Hydrology
2025, Vol. 13, No. 2, pp. 134-152
https://doi.org/10.11648/j.hyd.20251302.15

Research Article

Hydro-geopolitics and Agricultural Cooperation Among Nile Basin States

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Abstract

The Nile Basin is among the most contested regions in terms of water scarcity and the fair distribution of water resources. Food security remains a pressing concern for the countries within the basin, given their collective reliance on the Nile River and the growing pressures of climate change, population expansion, and limited resources. The challenge of achieving equitable and sustainable water use has fueled ongoing tensions, heightening the risk of conflict and further undermining regional food security. The paper examines the role of cooperation in specialised fields to achieve food security within the Nile basin countries. The study attempts to assess different collaboration options, water sharing and integrated cooperative approaches for better water management in addressing the multifaceted issues affecting food production, distribution and accessibility among the Nile basin countries and to assist riparian states in achieving food security. This paper advocates for a cooperative framework to promote dialogue and compromise, fostering regional stability and addressing shared challenges. Drawing from case studies and existing literature, it highlights the necessity of specialised expertise in disciplines such as agricultural science, hydrology, climatology, and technology in supporting food security initiatives. This paper argues that collaboration in specialized sectors is essential for achieving food security in the Nile Basin countries. It emphasizes the need to move beyond geopolitical rivalries by prioritizing common interests and fostering knowledge exchange, technical cooperation, and integrated approaches. By nurturing collaborative efforts and implementing context-specific strategies, the Nile basin countries can enhance agricultural productivity, alleviate hunger, and ensure a sustainable and prosperous future for their population.

Keywords

Food Security, Hydro-politics, Nile Basin, Riparian States, Water Management, Water Deficit

1. Introduction

Water is a vital element that supports and sustains all forms of life [30, 75]. It is indispensable for a happy and healthy life. Although water covers 71 per cent of the earth in its suitable form and quantity, it has limited availability at national, re-

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Received: 11 April 2025; **Accepted:** 3 June 2025; **Published:** 30 June 2025

gional, and even individual levels [95]. Water demand is also increasing rapidly with the changing lifestyle and development aspirations [19]. In developing and least-developed countries, sometimes non-cooperation attitudes regarding using or sharing water resources become so severe that it may result in food insecurity [67]. North Africa is mainly under water scarcity to various extents [121]. Food and Agricultural Organization (FAO, 2021) [39] states, "Since water is a primary requirement of food production, the level of water scarcity of any water-deficient country can be indicated through the degree of its national food imports" [74]. The prominent exploitative water use for growing food is an essential indicator of water deficiency or abundance. The water use in agriculture is more than ten times that used in combined municipal and industrial sectors [108]. Water is the fundamental component that shapes any economic action's size, character, position, and location. The necessary condition for agricultural development is reliable water availability for irrigation. Water has historically been a source of contention in international, national, and regional affairs, as it plays a critical role in shaping the political, social, and economic stability of nations and states [117]. Infact, access to water is essential for maximizing and safeguarding human and economic development, particularly in the Nile Basin countries.

The Nile Basin ranks among the most disputed regions when it comes to water scarcity and the fair allocation of its resources [16]. The cooperative management of limited water resources on equitable and sustainable terms continues to be a major challenge among the Nile Basin states. These countries are already burdened by underdevelopment, poverty, hunger, malnutrition, rapid population growth, soil erosion, environmental degradation, and the escalating impacts of climate change [70, 93]. Water in the region is utilized for various economic activities, including agriculture, irrigation, hydroelectric power generation, industry, and farming. Generally, conflicts related to water scarcity are framed around its use for agricultural and industrial purposes, rather than for meeting basic human needs such as drinking, washing, and cooking. Water availability becomes more important to food production and security in arid or semi-arid developing countries, where agriculture contributes to 80 to 90 per cent of respective economies [111, 46].

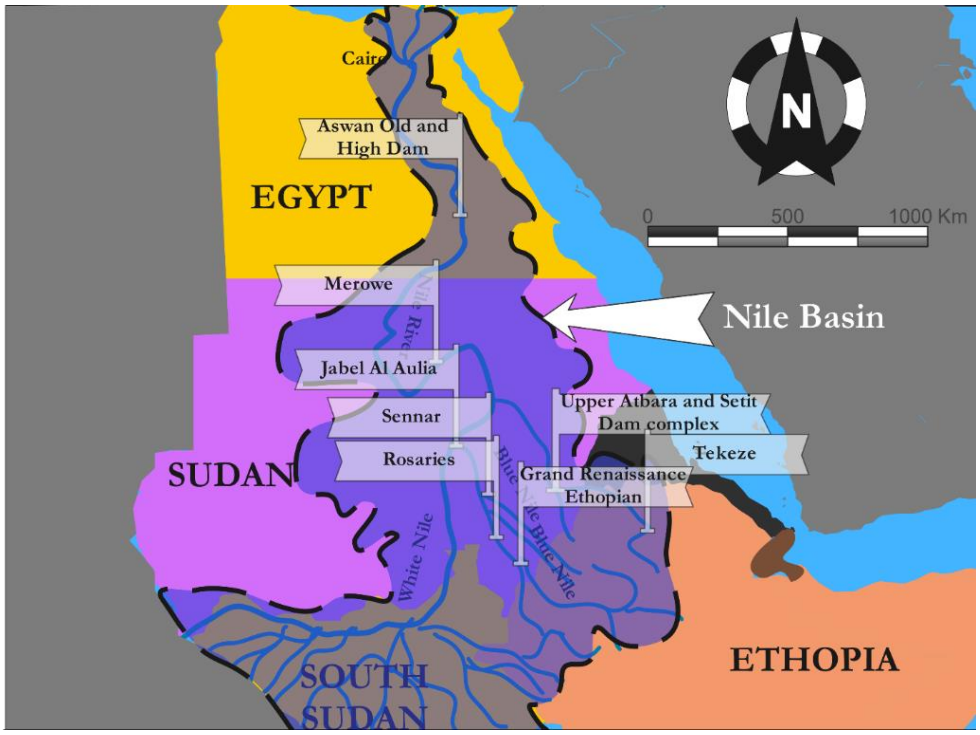
Food security remains a critical global challenge, and it is particularly pronounced among riparian countries of the Nile [15]. The countries bordering the world's longest river, the Nile, are profoundly interdependent on its waters for their survival and economic development [66]. However, the region faces numerous obstacles in its pursuit of food security, including climate change, population growth, limited resources, and socio-political complexities. To tackle these formidable challenges, fostering cooperation in specialized sectors emerges as a crucial strategy for achieving ensuring food availability in Nile riparian states.

The Nile Basin, a lifeline for millions, is shared by 11 riparian countries: Egypt, Eritrea, Burundi, Ethiopia, Sudan, South Sudan, Kenya, Tanzania, Uganda, Rwanda, and the Democratic Republic of Congo. These nations are not only geographically interconnected by the flow of the Nile, but they are also distinguished by a rich tapestry of diverse agricultural practices, economic systems, and cultural traditions [2]. Despite their differences, these countries share a common reliance on the Nile River as a vital lifeline for their agricultural activities. However, the distribution of its water resources has historically been a point of dispute, heightening the risk of conflicts over water usage and allocation [58]. The stakes are considerable, as disruptions to agricultural activities could result in food shortages and jeopardize the livelihoods of millions. The introduction advocates for a cooperative approach that transcends geopolitical boundaries and focuses on shared interests to overcome the complex challenges to food security in the Nile basin region [110]. It posits that by collaborating in specialised fields such as agricultural science, hydrology, climatology, and technology, these countries can leverage on their collective potential, knowledge and resources to develop sustainable and effective solutions [47].

The objectives of this cooperative effort are multi-faceted. Firstly, it seeks to foster dialogue and promote greater mutual understanding among the Nile Basin countries, encouraging them to work together towards common goals. By engaging in diplomatic negotiations and peaceful resolutions to water resource management, these nations can promote regional stability and avoid conflicts that would further exacerbate food insecurity [68]. Secondly, this collaborative approach recognizes the significance of specialised expertise in addressing this region's unique challenges [119]. With the help of cutting-edge research and technology, agricultural practices can be optimized to adapt to changing environmental conditions and improve productivity. Integrated approaches to water management can ensure the equitable distribution of resources, enhancing crop yields and agricultural resilience.

Lastly, this introduction asserts that cooperation in specialised fields is not only a pragmatic response to the challenges of ensuring food security across the Nile Basin region but is also a moral imperative. It emphasizes the urgency of looking beyond individual interests and embracing a collective vision of sustainable development and prosperity. By pooling their resources, knowledge, and efforts, the Nile basin countries can forge a path towards a future where food security is no longer a distant dream but a tangible reality for their people [60].

2. Study Area



Source: Based on Kevin et al., 2016 [64].

Figure 1. *Nile River basin dams.*

After decades of unsuccessful efforts to foster cooperation, the Nile Basin countries have continued to adopt conflicting positions over the use of the river's waters [4]. To achieve food security, the major Nile riparian states must transcend state-centric water development models and establish sustainable partnerships for the cooperative management of shared water resources. Therefore, the paper tries to assess options for collaboration and the potential for specialised fields in different countries for better water management and to assist countries in achieving food security.

The study area is Nile river basin and its major riparian countries (Figure 1), despite its impressive length and global recognition, the Nile's actual water volume is relatively modest compared to other great river systems. This reality makes the sustainable management and equitable sharing of its resources even more critical, especially given the growing pressures of population expansion, climate change, and development needs across the basin [104]. However, the river's flow is uneven and often disrupted by extreme climatic events. The hydrological and geopolitical dynamics remain central points of contention among the Nile Basin countries. The lower riparian states, Egypt and Sudan, have consistently asserted their acquired and historical rights over the Nile's resources. Historically, Egypt has acquired the hegemony in the Nile region, having considerable control in hydrological, political and legal affairs in the basin [103]. Consequently, upper riparians i.e. Ethiopia along with other countries have been marginalised in utilizing the Nile resources. Over a period of time upper riparian recognised and started their claims over the Nile Resources. But this is not as easy as it seems as Egypt is already exercising its hegemonic control in the basin. Control over these factors in the Nile means that the upper riparians do not have political and structural control and utilization of Nile water resources inside their boundaries. Countries then started using strategies to counter Egypt's strategies.

3. Methodology

The study is grounded on interpretative research design built on extensive literature. Therefore, this study highlights the "speciality" of different countries instead of "generality" backed by the specialists' views. The major researches are taken into consideration based on the real time data, geographical and temporal reach of the study. Thus, the study help identifies both critical problems but also offer solutions, rooted in strengths and experiences of specialised fields.

In order to assess the evolving dynamics of conflict and cooperation within the Nile River Basin, it is important to adopt a comprehensive and focused approach. Present study examines four major components that are shaping interactions

among the basin's riparian states. These components are: first, specialization in hydroelectricity i.e how countries harness the Nile's waters for energy production, which has become a key driver of development as well as competition. Secondly, specialization in agriculture and irrigation development-how nations expand their agricultural sectors to secure food supplies and livelihoods, placing increasing demands on the river's resources. Thirdly, specialization in food or fuel production-the choices countries make between prioritizing food security or biofuel crops, decisions that directly influence water usage patterns and economic strategies. And fourthly, specialization in virtual water trade-the strategic use of global trade to effectively "import" water-intensive goods, reducing domestic water stress while influencing international market dynamics.

Together, these four components provide a structured lens through which we can better understand the complex balance of conflict and cooperation in the Nile Basin today-and chart a path forward toward sustainable and equitable water governance. The data for this analysis were sourced from [21, 71, 72, 84].

4. Data Analysis -water Demands in the Nile River Basin Countries

Water demand has been steadily increasing throughout the Nile Basin countries, fueled by ambitious development projects and rapid population growth [13]. In the early 1990s, the Nile River directly supplied more than 55 cubic kilometres of Egypt's total water consumption of 65 cubic kilometers, with the rest coming primarily from groundwater extraction, water reuse, and treatment systems [55]. Since then, Egypt's population boom has intensified water needs even further [91, 73].

One of the most emblematic initiatives driven by this pressure is the Southern Valley Agricultural Development Project—more commonly known as the Toshka Project. Situated in Egypt's western desert, this bold project aimed to irrigate around 200,000 hectares of land, relocate millions of people, and divert approximately 5.5 cubic kilometres of Nile water from Lake Nasser through a 310-kilometer-long pipeline [45, 69].

As a result of such expansion, Egypt's total water demand climbed to 73.3 cubic kilometers by the year 2000, with the agricultural sector alone accounting for a staggering 60.7 cubic kilometers. Looking ahead, projections suggest that by 2025, agricultural water demand will soar to 69.43 cubic kilometers out of an anticipated total demand of 86.89 cubic kilometers [40].

Yet, despite these substantial efforts, Egypt remains heavily dependent on food imports. Nearly 40 percent of the nation's food and agricultural products are sourced from abroad [59]. This dependency highlights a worrying paradox: while Egypt invests heavily in land reclamation and irrigation, domestic food security challenges persist.

Moreover, massive desert reclamation initiatives like the Toshka Project have sparked internal tensions, raising fears about possible disruptions to water supplies in other parts of the country. These ventures have also placed enormous economic strain on Egypt's financial resources.

In parallel with desert reclamation, Egypt has invested significantly in its irrigation infrastructure. Major structures such as the Zifta, Isna, Assiut, and Nag Hammadi barrages, as well as the Damietta and Rosetta systems, have been built to control and distribute water flows [32]. However, declining water availability from the Aswan High Dam now threatens the efficiency and sustainability of these vital infrastructures.

The other major riparian in the Nile basin, i.e. Sudan, host a population of about 44 million and is increasing at a rate of more than 2 per cent annually [106]. Compared with the northern portion of Egypt, which obtains nearly no precipitation, is entirely dependent on irrigation for cultivation. Whereas 50 per cent of Egypt's total population depends on agricultural activity, the number is approximately 70 per cent or more in Sudan. Based on this fact, Some scholars contend that Sudan's reliance on the Nile is even greater than that of Egypt [52]. Sudan possesses 105 million hectares of potential arable land, yet it cultivates only 20 million hectares, with over 85 percent of the cultivated area relying on rain-fed agriculture [89]. Sudan requires additional water resources to meet the growing demand for agricultural production at the national level. Its plans to expand the area of irrigated agricultural land further intensify this need. Worsening land degradation and desertification have intensified Sudan's water challenges. Sudan maintains that it has already nearly exhausted its allocated share of Nile River water. By 2025, the country's potential demand for Nile water is expected to rise to 32 cubic kilometers, largely driven by the growing needs of its irrigation sector. By 2025, Sudan's potential demand for Nile water is projected to reach 32 km^3, primarily driven by increased irrigation requirements.

South Sudan is the newest state that came into existence in 2011. About 75 per cent of the entire area of this state is considered cultivable. With its high potential for agricultural production, some experts observe that with the development of appropriate and adequate infrastructure, South Sudan could become the breadbasket of Africa. In response to economic challenges and the urgent need to reduce dependency on oil revenues, South Sudan is actively adopting new economic policies aimed at accelerating agricultural output. Recognizing that sustainable development requires diversification, the state is taking bold steps to rebuild and strengthen its agricultural sector.

One such initiative is the Fruits and Vegetables Sector Strategy, launched to revitalize South Sudan's food basket and create much-needed employment opportunities [88]. Through this strategy, the country aims to significantly increase its share of agricultural exports, offering a pathway toward greater economic stability and food security. South Sudan's natural advantages - a favorable climate and rich,

fertile soils - make it ideally suited for the cultivation of fruits and vegetables. These conditions present a tremendous opportunity to not only nourish its own population but also tap into promising markets across the region and the world. If nurtured carefully, this sector could drive inclusive economic growth, strengthen livelihoods, and enhance South Sudan's position in regional and global agricultural trade. In short, agriculture could become a cornerstone of a more resilient, diversified, and prosperous future for South Sudan.

Both Sudan and South Sudan have recently announced plans to construct new dams along the Nile River [12]. Historically, Sudan's ability to undertake large-scale water infrastructure projects was limited. However, times are changing. In recent years, Sudan's geopolitical significance has grown considerably, supported by an influx of foreign investments, particularly from Arab nations and China.

Sudan is no longer merely a bystander in Nile Basin politics. It is emerging as a serious contender in the competition over the river's vital resources. Currently, Sudan is actively constructing several hydropower projects along the Nile. More importantly, it has laid out ambitious, practical plans to expand its irrigation capacity plans that, if fully implemented, would require water withdrawals exceeding the limits set by the 1959 Nile Waters Agreement. This marks a major transformation in the region's dynamics. Sudan is steadily shifting from a historically passive role to one of assertive agency, challenging Egypt's long-standing dominance over Nile water allocation. If these trends continue unchecked, Sudan's expanding infrastructure projects could pose serious risks to basin-wide stability. The delicate balance of interests among Nile Basin countries could be destabilized, reshaping regional relationships in profound and potentially unpredictable ways. The future of the Nile will depend not only on national ambitions but on the ability of all basin countries to manage these competing interests through dialogue, cooperation, and a renewed commitment to equitable resource sharing.

Like Sudan and Egypt, Ethiopia holds tremendous significance when it comes to managing and sharing the waters of the Nile. The Ethiopian highlands are the source of approximately 86 percent of the Nile's total flow-a figure that surges to nearly 95 percent during the flood season. This remarkable contribution places Ethiopia in an undeniably critical position in the management of the river's resources.

However, it is important to note a crucial factor: Ethiopia is not bound by any formal agreements with either Egypt or Sudan regarding the sharing of the Nile's waters. This absence of binding legal frameworks has created a fundamental asymmetry in basin politics, fueling tensions and disputes over water rights and future resource utilization.

Given its upstream advantage and the sheer volume of water it contributes, Ethiopia wields considerable influence over the future of the Nile. How Ethiopia chooses to manage this responsibility-whether through unilateral action or cooperative engagement-will have profound implications not only for its own development but also for the stability and prosperity of the entire region.

As the pressures of population growth, climate change, and economic development intensify, the need for inclusive dialogue, mutual respect, and equitable resource sharing has never been more urgent.

Agriculture continues to be the cornerstone of Ethiopia's economy, contributing approximately 40 percent to its Gross National Product (GNP), generating 90 percent of its export earnings, and employing nearly 85 percent of its population. Most agricultural activities are concentrated in the highland regions, which benefit from ample rainfall. Despite having an estimated irrigation potential of 3.5 million hectares, Ethiopia has developed only about 5 percent of this land for irrigation [51].

Ethiopia has faced persistent food insecurity, frequently experiencing major food shortages that have necessitated increased food imports. The famines of the 1970s and 1980s were particularly devastating, leading to widespread suffering, civil unrest, and the eventual collapse of ruling regimes [35]. Motivated by these experiences, successive governments have prioritized achieving national food self-sufficiency [100, 101]. The current administration is even more determined to secure food security and prevent future famines, recognizing the political risks of continued vulnerability.

In its effort to strengthen food security and drive economic growth, Ethiopia is actively expanding its irrigation programs. These initiatives are vital for the country's development but carry significant implications for the region, as they have the potential to substantially reduce the downstream flow of the Nile. Positioned upstream, Ethiopia holds a strategic advantage over the river's flow. With an urgent need to boost agricultural productivity and ensure food sovereignty, Ethiopia firmly asserts its sovereign right to utilize and manage the water resources within its territory. This assertion reflects a broader reality faced by many upstream nations: the right to harness natural resources for national development must be balanced with the responsibilities of regional cooperation. As Ethiopia moves forward with its irrigation expansion, the challenge for the Nile Basin countries will be to find pathways toward mutual understanding-where sovereignty and shared responsibility can coexist for the collective benefit of all who depend on the Nile. However, progress has often been hampered by economic constraints, technical challenges, and political instability.

The shifting global landscape has reinforced the determination of Ethiopian policymakers to accelerate the development of the country's internationally shared water resources. Internally, Ethiopia has experienced relative stability, while its relations with Western nations have notably strengthened in recent years. Capitalizing on the window of opportunity created by Egypt's domestic turmoil in 2011, Ethiopia launched the construction of the Grand Ethiopian Renaissance Dam (GERD), a monumental multi-purpose project on the Blue Nile. Originally designed to produce 5,250 megawatts of electricity, the dam's planned capacity was later increased to

6,450 megawatts [105]. Subsequently, Egypt-heavily reliant on the Nile River for its freshwater supply-accused Ethiopia of exploiting Egypt's internal instability to advance the construction of the dam. Egyptian government considered this an existential threat and a matter of national security. Although Egypt initially opposed the construction of the dam, its reaction was less belligerent and threatening than in the past [87]. Instead, the two key Nile Basin countries eventually engaged in cooperative dialogue to assess the potential impacts of the GERD on the Nile's flow [53].

The filling of the GERD's massive reservoir, with a total capacity of 74 billion cubic meters, commenced in July 2020, and the dam began generating electricity for the first time in February 2022. Out of 13 turbines at the dam, the two turbines generate 750 megawatts of electricity [6]. Ethiopia has already filled its vast water reservoir in August and September 2022. Egypt observed and became highly anxious and believed it would cause severe interruptions to its water supplies from the Nile River. It may also lead to catastrophic water and food shortages throughout the country. Given the present comparative political and economic situation, Ethiopia hopes to expand its agricultural and irrigation capacities [38]. Ethiopia's unilateral construction of multiple dams reflects a shifting discourse on the Nile-from a focus solely on Egypt's hydro-hegemony to an emerging emphasis on cooperative water-sharing negotiations [84]. By completing the largest dam in Africa, Ethiopia has significantly strengthened its position. However, the dispute over the GERD between Ethiopia and Egypt may resurface in future scenarios.

Other Nile basin countries are also planning to utilise more Nile water for backward areas to fulfil food security for their citizens. For example, Tanzania, Uganda, Rwanda, and other countries have started many projects on the Nile. So there will be challenges in Nile basin countries with feeding more people and hence more water demand and climatic-related water shortage in the future. Therefore, each country needs to be specialised according to different options for cooperation for better water management.

5. Discussion-specialisations of Different Countries to Attain Food Security

Considerable population growth and food insecurity in basin countries indicate that agricultural production needs to increase. In most Nile River basin countries, agriculture is predominantly carried out by a sustenance rain-dependent system with low productivity and production and high-level variable climatic factors. High agricultural production and large-scale irrigation in the arid lower riparian regions are often seen as models of agricultural growth for other countries within the basin. However, the concerns are that irrigation growth in the upper riparians could destabilise existent productions in lower riparians. A critical question is to what magnitude will the upper riparian's growth and development by water management infrastructural inputs affect water availability for the lower riparians?

In most African countries, water inaccessibility is an urgent restraint on livelihoods and contributes to the increasing poverty rate. In the Nile Basin countries, a paradox exists where access to water is generally limited in the upper riparian or highland regions, despite the abundance of water resources there. In contrast, well-developed infrastructure has significantly enhanced lower riparian access. Various strategies can be defined by which countries can specialise in different fields according to climate suitability, location, and maximum outcome by mutually agreed mechanisms. Other countries have advocated and started unilateral or multilateral projects in the Nile basin. The necessary specialised fields which can be taken into consideration are as follows:

5.1. Specialisation in Hydroelectricity

While facing challenges associated rapidly growing populations, the Nile riparian also face significant difficulties in ensuring their food security and meeting energy needs. Many of these nations rank among the world's poorest in terms of gross domestic product and levels of food security [42]. Although the Nile Basin countries collectively possess an estimated hydro-power potential of 140,000 megawatts (MW), only a small portion of this potential has been harnessed-largely with Egypt as the exception. The upper riparian countries have a vast resource for hydro-power development because they have suitable natural sites for constructing water reservoirs.

The electricity situation is paradoxical as the majority of people do not have electricity and the infrastructure required to secure electricity. The average per capita/year, electrification rate is 30 percent. If Egypt and Sudan are excluded, it drops to 15 per cent; Economic Consulting Associates (2009) [31], states it is a low proportion. Hydroelectricity is under-exploited in most basin countries, affecting development and growth. Therefore, the basin countries have planned several water resource development projects. Some of the planned projects have already been started, and some other projects are in the pipeline. Key dams, hydroelectric projects, and major water supply structures along the Nile include the Aswan High Dam in Egypt, the Grand Ethiopian Renaissance Dam (GERD) in Ethiopia, and the Sennar, Jebel Aulia, and Roseires dams in Sudan. The major projects on the Nile are given in figure 1. Hydro-power dams and their power generated offer other benefits, including additional water for irrigation, water storage mechanisms, controlled release of water, leading to further industrial and social development.

Many countries have started constructing dams on the Nile River and signing agreements. In Sudan, a major project maned- the Upper Atbara and Setit Dam Project, led by a Chinese company is underway. This ambitious initiative consists dams i.e. the Rumela Dam on the Upper Atbara River and the Burdana Dam on the Setit River, both dams are lo-

cated south of the existing Khashm-el-Girba Dam. The goals of this project are clear and impactful. It aims to expand the irrigated areas significantly and enhance agricultural production in the New Halfa region, an area that currently depends on the Khashm-el-Girba Dam for water regulation and flood control. By improving irrigation infrastructure and managing river flow more effectively, the Upper Atbara and Setit Dam Project holds the promise to revitalizing eastern Sudan's agricultural sector, boosting food security, and contributing to the region's overall economic stability. It is a powerful example of how strategic investments in water management can drive broader development goals across the Nile Basin.

Following its successful referendum and secession from Sudan, South Sudan has begun to actively explore several hydropower projects aimed at supporting the country's modernization and economic growth. One of the key initiatives under renewed consideration is the Nimule Dam project, situated near the border with Uganda. Initially proposed in the 1970s, the project is now viewed as a vital step toward utilizing the Juba-to-Nimule stretch of the Nile River for enhanced power generation [37]. Furthermore, there is discussion around revisiting the Jonglei Canal project. However, this is a highly political and sensitive issue within South Sudan. Any move to restart the canal would demand careful, inclusive, and cautious deliberation, given the historical tensions and concerns associated with it.

South Sudan's energy ambitions reflect not only a drive for modernization but also a strategic move to secure a sustainable future for its people. Yet, these initiatives must be approached thoughtfully to balance development goals with the socio-political realities on the ground [76].

With its vast hydropower potential, abundant water resources, and steeply sloping terrain, Ethiopia is positioned to become the leading power broker in the Nile Basin. The Blue Nile alone holds an estimated hydropower potential of approximately 13,000 megawatts. Currently, Ethiopia has at least six new dams proposed and four others currently under construction [79]. The country's first major dam, the Finchaa Dam, was completed in 1973 on the Finchaa River, a tributary of the Blue Nile. Another major project, the Tekeze Dam-located on the Tekeze River near the Eritrean border-was completed and became operational in 2009. Standing at 188 meters, the Tekeze Dam holds the distinction of being the tallest arched dam in Africa. The project offers the advantage of supplying a consistent, year-round water flow to downstream regions, in addition to generating 300 megawatts of electricity. However, there are concerns regarding high construction costs, sediment accumulation, and potential ecosystem loss.

After Gilgel Gibe III and Tekeze Ethiopia started the third largest dam (GERD) in 2011, as of September 2022, the work stood at 83.3 per cent accomplished. According to Kifle Horo, the GERD project engineer, civil works on the dam are 95 percent complete, while electromechanical works have reached 61 percent completion [8]. Once fully operational by 2025, the Grand Ethiopian Renaissance Dam is projected to generate more than 6,000 megawatts of electricity, providing a major boost to African economies. Ethiopia has successfully completed the third filling of the GERD, and in early August 2022, Prime Minister Abiy Ahmed inaugurated the operation of the dam's ninth unit. This development has enabled Ethiopia to harness 270 megawatts of power from the second turbine now in operation [102].

Situated about 40 kilometers from the Sudanese border, the GERD is anticipated to provide electricity to 65 million people, stimulate growth in industrial and agricultural sectors, expand essential services, and lift millions of Ethiopians out of poverty. Ethiopian authorities have also stated that the dam will bring benefits not only to Ethiopia but also to Egypt and Sudan.

Ethiopia frequently defends the project by highlighting the evaporation rates, which are significantly lower in Ethiopia in comparison to Egypt and Sudan. Many scholars support this view, arguing that relocating storage reservoirs from downstream areas, where evaporation losses are higher, to the Ethiopian highlands could result in significant water savings. Research suggests that the 10 billion cubic meters of water lost annually to evaporation at the Aswan High Dam could be halved by storing water upstream in Ethiopia, thereby conserving enough water to support half of Egypt's annual grain production [114, 92].

Uganda's first major hydropower project, the Nalubaale Dam-formerly known as the Owen Falls Dam-was completed in 1964 at Jinja. This landmark project marked the beginning of the country's reliance on the Nile for energy generation. Further downstream, the construction of the Bujagali Falls Dam faced a four-year delay due to various setbacks but eventually commenced in 2010. The Bujagali project was designed to double Uganda's power generation capacity, a major milestone in meeting the country's rising energy demands. Following Bujagali's completion, Uganda moved forward with the Isimba Dam, located near Karuma Falls. In addition, two smaller run-of-the-river projects namely North Ayago and South Ayago, are in the pipeline, collectively expected to add at least 500 megawatts to Uganda's energy supply. Despite these substantial developments, Uganda continues to grapple with high energy demands, prompting plans for the construction of even more hydropower dams in the future [109]. It is crucial to acknowledge a recurring oversight: the environmental issues, mitigation measures, and sustainability plans that should be integral to dam projects are often inadequately addressed or entirely absent in project planning for Nile basin countries.

There is a vast potential for hydro-power generation in the basin countries. With the introduction of hydro-power generation in the twenty-first century, the surge in hydro-electric power generation recorded many fold capacities visible in table 1.

Table 1. *Installed vs. potential hydro-power capacity in the Nile Riparian.*

Country	Hydro-power potential capacity (MW)[1]	Installed capacity 2019 (MW)[2]	Estimated installed capacity 2021 (MW)[3]
Burundi	27	0	27
D. R. Congo	78	0	0
Egypt	2,320	2,282	2,282
Eritrea	NA	NA	NA
Ethiopia	16,000	1,071	7,071
Kenya	216	83	83
Rwanda	47	0	27
South Sudan	2,570	0	0
Sudan	4,873	1,727	1,727
Tanzania	280	16	43
Uganda	4,723	1,004	1,738
Total	31,134	6,183	12,998

Source: (NBI, 2021) [84].

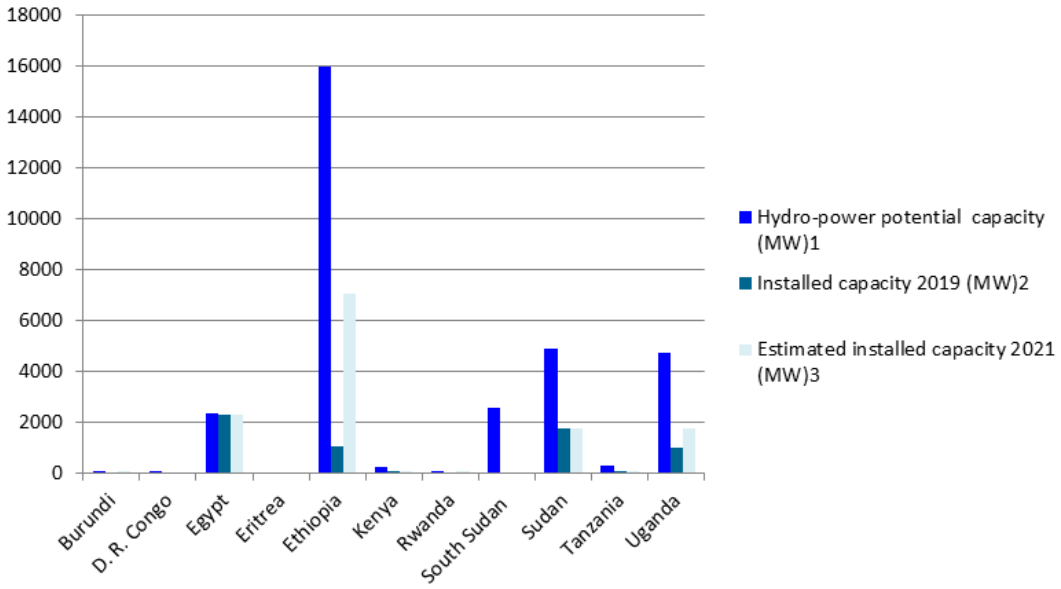


Figure 2. *Installed vs. potential hydro-power capacity in the Nile Riparian.*

Although, Burundi, the Democratic Republic of Congo (DRC), and Rwanda receive relatively higher rainfall, they participate in power development initiatives in the region as they face financial constrains to meet their pressing need for electricity. The Kagera River, contributes significantly in balancing water of Lake Victoria, which originates in Burundi and forms sections of the borders with the countries like Uganda, Rwanda, and Tanzania. In a collaborative effort, these three countries are building the versatile Rusumo Dam. The power plant at Rusumo Falls, where the Kagera River delineates the boundary between Tanzania and Rwanda, is set to supply electricity to key areas including Kigali to Kabarondo in Rwanda Gitega in Burundi, and Biharamulo in Tanzania.

Alongside these joint initiatives, the riparian countries are also independently pursuing the expansion of their hydro-power production capacities. Under the subsidiary action programs of the NBI, regional bodies such as NELSAP (the Nile Equatorial Lakes Subsidiary Action Program) and EN-TRO (the Eastern Nile Technical Regional Organization) are

actively involved in developing additional shared multipurpose projects aimed at benefiting all riparian states.

Ethiopia could benefit from its riparian geographic location. As Robert O. Collins debated that Ethiopia is a natural geographic location that can regulate and manage the Nile River water flow, constructing dams upstream, particularly in Ethiopian highlands, would increase Egypt's water supply [25, 99]. In Ethiopia and Southern Sudan, lower evaporation rates are favourable for constructing new hydro-electric projects. If the dam construction moves upstream, two significant advantages are sedimentation control, including controlling riverbed erosion and the potential hydro-power production. One of the many positive outcomes of generating hydro-power in upper riparians is that lower riparians might benefit from drought and flood mitigation and the reduction of siltation [62]. However, the geographical advantage of Ethiopia has been limited by asymmetric power relations. The primary goal of Ethiopia isto alter the existing dynamics in the Nile basin countries and to create new hydro-geopolitical strategies based on more equitable principles and water allocations [7]. In recent times Ethiopia has started the unilateral development of Nile water resources. Ethiopia's earlier unilateral development efforts led to growing mistrust and tensions in its diplomatic relations with lower riparian states, particularly Egypt. However, the current approach is shifting away from unilateral actions, as all Nile Basin countries are now participating in a cooperative framework aimed at establishing a more equitable, basin-wide management system [120]. This framework promotes shared control of water resources among both upper and lower riparian nations. Nevertheless, Ethiopia has not entirely ruled out the possibility of pursuing unilateral infrastructure projects in the future should cooperative efforts fail to result in a new, binding agreement.

If Egypt were to invest in dam construction in upstream Ethiopia, it could gain greater influence over the seasonal flow of the Nile River and enhance its capacity to manage upstream water resources. Ethiopia, in turn, would benefit from increased electricity production, additional revenue from water storage, and the potential to sell electricity to Egypt. However, persistent fear and zero-sum thinking have prevented the realization of such mutually beneficial solutions. The overarching developmental goals of most Nile Basin countries remain focused on reducing poverty, boosting agricultural production, and ensuring food security and energy supply for industrial growth [18]. Despite these shared priorities, region-wide transboundary electricity trading has still not happened, largely because of the complexities involved in securing multi-country agreements.

5.2. Specialisation in Agriculture and Development of Irrigation

The Nile River Basin covers approximately 3.2 million square kilometers and is shared among 11 riparian countries. The basin is confronted with rapid population increase, putting increased pressure on its natural resources. Around 87 percent of the Nile Basin's land area is under rainfed agriculture, which supports the livelihoods of large rural populations, particularly in the upper riparian countries [82]. Currently, irrigation needs across the basin span 6.4 million hectares, with plans underway to expand irrigated areas by an additional 3.8 million hectares by 2050 [80]. Irrigation schemes are calculated and need more improved facilities and likely need more water savings through enhanced irrigation techniques and efficient ways of utilisation of water.

With the exception of Egypt and Sudan, which have a long-standing history of irrigation and control over Nile waters, most other Nile Basin countries have traditionally relied more heavily on rain-fed agriculture to make use of their available water resources [80]. This dependence is largely due to factors such as inadequate infrastructure and financial resources, weak governance, and persistent civilian conflicts. As population across these riparian nations continue to grow, the demand for water, food, and energy is increasing rapidly. In response to widespread poverty, some countries have opted to sell land to foreign investors, aiming to develop agricultural infrastructure, create jobs, and inject much-needed capital into regions facing extreme hardship [56]. The repossession of desert lands has enabled Egypt to inflate its agricultural productions by utilizing drip irrigation systems fed by ground-water reserves. Efforts to conserve water have also been supported by the adoption of drip irrigation and plastic greenhouses. While these technologies remain costly for traditional farmers, many investors have successfully implemented them, supplying produce to local markets.

The irrigation potential is considerable in many Nile basin countries, of which only a fraction of land is irrigated, especially in upper riparians [14]. It is clear that, apart from Egypt and Sudan, the extent of irrigated land in the Nile Basin countries remains minimal. These nations largely rely on rainfed agriculture and therefore require the adoption of efficient and cost-effective irrigation methods to boost agricultural productivity. The Irrigation potential and the irrigated area of the basin countries are given in table 2.

Table 2. *Irrigation potential of the Nile basin countries.*

Country	Irrigation Potential (1000 ha)	Irrigation Area (1000 ha)
Burundi	80	0.05
D. R. Congo	10	0.08

Country	Irrigation Potential (1000 ha)	Irrigation Area (1000 ha)
Egypt	4,420	2,923
Eritrea	150	5.8
Ethiopia	2,220	32.1
Kenya	180	9.8
Rwanda	150	3.3
Sudan	4,843	1,946
South Sudan	NA	NA
Tanzania	30	14.1
Uganda	202	25.1
Total	12,285	4,959

Source: (Marc Jeuland et al., 2017) [72].

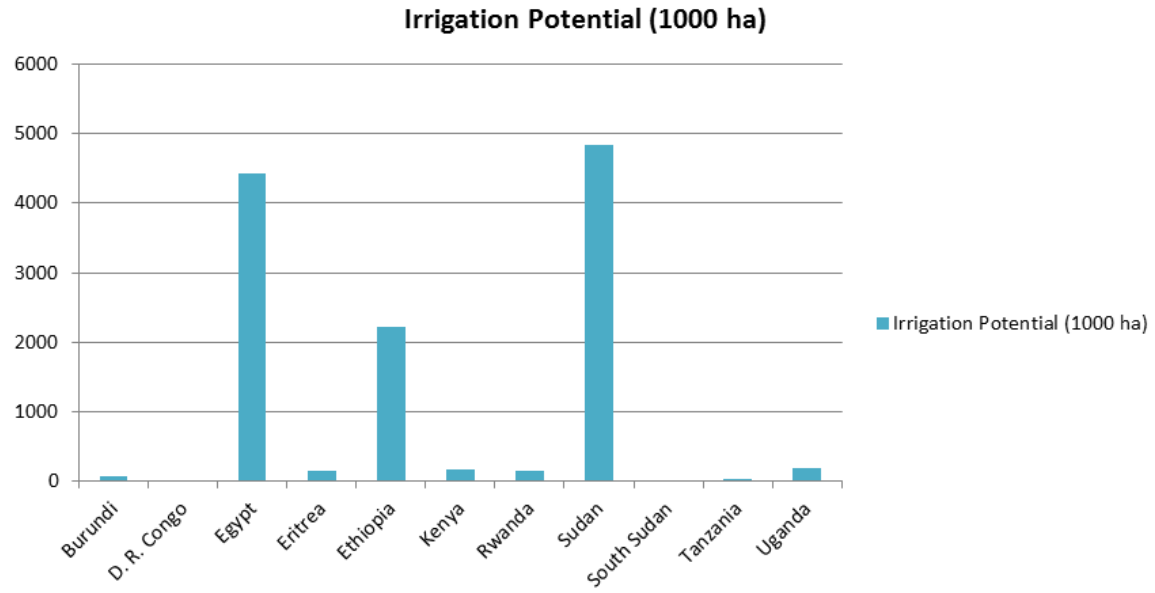


Figure 3. *Irrigation potential of the Nile basin countries.*

In the Nile riparian, agriculture remains the primary sector consuming the largest share of water resources. However, water scarcity-both physical and economic-continues to pose the greatest constraint on agricultural development across the region [118]. Physical water scarcity is particularly severe in the arid and semi-arid areas. Moreover, agriculture increasingly contends for water with other sectors like industrial and domestic. As population growth accelerates, it is expected that the share of water allocated to agriculture will decline [5]. In terms of economic use, the water scarce regions require significant investment in water storage infrastructure and management, to enhance water availability and accessibility. Nevertheless, effective policies are crucial for ensuring these water resources are used efficiently and sustainably [44].

The agriculture sector holds enormous importance for its significant contribution to the GDP in the basin countries, which accounts for about 20 per cent on average [83]. Furthermore, the agriculture sector supports both agricultural and industrial activities, contributing to the growth of non-agricultural enterprises in rural and urban areas across the basin countries. Agriculture also strengthens regional cooperation and integration through trade in agricultural products. Also, increasing food production could directly trigger poverty alleviation. It can also influence cost-effective living by reducing food prices in the region. Rising population, higher incomes, and changing food habits are driving greater demand for food, thereby increasing the need for water in agricultural activities. Consequently, competition for water between agriculture and other sectors-such as domestic use, industrial needs, and ecosystem conservation-is likely to intensify as

demands in these areas continue to grow. Furthermore, water stress will also increase due to its mismanagement in the agricultural sector and environmental pollution [1]. For example, soil erosion, surface-water, ground-water pollution, and increased salinity may rise with the intensification of agricultural activities. Therefore, the farm sector is likely to remain of critical concern for policymakers and managers of water resources. Food production in the Nile Basin region is closely tied to the development of agriculture and the effective management of water resources. Achieving this requires a comprehensive understanding of the region's environmental characteristics, the socio-economic conditions of farmers, and the spatio-temporal variations that influence agricultural practices.

The irrigated area in the Nile Basin is projected to expand by over 50 percent by 2050 [17]. However, studies warn that substantial water shortages could occur if all planned agricultural expansions rely solely on water from the Nile or its tributaries [61]. Major large-scale irrigation developments are proposed, particularly in Ethiopia and Sudan. Egypt and Sudan, in particular, depend almost entirely on the Nile for their irrigation needs.

In Sudan, out of an estimated 105 million hectares of arable land, nearly 18 million hectares are currently under cultivation [24]. While much of the land across the Nile Basin remains dependent on rain-fed agriculture, large-scale irrigation projects are actively being planned in Sudan and are already being implemented in Egypt.

In Egypt, the Al-Salam Canal, which is partially constructed beneath the Suez Canal, reroutes water from the Damietta branch of the Nile, for irrigation purpose in northern Sinai. Furthermore, in 1997, Egypt initiated the development of the Toshka Lakes by constructing canals and pumping stations to channel surplus water of the Nile into a natural depression approximately 300 kilometers west of Lake Nasser. The New Valley Project, which is designed to accommodate around 3 million population and to support irrigation to approximately 25,000 square kilometers, will demand an additional 5 billion cubic meters of water annually [26]. However, this ambitious expansion relies heavily on the availability of surplus water, a dependence that poses significant future risks if such excess water cannot be guaranteed to sustain these projects.

Meanwhile, upstream Nile countries, traditionally dependent on rainfall, are increasingly experiencing frequent droughts. Faced with rising food demands and high production costs, these nations are expanding their agricultural activities, often necessitating the development of new irrigation systems. For instance, Tanzania's Ministry of Water and Irrigation has initiated the construction of a pipeline to draw water from Lake Victoria to supply the Tabora, Igunga, and Nzega regions, benefiting approximately 400,000 people [77]. Other upstream nations, driven by the urgent need to combat hunger and poverty, are also asserting stronger claims over the Nile's waters through plans for the construction of multi-purpose hydroelectric dams. Rising climate variability, rapid population increase, escalating food prices, and increasing food insecurity are further pressuring larger, wealthier countries to seek alternative solutions, whether by purchasing food or producing it beyond their own borders.

A major challenge facing water resource management in the Nile basin, is balancing the rising water demand for irrigation with the limited available supply. Water savings from improved irrigation technologies alone will not be sufficient to meet the additional requirements of planned agricultural expansions. Even under an ideal scenario of maximum efficiency, a water deficit would still remain. However, improving irrigation efficiency may prove vital in alleviating water stress and promoting the sustainability of the Nile ecosystem.

5.3. Specialisation in Food or Fuel

The food and fuel debate is an essential discussion over the increasingly large-scale investment in agricultural land of developing nations, particularly in Nile basin states which are already low in production of food crops. It is related to the options between food and fuel. Biofuel production is the primary concern of large-scale land investment and is figured to use 1 per cent of total water for irrigation of the globe [23]. The water resource can be influenced measurably if the biofuel crops are irrigated. In the case of rain-fed agricultural production, the water quality can also be adversely affected by pesticide use and fertilisers that will run off to the surface water and ground-water [54]. The UN Special Rapporteur argues that the rising production of biofuels is a major factor driving up food prices, thereby displacing large populations who can no longer afford the cost of sustaining their households [36]. Across the Nile Basin countries, where widespread poverty, malnutrition, and hunger persist, and agricultural and irrigation infrastructure remains underdeveloped, a critical question arises: should the priority be to cultivate food crops or energy crops?

As the White Nile adds only 15 per cent and the Blue Nile accounts for approximately 85 per cent to the total Nile River discharge, no significant issues about transboundary impacts have been raised by downstream riparian countries in the past [3]. However, this trend appears to be shifting as in Ethiopia and Sudan, the upstream and midstream countries of the eastern Nile Basin, have over the past few decades, awarded contracts for nearly a million-hectares of land to big investors. Similarly, in Sudan, external institutions and organizations have been involved in land reforms since the 1980s, aimed at promoting the cultivation of cash crops such as groundnuts, cotton, and sugar [65, 63, 20]. These agricultural projects have utilized Sudan's share of water as allocated following the 1959 Nile Water Agreement. Consequently, Egypt- who is historically the primary consumer of Nile River water, has expressed concerns over the potential impacts of these developments on its future water security.

Land grabbing is a new process for Ethiopia, where 85 per

cent of the entire runoff of the Nile waters originated [3]. The current project, like the filling of GERD and future projects, is supposed to raise the Nile waters utilisation of Ethiopia that till now has not been fixed. Two critical issues need to be addressed. First, the exact amount of water that these upstream projects will consume remains uncertain, yet they are expected to greatly influence water availability in downstream regions. Moreover, Ethiopia is not involved with the downstream neighbouring countries and has no specific water allotments, and it has started unilateral projects on the Nile River. In essence, there are no legal hindrances to enhancing water usage substantially. In Egypt's favour, there is an increasing interest that programs will be rendered in a small amount of available water during year storage at Lake Nasser. In the basin, there is a heavy focus on states' domestic independence and security, enabling governments to determine their domestic growth plans and manage the available resources for their domestic socio-economic developments.

The Nile River Basin offers a critical case for analyzing the potential transboundary water impacts of land grabbing. In the White Nile region, Kenya, Uganda, and Tanzania have become prominent destinations for foreign investors, while in the Blue Nile region, Ethiopia and South Sudan have attracted significant investment, particularly from companies engaged in the biofuels industry [48]. Additionally, South Sudan-the newest member of the Nile Basin-is increasingly being targeted by external investors due to its vast potential for large-scale agriculture, with several land deals already finalized [28]. Since 2000, an estimated 10.3 million hectares of land across 11 Nile Basin countries have been acquired, primarily through leases or licenses, by foreign investors. According to Angela Harding, the Data Coordinator for the Land Matrix Africa team [78], a wide range of actors are actively involved in large-scale land acquisitions. These investors can be broadly categorized into three groups. First, there are the Asian and Gulf nations, including China, South Korea, India, Saudi Arabia, Qatar, the United Arab Emirates, Libya, and Syria [21]. These countries are seeking to secure agricultural resources beyond their borders to address food security and economic interests at home. Second, sovereign wealth funds such as Al-Qudra are playing a critical role [50]. These state-owned investment vehicles are channeling significant financial resources into African land markets, often with long-term strategic goals. Third, we see private equity firms from around the globe entering the scene. Companies such as Karuturi Global, Saudi Star [49], and Citadel Capital [81], are making substantial investments, further intensifying the competition over land and water resources. Understanding who the key players are is crucial to analyzing the broader implications of land deals for food security, local livelihoods, and environmental sustainability across the continent's land investments in Africa, it is important to recognize that these large-scale acquisitions are commonly referred to as "land grabs" [41], with selected examples listed in Table 3. Meanwhile, despite repeated pledges-including the commitment to allocate at least 10 percent of national budgets to agriculture under the Maputo Declaration-African governments have largely failed to meet these investment targets [107].

Table 3. *Land grabbing in Nile basin countries: A selection.*

Buyer	Vender	The portion of land accumulated (km^2)
Citadel Capital	South Sudan	55,777.00
South Korea	Sudan	6,879.70
India	Ethiopia	404.69
Saudi Arabia	Ethiopia	101.17

Source: (Brown, 2011); (Manson, 2011). [21, 71].

Thus, one may question whether biofuel production constitutes a legitimate agricultural investment, especially given that ensuring food security will be of critical importance in the future. In terms of the basin countries, such concerns contribute to the international dimensions of the issue. Therefore, establishing investment projects in land or water grabs reduces local people's space availability for economic activities. Even disputes between Ethiopia and Egypt over utilising the Nile resources have led to the possibility of war. Current pressure and surge for lands in Ethiopia for bio-fuel production come primarily from the companies of India and Saudi Arabia [86]. Therefore, other international actors may escalate possible disputes between Ethiopia and Egypt in the context of energy markets.

5.4. Specialisation in Virtual Water Trade

Primarily, the concept of virtual water denotes the veiled movement of water embedded in the making and trading of products, especially agricultural and industrial goods. Interestingly, the idea of virtual water was first introduced in London in 1944. At that time, however, the practical significance of embedded water in global trade was minimal and received little attention. Today, the concept has gained critical relevance. As water scarcity intensifies across many parts of the world, the virtual water content of traded goods has profound implications for national water security, food production strategies, and international trade relations. Later Tony Allan developed the concept in several of his works [10, 11] and afterwards by other scholars. The idea of virtual water is naive and has attained considerable political shape. Fraiture et al. [43] analyzed the impact of virtual water on global water use, setting a foundation that many scholars later expanded upon. Water is essential for producing various food products, including vegetables, cereals, dairy, and meat. The amount of water required to produce a single product is referred to as

virtual water. Whereas the associated concept of the water foot-print measures the direct and indirect water usage related with a producer or consumer. Together, the ideas of virtual water and water foot-print create a comprehensive framework that connects diverse sectors and issues, offering valuable tools to promote more efficient water management by shaping production and trade decisions [9]. Evaluating virtual water is particularly important in water management studies, as it allows for integrated comparisons of crops and livestock based on their respective water requirements [22].

For countries facing water scarcity but possessing abundant land, importing virtual water offers a limited yet strategic approach to managing their water resources. Virtual water trade not only conserves domestic water supplies but also contributes to improving global land use efficiency [29]. Currently, the exchange of virtual water between nations accounts for roughly 15 percent of total global water use, including that utilized in rain-fed agriculture [98].

To illustrate, it takes nearly 1000 litres of water in producing 1 kilogram of wheat, whereas the requirement of water goes beyond 5 to 10 folds when producing 1 kilogram of meat [94]. On average, cereals and other crops constitute about 64 per cent of global virtual water trade, while animal products account for approximately 25 per cent, and other goods make up the remaining 11 percent. Through virtual water trade, water-abundant states can assist water-scarce countries in meeting their domestic water needs, fostering greater global resource sustainability [33]. Instead of producing water-intensive goods domestically, importing countries can conserve their limited water resources for other essential uses. Water-scarce nations, therefore, can strategically import water-intensive products instead of producing them domestically allocating their own resources to produce them locally. In this way, actual water savings can be achieved by saving consistency over water resources worldwide. However, importing states require not being water scarce to receive virtual water.

In respect of total water used for rice production and virtual water trade, the leading countries are India, Thailand, Pakistan, and Vietnam, collectively accounting for approximately 76 percent of global virtual water exports [85]. A significant portion of the population in North Africa, the sub-Saharan Africa, and the Middle East can address water scarcity through the import of virtual water [57]. The three key Nile River Basin countries, Ethiopia, Egypt, and Sudan, offer a compelling case study for virtual water trade, highlighting potential areas for cooperation and coordinated water management strategies. Weyler [113], suggests that the area under irrigation in Sudan may be extended at the expense of Ethiopia and Egypt. But as there is less possibility for irrigation in Ethiopia due to its topography, fortunately, regionally and domestically, they are developing hydro-power potential, cutting down losses from evaporation and increasing available hydro-power potential. Sudan and South Sudan may produce better crops than Egypt and Ethiopia. The presence of many labourers in Ethiopia, Sudan and South Sudan indicates transboundary cooperation, which will make better income in all the countries by exchanging the duo that may improve the food security situation [115]. Egypt has a comparative benefit in producing cash crops of higher value for exporting to Middle Eastern and European countries. Aggregate benefits from the production could be raised in the region if Egypt reapportions some amount of its used water to higher value fruits and vegetables [113]. Egypt's demand for water for agriculture can be reduced if a minor shift toward horticulture occurs. Weyler also anticipated that Egypt and Sudan might assist in developing water resources to Ethiopia, provided they would get energy. It can be considered Cooperative agreements based on factors beyond water alone will be essential for achieving sustainable development in the basin.

So far, trade of virtual waters in the Nile basin has not been established to directly add to the Nile region's development. The primary cause is the scarcity of regional markets. Without functional, regional, and local markets, favourable costs and relative benefits cannot be proved. At present, well-functioning markets are largely absent in many of these countries. Egypt, however, possesses a relatively well-developed and efficient market, especially for agricultural products. Yet, much of its trade is oriented toward Europe and the Middle East. In this context, Egypt’s water appears inexpensive to Middle Eastern markets, reflecting relative benefits and lower potential for conflict. However, when assessed at the basin level, which is the appropriate scale for water resource management, it is observed that the water of Egypt is comparatively costly.

The three primary strategies for enhancing agricultural production in Nile Basin countries through virtual water include expanding cultivable land, increasing cropping intensity, and improving yields or harvest frequency. However, since most Nile Basin countries lie in arid or semi-arid zones, expanding the area under cultivation remains a significant challenge [34]. An increase in cropping intensity will need more fresh water influencing optional uses. In a basin like the Nile River, where there is no extra water supply, virtual water is the means to enhance the level of food security. Thus, virtual water trade can be effectively leveraged to enhance the efficient use of global water. By promoting production in regions better suited for water-intensive activities, particularly within the Nile Basin, this approach can help achieve water security in water-scarce areas and reduce pressure on natural resources.

6. Discussion and Result

This section outlines the key findings of the article and examines the potential role of diplomacy in shaping the future of the Nile River Basin. Conflicts in the basin have deep historical roots, dating back to the colonial era, and continue to manifest today as enduring geopolitical tensions between countries [97]. These longstanding disputes spill over into the management of transboundary waters, positioning water as

both a resource and a catalyst in broader multidimensional conflicts within the Nile region [96]. Yet, despite these challenges, the Nile Basin countries share a long and rich history marked by deep cultural, social, and spiritual ties.

Globally, data from the first decade of the 21st century reveals an encouraging trend that only 33 percent of recorded transboundary water-related incidents were identified as conflicting or inconsistent, while the majority- 63 percent were peaceful and cooperative, and 4 percent were considered neutral [27]. Majority of the conflicting incidents during this period were concentrated in river basins across South Asia, followed by Eastern Europe, North America, Sub-Saharan Africa, and the Middle East and North Africa (MENA) region [27]. On the other hand, Lancang-Mekong Basin in Southeast Asia's stands out as an example of growing bi-lateral and multi-lateral cooperation [112], showing us that even highly contested watersheds can become platforms for collaboration. Unfortunately, the Nile Basin has often been framed through narratives of conflict and tension [116]. Disputes over water rights, competing national interests, and historical grievances have long shaped relations among its riparian states.

The Nile is vital not only for long-lasting economic development but also for ensuring the health and social well-being of the region's population. As basin-wide population defend themselves against the changes in nature, enhance their food security, develop food and cash crops and develop energy for economic development. Therefore, any future water crisis in the basin is supposed to limit social and economic development and can be a possible root cause of conflict among the basin countries. All Nile riparian countries strongly advocate for expanding irrigated agricultural land to meet rising food demands and drive economic growth. However, states like Burundi, the DR Congo, and Rwanda-currently less engaged in Nile water-related discussions, could pose challenges to the protection and sustainable management of the river's resources if they remain outside an inclusive and coordinated Nile water-sharing framework. A unified and legitimised way can only achieve this. The water development can be attempted expeditiously in a transboundary river basin. To avoid new water conflicts in the basin countries, new strategies that may be specialised fields for each country will be needed to satisfy the water demands and needs. Ethiopia could specialise in hydro-power generation. In the case of the GERD, Ethiopia could mitigate the immediate downstream impacts by prolonging the reservoir's filling period. On the other hand, Egypt must invest in unique farming systems and more effective irrigation methods, planting less water-intensive crops and storing water in fewer evaporation regions, reducing the water remains. Sudan and South Sudan may invest in agricultural infrastructure. Other countries may also utilise their specialised fields to combat the issue of food insecurity. So there is an acute need and actions required for specialised fields to prevent tension and conflicts. Among the changes in water reallocation within the basin, Egypt and Sudan stand to lose the most in the absence of cooperation, yet they also have the greatest potential to benefit from collaborative approaches.

7. Conclusion

A review of the literature clearly suggests that a multilateral agreement offers the most suitable and sustainable path for addressing the future water supply and demand challenges in the Nile Basin. Such an agreement would not only allow for the equitable development and utilization of the basin's multiple-use potential, but would also transform the Nile's vast water resources into a foundation for significant socio-economic development and improved well-being across all riparian states. Through coordinated efforts across specialized sectors, this approach could ensure food security for the entire population within the basin.

The private sector also plays a pivotal role in the agricultural sector throughout the region. As global food demands soar and prices fluctuate, external firms are increasingly showing interest in acquiring agricultural lands. All Nile Basin countries-excluding Eritrea, Egypt, and Burundi-have approved land allotments to foreign investors. In fact, over the last two decades, approximately 12 million hectares have been leased out, with Sudan, Tanzania, and Ethiopia alone accounting for more than 90 percent of this total [90]. This trend, however, warrants careful reconsideration to ensure it aligns with the long-term food security and development needs of local populations.

Today, the majority of the Nile Basin's people rely heavily on agriculture for their nutrition and livelihoods. Yet agricultural activity in the region remains largely subsistence-based, strained further by rapid population growth. Despite the basin's vast potential, many riparian communities still struggle to meet their basic nutritional needs.

Thus, for many Nile Basin states, reforming the agricultural sector is not just an option-it is the key to eliminating poverty and strengthening domestic food security. This can be achieved by adopting strategies that specialize in crops and farming methods best suited to each region's climate and resources, implemented through mutually agreed mechanisms.

Diplomatic solutions and regional cooperation in specialized fields are not simply idealistic aspirations; they are essential. Only through collaboration can we reach a true win-win outcome-boosting food production, alleviating poverty, and securing livelihoods for millions across the Nile Basin.

Moreover, rising water demand in Egypt highlights the broader regional reality: water scarcity is not a challenge confined to one country-it affects the entire Nile Basin. Managing this growing demand sustainably, equitably, and collaboratively is not merely desirable; it is absolutely necessary to secure the future of millions who depend on the life-giving waters of the Nile.

Abbreviations

FAO	Food and Agricultural Organization
GNP	Gross National Product
GERD	Grand Ethiopian Renaissance Dam
DRC	Democratic Republic of Congo
NBI	Nile Basin Initiative
NELSAP	The Nile Equatorial Lakes Subsidiary Action Program
ENTRO	the Eastern Nile Technical Regional Organization
GDP	Gross Domestic Product
UN	United Nations
MENA	Middle East and North Africa

Conflicts of Interest

The authors declare no conflicts of interest.

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