plants in Syria. The goal of this research is to increase the use of renewable energy, specifically wind and solar, to power water treatment plants in Syria, where water is polluted by heavy metals and other contaminants.

2. Background Of the Study Area

Syria, officially known as the Syrian Arab Republic, is a Western Asian country in the Eastern Mediterranean, and it is divided into 14 subdivisions. The Mediterranean Sea surrounds it on the west; Turkey on the north, Iraq on the east and southeast; Jordan on the south; and Lebanon and Israel on the southwest. To the west of the Mediterranean Sea is where Cyprus is situated. Syria is a hilly country that also contains plains and deserts with abundant vegetation. Damascus is Syria's capital and largest city. Syria is located between 32° and 38° north latitude and 35° and 43° east longitude. Syria's climate is dry and hot in the summer and chilly in the winter. On the coast and in the western mountains, the Mediterranean climate features two distinct seasons: the warm and dry summer (May to October) and the generally cool and rainy winter (November to April). Syria receives adequate rainfall in the west during the winter and to a lesser extent in the spring and autumn. Summer in the west is almost entirely dry, with very little probability of rain along the Mediterranean coast. The amount of precipitation in the inland areas of Syria is much lower throughout the year than in the rest of the country. In the summer, the central and eastern areas of Syria receive nearly little rain and only a little rain in the winter. In Syria, one of the most significant sources of water is precipitation in the form of rain. The annual rainfall resource is projected to be 46 billion cubic meters on average. This figure is substantially lower during drought years. Furthermore, both in terms of location and time, rainfall is unevenly distributed. In Syria, there are sixteen tributaries and rivers, five of which are shared internationally. Their flow accounts for nearly 75% of the total organized surface water resources in the country and more than 45% of the accessible water resources. The majority of the country's geological formations have groundwater. Some of the most important aquifers are nonrenewable (fossil water); therefore, their extraction is called mining. In almost all places, historical and contemporary data show that groundwater withdrawals considerably outnumber natural recharge rates [6]. Groundwater harvesting is becoming a major source of fulfilling the drinking needs of many families in Syria due to the paucity of surface water in many locations and cities. However, using untreated groundwater for drinking is not a safe practice, as research has demonstrated that heavy metal contamination has damaged groundwater quality. In Syria, a high proportion of nitrate is also discovered in groundwater resources [7]. Numerous kinds of research on the quality of groundwater have found that nitrate originates from a number of nonpoint and point sources of contamination, including industrial, urban, and agricultural activities. The use of nitrogen-based fertilizers is the most common human source of NO3 in shallow groundwater systems [8]. Syria is a semi-arid country with dwindling water supplies. Agriculture

is Syria's most water-intensive industry, accounting for over 85% of the country's available water. Domestic water uses account for just around 9% of total water consumption. Syria's fast population growth, which reached 2.7 percent in 2006 [9], was a significant challenge before the civil war, resulting in a quickly rising demand for urban and industrial water. During our research, we discovered that many areas of Syria's surface and groundwater resources are polluted. The presence of heavy metals, high nitrate concentrations, and other dangerous compounds are the main sources of pollution.

3. Discussions

According to the findings of previous studies, as indicated in (Appendix I) of this paper, it has been established that groundwater and surface water pollution is a widespread problem across the entirety of Syria. Their investigation also revealed that the discharge of irrigation wastewater in Syria is responsible for the elevated saline levels seen in the country's groundwater. In addition, there is a high level of contamination caused by untreated sewage water, nutrients, and pesticides that come from the agricultural fields that are located nearby. According to the results of tests that were carried out on Syria's surface water, the country's water supply is polluted with a significant amount of biochemical oxygen demand (BOD) and ammonia [10]. The high levels of pollution resulting from concentrated agricultural and industrial activities pose a threat to drinking water sources. In addition to this, there is a significant amount of pollution that is brought on by industrial waste, which can include nitrate, phosphate, and heavy metals [9]. The discharge of sewage into the Awaj basin has led to the contamination of the spring water there, making it unsafe to drink [11]. Some of the wells in Ghouta have nitrate levels that are unsafe for human consumption because they are above the limits that have been established [12]. Because of the discharge of sewage and the use of fertilizer, wells in the coastal region that are used for drinking water have high concentrations of nitrates and ammonia [13]. These contaminations make the water unsafe to drink. Another factor that contributes to the excessive salinity of water in some wells is the intrusion of salt water into fresh groundwater aquifers. As a consequence of this, the water industry in Syria is facing significant challenges as a result of contamination and over-exploitation. The demand for water in Syria, particularly for irrigation and agricultural activities, poses a significant problem for the country's already limited and scarce water resources.

3.1 Water Resources in Syria (Ground and Surface Water)

The total water resources in Syria have only been the subject of a relatively small amount of investigation. Nonetheless, Kaisi et al. [14] discovered that Syria's total yearly available managed water resources are approximately 14218 million cubic meters (MCM), while the country's average annual consumption is approximately 17566 MCM, resulting in a 3348 MCM water shortage. Throughout this research, we realized that the majority of previous research had focused on particular water basins in Syria's various sectors or areas. Abo, et al. [15] conducted research on groundwater recharge in the Al Zerba basin. The hydro-chemical parameters of an alluvial aquifer in Damascus Oasis were investigated by Abou Zakhem, et al. [9]. This research was carried out by Hamade, S., and Tabet, C. [34]. Hydrochemistry and environmental isotope techniques were used by Asmael, et al. [16] to investigate the groundwater source and recharge mechanisms in the upper Awaj River basin (Syria). In 2008, E. Luijendijk and A. Bruggeman [35] investigated groundwater resources in the Jabal Al Hass region of northwest Syria. Their research consisted of an analysis of how the water resources in their study area had been utilized in the past, as well as their potential for future application. A review of the literature on the state of water resources in the Syrian coastal region between 2000 and 2010 was conducted by the authors Faour, G., and Fayad, A. [17]. When it comes to the socio-economic development of arid and semi-arid nations, groundwater is one of the most important factors. According to the Geological Survey (USGS) of the United States, groundwater is defined as water that is found underground in saturated zones below the surface of the land. In dry and semiarid regions, groundwater is a significant source of drinking water and irrigation. These environments are characterized by a lack of renewable water supplies, low annual precipitation averages, and high evaporation rates. Groundwater constitutes one of the most crucial resources for these kinds of environments [15]. The majority of these areas in Syria rely on groundwater for irrigation, drinking water, and agricultural activity. The groundwater aquifer is contaminated by chemical leachate and has a high percentage of toxic substances, so this is a bad practice. Following an in-depth examination of nearly thirty scholarly papers during our research, it is vital to recognize that Syria has six primary water basins:

i. Barada & Awaj basin,
ii. Orontes basin,
iii. Dajleh & Khabour basin,
iv. Coast basin,
v. Al-Yarmouk basin, and
vi. Euphrates basin.

According to a hydrological survey, these six basins are Syria's most important and widely used water basins. On a large scale, these six basins are divided into two regions: the southern, central, and eastern portions make up region one. The nitrate concentration within that zone is a result of human activity in these regions. The second area consists of the southwest, western, and northwestern parts of the country. This area has a high level of pollution susceptibility, as evidenced by the high levels of nitrates in sewer water.

3.2 Renewable Energy in Syria

Syria, a Mediterranean country, has an almost limitless supply of solar and wind energy, both of which can be used for a wide range of purposes. Despite this, the general population and private sectors are still quite modest in their use of renewable energy resources. This is due to several factors, the most important of which are the readily available and low-cost conventional energy resources, the high initial installation and production costs of renewable energy sources, and the restricted amount of space available for such setups. Despite numerous challenges, renewable energy is having its strives in Syria. In 2015, it was estimated that 23.1 percent of the energy produced in the country came from renewable energy sources, totaling 5,534 TWh (16 percent

hydro and 7.1 percent non-hydro renewables) [18]. Syria has significant solar and wind energy potential. It is estimated that Syria receives 5 kWh/m² of sun radiation each day, or 1800 kWh/m² annually. Mountainous West areas average 4.4 kWh/m², whereas deserts average 5.2 kWh/m². Sunlight is available 2,820 to 3,270 hours a year [19]. Renewable energy can ensure the nation's energy independence. Wind and solar power are potential renewable sources [19]. Figure 1 indicates the world's leading countries in renewable energy technology as of 2018. China tops the list with approximately 1,398,207 Gigawatt per hour (GWh). Next is the United States of America, with about 572,409 GWh and followed closely by Brazil with 426,638 GWh.

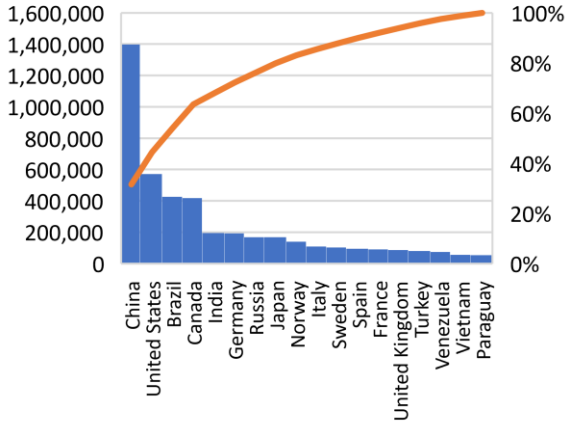

Figure 1. Leading countries in renewable energy 2018

3.2.1 Wind Energy

The wind is a potential renewable source of energy for the nation of Syria. To harness the strength of the wind and generate electricity, a wind turbine must be used. To harness wind, more than twenty different places throughout Syria had their winds measured. These facilities were used to evaluate wind energy's vast potential and, consequently, the economic viability of using it in the future. Solar and wind energy are abundant and free for residential usage, but they're not always easily accessible due to technical issues. In the last three decades, solar and wind energy have received increased attention due to economic and environmental factors. Solar and wind energy technologies, as well as storage and analysis, are all featured. In their study on the potential for wind energy in Syria, Al-Mohamad, A., & Karmeh, H. [20]. came to the conclusion that the country's wind resources might produce at least twice as much electricity as it currently consumes. After a careful investigation of previous studies' data, they found that the country may be categorized into four zones. In region 1, the average wind speed is 5 to 12 m/s for seven months of the year. For four months of the year, the average humidity in Region 2 is 34.9%, and the wind speed ranges from 4.5 to 10 m/s. Areas 3 and 4 have moderate winds, 4.5-7 m/s [21]. However, several parameters, including wind turbine design, hub height, wind efficiency, and energy losses, may also affect the quantity of power that may be generated by wind [20]. Despite its enormous potential to harness the wind as a source of energy in Syria the utilization of this technology remains a serious challenge due to several factors, including political instability, and the lack of social-economic stability.

3.2.2 Solar

One of Syria's many advantages is that the sun shines brightly. Annually, Syria receives an average of 1825 kWh/m² of solar energy, which equates to about 5 kWh/m² of solar radiation per day for the entire country (insolation). More than 2800 hours a year can be spent harvesting solar energy, although there are varying amounts of sunny time accessible each year. Every year, there are an average of 38 to 45 days that are clouded over. Scientists and engineers rely on accurate climate data, which is why a huge number of meteorological stations have been established across the Syrian environment. For solar energy projects, this is especially true before any feasibility studies have been conducted on the designs. A study by Al Maleh, H. et al. [22] found that if the Syrian government focused more on improving the efficiency of solar energy while rationalizing its use, it would alleviate the country's energy difficulties the fastest. Figure 2 is a photovoltaic map of Syria indicating the solar energy potential of the country from 1999 to 2018.

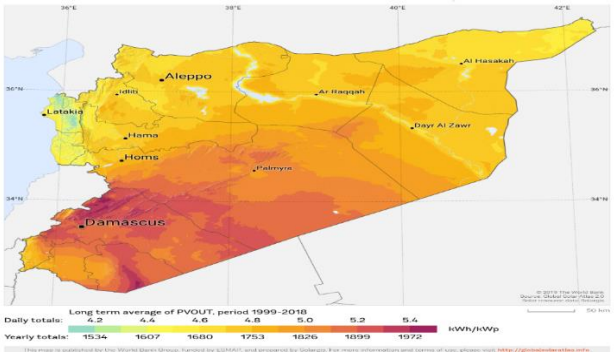

Figure 2. Solar resource map of Syria [23]

3.3 Desalination of Water Using Solar Energy

Two essential resources that continue to have an impact on the development of human civilization are water and energy. Both energy and water are necessary for the production of energy in its usable form [24]. Using groundwater or aquifer water in Syria has become a major issue due to the country's rising drought, which has been linked to climate change. Furthermore, the demand for agricultural operations in Syria is putting pressure on the already scarce limited water resources. To address this problem, there is a need to use solar energy as a renewable power source for water desalination. For instance, Damascus, the capital of Syria, has average solar radiation of 7.5 kWh/m² per day, which is about 2117 kWh/m² per year of solar energy [21]. If this energy is adequately harnessed, it is sufficient to operate a small-scale water desalination facility near Damascus. If this applies to the city of Damascus, then it applies to the city in Syria. It evidences a vast and endless amount of solar energy, which can be highly useful for a variety of purposes, given Syria's immense solar resources capability. It is one of the most innovative and viable technologies that can be successfully implemented to use solar energy as a power source for water desalination.

3.4 Wastewater and wastewater treatment in Syria

Syria's scarce water resources are stressed from overexploitation owing to agriculture. Climate change-related drought has impacted Syria's water resources in recent decades. According to past studies, groundwater and surface water contamination are ubiquitous in Syria. Their investigation also demonstrated that Syria's excessive salinity levels are due to irrigation wastewater discharge. Untreated sewage water, fertilizers, and pesticides from surrounding farms also cause contamination. Most human water activities produce wastewater, statistics show. Over 80% of the world's wastewater and 95% of most of the world's developing countries remain untreated [25]. There have been recent, concerted initiatives in Syria to purify wastewater for later usage. Given Syria's dire water situation, this is an important step toward stabilizing the country's water crisis and preventing health problems. Installing and maintaining wastewater treatment systems ensures that effluent quality is within acceptable standards and hence safe for the environment [12]. Over the past two decades, wastewater treatment facilities (WWTPs) have gained popularity in several Syrian cities. Significant initiatives are ongoing to improve water management, with an emphasis on the delivery network, retention, and hygiene. According to the country's Ministry of Health 2000 report, indicate that the bulk of Syria's more than a dozen WWTPs are not functioning properly, they serve a vital function in the country's many smaller villages. Syria's few operational wastewater treatment plants (WWTPs) rely heavily on power and suffer from a lack of sludge removal as their primary challenge [10].

Environmental challenges to water delivery are something the Syrian government is working to fix. Sewer lines and treatment plants have always been planned to help reduce water pollution, increase water efficiency, and decrease sewer fees. In Syria, sewage treatment plants have a variety of operational, design, and treatment-related issues, particularly in smaller areas. Syrian wastewater treatment practices lack a clear strategy and the option to select a treatment technology and level of treatment [25]. We would like to direct your attention to Syria's Water Resources authority, which has also published a guide for researching and selecting wastewater treatment inventions in Syria, highlighting the most effective technologies for the Syrian environment. The Rotating Biological Contactor (RBC) is an efficient method of treating wastewater in Syria's smaller communities.

3.5 Recommendations

According to the findings of previous research, it is necessary to construct small-scale wastewater treatment plants in a number of Syria's cities in order to improve the quality of the country's water supply. Utilizing Techno-economic Assessment is strongly suggested throughout this process. During the planning stages of this modest-sized wastewater treatment facility, the RET Screen program should be utilized. The authorities responsible for the construction of a wastewater treatment plant on a smaller scale should take into consideration the chemical, biological, and physical processes involved in water purification. The water's electrical conductivity and pH level should be given a high level of importance. Prioritizing the removal of heavy metals, the Biological Oxygen Demand (BOD), and the neutralization of nitrates are crucial during the water treatment process. It is also strongly suggested that, all across the nation, a desalination water treatment facility on a smaller scale be built to improve the overall quality of the water available for use in agriculture as well as in residential settings. Additionally, if farmers switched to drip irrigation, it might assist reduce water use as well as demand for water and losses caused by agricultural activities.

4. Conclusion

It is feasible to deduce that changes in climate will have a substantial impact on Syria's water supplies due to the country's variable climate. Additionally, potential regional conflict may be having a significant impact on water balance. These findings were reached after a careful review of previous studies on water resources and wastewater management in Syria. In addition, according to the findings of studies on water quality, domestic and industrial waste has contaminated groundwater and surface water all over the country, particularly in areas with dense human populations. The use of fertilizers, which raises nitrate levels, and the contamination of sewage water and animal waste, both of which are caused by human activities, have a significant impact on the environment. Large increases in nitrate and feces concentrations have revealed this influence in a number of agricultural zones in the mountainous region as well as the plain area. Additionally, the water quality in Syria's major river basins is getting worse due to the discharge of commercial and industrial wastewater as well as household wastewater that hasn't been properly treated or hasn't been treated at all. RBCs, or rotating biological contactors, are the most efficient way of treating wastewater in Syria's smallest settlements because they satisfy the bulk of their needs.

Ethical issue

The authors are aware of and comply with best practices in publication ethics, specifically with regard to authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The authors adhere to publication requirements that the submitted work is original and has not been published elsewhere.

Data availability statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Conflict of interest

The author declares no potential conflict of interest.

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Appendix I

Table 1. List of the previous studies about Syria's available water resources

References	Aim	Method	Data	Main Findings
[1]	This paper's primary objective is to assess the potential for saving potable water by flushing toilets with greywater in a typical Syrian city.	Interview	About 35% of the drinking water could be saved if using treated grey water for toilet flushing.	This study demonstrates the need to increase public awareness of the benefits and safety of reusing treated greywater.
[2]	This study aims to provide a brief background on water supply and use in Syria, describe the pressure on water resources for agriculture, analyze key issues and constraints facing this sector, and make recommendations for efficient utilization.	review	review	The Water Balance for Syria indicates that the majority of basins are in deficit, according to the paper. The deficit will worsen, particularly in basins encompassing large urban areas, if the country's population continues to grow at the current rate (approximately 3%) and if water use efficiency is not improved.
[5]	This survey paper aims to investigate the global demand for renewable energy, the types of RES used on a domestic scale, and to draw useful conclusions on the public's use and acceptance of RET and RES.	Review	review	This study demonstrates that global energy crises can be mitigated by incorporating renewable energy sources into power generation.
[6]	The purpose of this paper is to examine groundwater resources in Syria, focusing on the underlying natural and anthropogenic influences on water resources.	review	Academic published data and geospatial dataset	In the Neogene aquifer system, low aquifer productivity and water quality issues restrict groundwater extraction. Chemical leachate has contaminated groundwater in the aforementioned regions.
[7]	Damascus Oasis groundwater quality in relation to heavy metal concentrations will be investigated.	experimentation	pH, temperature, electrical conductivity (EC) and total alkalinity (ALK)	Heavy metals contaminate groundwater quality.
[9]	The purpose of this paper is to determine the hydro-chemical characteristics of the alluvial aquifer in the Damascus Oasis, where nitrate contamination of groundwater has been increasing over the past several decades.	Quantitative sampling method	High Ph value, $Ca^{2+} > Na^{+} > Mg^{2+} > K^{+} = HCO_3^{-} > SO_4^{2-} \geq Cl^{-}$. High Na+, and SO4 2−	The paper concludes that the central portion of the study area is where pollution is most prevalent (the Transitional zone). Thus, irrigated areas are most likely to be impacted by nitrate pollution. Over 51.8% of the water samples exceed the maximum contaminant level (MCL) of 50 mg/l set by the Syrian drinking water standard.

[15]	The purpose of this study was to evaluate the natural groundwater recharge in the Al Zerba catchment and the surface-groundwater interaction.	Quantitative analysis method	Derived data	The results indicate that groundwater pumping has a negative effect on the long-term decline of groundwater levels, especially during the dry season, whereas no significant effects of vegetation on groundwater were observed.
[11]	This paper focuses on enhancing the water quality of the Barada and Awaj Rivers by analyzing the pollution sources and proposing a set of policy measures.	review	review	This study aims to provide a general analysis of water pollution in the Barada Basin, Syria, by estimating the number of contaminants generated by socioeconomic activities and proposing a set of policy measures to address the issue.
[10]	The purpose of this investigation is to assess the performance of the treatment system in terms of biochemical oxygen demand (BOD), total suspended solids (TSS), nitrate (NO3-), and phosphate (PO4-3) parameters.	qualitative method	The average influent BOD5 concentration was (113 mg/l), while the average effluent BOD5 concentration was (27 mg/l). The maximum influent BOD5 concentration was (205 mg/l), while the maximum effluent BOD5 concentration was (94 mg/l). The minimum influent BOD5 concentration was (21 mg/l), while the average effluent BOD5 concentration was (9 mg/l).	The study found that the concentration of nutrients is lower than what is required.
[12]	The purpose of the study was to recommend modifications to wastewater treatment technology that would increase its effectiveness. The purpose of the study was to recommend modifications to wastewater treatment technology that would increase its effectiveness.	laboratory experiments.	COD high, PH high	Compared to the recommended values for industrial wastewater treatment, the dosages of chemical additives for wastewater treatment were high, according to the study.
[25]	The purpose of this study is to analyze the current state, evaluate the design and operation of the wastewater treatment system in small communities, and propose solutions for its future development.	Literature review	Literature review	Deterioration of water quality in the major river basins of Syria due to untreated or inadequately treated domestic wastewater, commercial and industrial wastewater from specific activities. The sewage system, particularly in small communities, is plagued by numerous issues. 98% of smalltown treatment plants use activated sludge with extended aeration, which does not meet their requirements and does not provide high-efficiency wastewater treatment.
[26]	This paper aims to provide a comprehensive and critical review and update of Syria's current water resources and needs, as well as their projections through 2050.	Literature review	Past available data	Improving public awareness and participation in water projects at the local, regional, and international levels may be a solution for more sustainable and efficient

				water conservation measures in Syria, according to the paper.
[27]	This study's objective is to examine Syria's water balance and the management systems currently in place.	Literature review	Past available data	The study concludes that the current Water resource management systems in Syria are inadequate and that the lack of appropriate solutions to the hydrological system's circularity could have a significant future impact on the standard of living of its citizens.
[28]	The specific goals of this study are to integrate a large suite of geochemical and isotopic tracers (2 H, 18O, 13C, 3 H, 14C) in order to differentiate between different major geographic zones of renewable, semi renewable, and nonrenewable groundwater resources in The Regional Deep Cretaceous Aquifer (RDCA)	Quantitative sampling method	Chemical and isotopic data of groundwater	Integrated data presented in this study indicate that the majority of Syria's deep groundwater was formed under more humid climatic conditions and is located in a region that currently experiences arid climatic conditions and receives little natural recharge.
[17]	is to examine the condition of water resources in the coastal region of Syria from 2000 to 2010	review	review	War has resulted in the destruction of water treatment and distribution facilities.
[29]	In the peri-urban area of Aleppo, Syria, where wastewater irrigation is common, the health effects of wastewater irrigation on children aged 8 to 12 will be investigated.	survey sampling and data collection	disease in fresh-water irrigated is 0.98, and 0.78 for children in wastewater irrigated areas.	Children in areas irrigated with fresh water were affected by influenza, whereas nine out of ten children in areas irrigated with wastewater were infected.
[30]	This study aims to detect the presence of Giardia cysts and determine their prevalence and concentration in Al-Jinderiyah region wastewater and river water samples.	laboratory testing	Giardia cysts in 87.5% of the influent samples (S1) and 75% in effluent samples (S2)	The study revealed that the presence of Giardia cysts in wastewater samples varied based on the period of collection.
[31]	This paper describes the wastewater reuse situation in Syria and discusses the ideal policy to be adopted along with some application types of water reuse that can be developed and implemented in drought-stricken regions to meet water demands.	Literature review	Collective data	This paper demonstrates that many of the current problems with wastewater quality can be addressed and resolved using dynamic optimization and geo-information technologies, which are already having a profound effect on research in water quality and environmental protection.

[32]	This study investigates the impact of food and agricultural policies on the use of groundwater in Syria.	Probability sampling method	Elevation (m) Average precipitation (mm) Average evapotranspiration (mm)	This study demonstrates, from a macro perspective, that policymakers face the challenge of balancing short-term productivity growth with the long-term negative effects of groundwater depletion.
[33]	This study's primary objective is to examine Syria's water management policies within the context of recent trends toward more market-oriented agricultural policies.	review	analysis	The paper concludes that Syria's water balance is inadequate.
[34]	The primary objective of this article is to estimate the effects of climate change, population growth, and human activities on water problems in the Ghab Region and to examine how to better plan for the future use of water resources.	Literature review	Review	The paper demonstrates that the overexploitation of groundwater in the Ghab Region is not solely attributable to climatic fluctuations and population growth, but also to human activity that is out of control (drilling of illegal water wells).
[35]	This study aimed to determine the viability and limitations of a low-cost, water-balance-based approach for assessing groundwater resources in a semiarid environment.	Quantitative research method (survey)	Low Ph, High salinity, Electrical conductivity	Comparing current groundwater levels to observations from the past, the study concludes that groundwater levels in the Jabal Al Hass region have decreased significantly over the past three decades. The annual rate of depletion of groundwater resources ranges between 9.5106 and 118106 m3.
[36]	This study's primary objective is to examine Syria's water management policies within the context of recent trends toward more market-oriented agricultural policies.	Literature review	Review	This study finds that Syria's water balance indicates that the majority of basins are in deficit.
[16]	This study aims to (I) determine the origin of groundwater and its geochemical evolution based on rock-water interactions within the context of its complex geology and morphology, (ii) identify the main hydro-geochemical processes controlling the water quality in the study area, and (iii) comprehend the recharge processes and identify the main hydrogeological units in the study area.	Sampling analytical method	Available data	The fluctuation of groundwater level is governed by atmospheric precipitation and anthropogenic influence as groundwater abstraction increases.

[37]	the main purpose of this study is to analyze water management policies in Syria in the framework of the recent developments toward more market-oriented agricultural policies.	review	analysis	the paper fines that the water balance in Syria is low.