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Egypt, Factor 6: Sustainable Agriculture

Ameliorating Sedimentation in the Aswan High Dam to Sustain Agriculture and Water Management in Egypt

Background

Water is the basis of life. For centuries, humans have lived near bodies of water like rivers, lakes, and the oceans for fertile land, fishing, and maritime trade and travel. The first successful civilizations and societies were based in river valleys. In the past few decades, the world has been able to take greater advantages of the natural environments with dams. Dams are able to collect or distribute water, generate electricity via hydropower, and supply man-made lakes called reservoirs. Reservoirs that are created by dams prevent flooding and provide water for irrigation, human consumption, industrial use, and aquaculture. However, despite these benefits, reservoirs also form the basis for many environmental problems. One of these main consequences is the sedimentation that occurs in reservoirs. Rivers typically carry sediment down their riverbeds. Dams block this flow of sediment, which leads to downstream erosion and sediment build-up within the reservoir. Since the sediment is collected in the dam and is unable to travel downstream, erosion occurs, which in turn damages land and farms downstream. As sediment collects in the reservoir, it takes up space that can be used for water, thus decreasing the effects of hydropower and limiting the available water for irrigation. A region where these impacts have reached a critical state is in Egypt, where the Aswan High Dam has led to sediment build-up in Lake Nasser. To address and improve the situation better methods need to be developed to reduce the negative aspects of sedimentation. This can be done through better engineering approaches, especially bypass tunnels, sluicing, and as a last resort "drawn-down flushing" to maintain the Nile, Egypt's greatest gift.

There are approximately 88.5 million people in Egypt, and nearly all of them are native Egyptians. Egypt is just over 1 million square kilometers, or 386,102 square miles, in size (CIA World Factbook). Bordering the Mediterranean Sea in northern Africa, Egypt is a vast desert that is interrupted by the fertile Nile valley and delta. This North African country usually experiences two seasons, a mild winter and a hot, dry summer that ranges over a hundred degrees Fahrenheit. In most areas, Egypt receives fewer than eighty millimeters of annual precipitation, and the wettest area only receives 200 millimeters (World Weather & Climate Information). Out of more than one million square kilometers of land, only 3.6% of the land, mostly along the Nile delta, is available for agricultural practices due to low annual rainfall (CIA World Factbook). A desert nation, Egypt has always been dependent on the Nile River for its annual flood to irrigate the lands for harvest.

Average Family

The average household in Egypt consists of four people, typically two children with a mother and a father (ArcGIS). Most children attend school, which has led to a nation-wide literacy rate of 73.8%. However, this is not equal between men and women. Men typically attend school for a year longer than women and have a literacy rate of 82.2%, whereas women have a rate of 65.4% (CIA World Factbook). Compared to neighboring nations in the Middle East and North Africa, Egypt's education system is quite impressive. Children go through nine years of elementary school and then attend high school for three more years (Classbase). The book *Hungry Planet: What the World Eats* reports the average Egyptian family spends $68.53 US dollars per week on food. The author, Peter Menzel, claims the typical Egyptian diet consists of peppers, potatoes, bananas, tomatoes, processed meat, and other vegetables along with wheat and rice. Egypt's health care system is very elaborate and consists of many public entities handling management, finance, and the provision of care. With many different public NGO's, there is acceptable access to

health care across the nation. However, since the government does not take direct control of the health care system, the system is below acceptable. In hospitals across the country, the conditions are "alarming" due to poisoned water, animals wandering the halls, and bloody bandages on the floor (Rios). Annually, the Egyptian government only invests 1.5% of it GDP on health expenditures for its 88.5 million citizens. Due to limited government funding and involvement, Egypt has become a nation with the highest prevalence of hepatitis C (14.7%), very high rates of obesity (17.6%), and endemic poverty (Rios). The average Egyptian lives in poor conditions and has limited job opportunities which is seen in the nation's 34.3% unemployment rate, 38.7% for males and 52.2% for females (CIA World Factbook). Most citizens do not live in urban centers, but instead in the rural environment, where 58% live and 29% participate in agriculture in the Nile River delta. The typical family farm in these rural areas is less than 0.84 hectares with only 19.6% of farms being greater than that. In the eastern Delta region, the commonly grown crops are mango, strawberry, green beans, peach, citrus and cantaloupe. In the middle Delta region, they usually grow citrus crops. Finally, in the western Delta region, crops typically include cotton, rice, potatoes, citrus, and grapes (FAO). The industrial sector in northern Egypt also attracts workers, receiving 24% of the country's workforce to produce products like textiles and chemicals.

Current Situation

Egypt is currently divided, politically and religiously, and facing terrifying economic and political challenges. Violent protests have led to mass division, and foreign powers like European nations are standing up to financially assist Egypt in their democratic transition (New Europe). The nation is split politically between Islamist and secular groups while the Egyptian military remains the country's judge and decision-maker. Government leaders and elected parliament have continuously been overthrown in the past half-decade. The current political vacuum has led to political tensions between the military and several political parties vying for power, including fundamentalist Islam groups and several secular groups. Political uncertainty has led to labor strikes, protests, religious tensions, and an increase in violence and criminal activity (About News).

Currently, the Egypt economy is in a state of frenzy. The economy is already short on financial resources, and political issues make it very difficult for funding to be dedicated to environment issues. A fragmented government has decreased the ability for initiatives and environmental funds to resolve and regulate the effects of the Aswan High Dam on the Nile River and Nile Delta.

Although addressing the issue in this paper will prove beneficial, there are still many problems that will affect Egypt in the decades ahead. For example, the rising oceans level are constantly wearing away the Nile Delta (*Ocean and Coastal Management*). Another issue is the horrendous levels of air pollution, especially in large cities like Cairo (Air Pollution in Cairo – the Cost).

Benefits of the High Aswan Dam and Lake Nasser

The High Aswan Dam, completed in 1970, cost Egypt about $1 billion to construct. The dam supplies the manmade reservoir Lake Nasser which can hold almost 6 trillion cubic feet of water (Britannica). The benefits of the dam are distributed to both Egypt and Sudan, although Egypt experiences more of the environmental impacts of the dam and reservoir. The annual floods have historically been an important event in Egyptian, and now man can control this momentous occurrence. When floodwaters are most needed, a controlled flood can maximize the water's utility on the irrigated land. Also, the dam has 12 turbines which generates enormous amounts of power through the process of hydropower. Finally, Lake Nasser supports a large fishing industry (Britannica).

Problem

Nearly all of the water in Egypt comes from the Nile. The quality and quantity of the river water is beginning to become threatened by sewage, industrial waste, and wastewater. Another reason for a decrease in quantity of water available on the Nile is the High Aswan Dam, which reduces the water flow

and traps the beneficial and nutrient-plenty silt. The nutrient-rich silt used to fertilize fields along the Nile for agricultural problems, but now, poor, rural farmers must use chemicals to fertilize the land, that negatively affect the environment even more. The 1 million tons of artificial fertilizers are not sufficient to replace the previous 40 million tons of silt that fertilized the land before the construction of the High Aswan Dam (Britannica). Due to the lack of sediment in the river after the Aswan High Dam, the Nile Delta has begun to decrease and has resulted in erosion (Countries Quest). Additionally, the lack of nutrients downstream has hurt the fishing industry off the Egyptian coast. From 1962 to 1968, the amount of the sardine catch off the Egyptian coast decreased from a plentiful 18,000 tons to a meager 460 tons. By 1992, it had recovered to 8,590 tons, yet still had not returned to the levels before the construction of the dam (El-Sayed).

Sediment is collected on the Aswan High Dam and the manmade Lake Nasser which receives reservoir water from the dam. The lack of sediment downstream has many negative effects, but the buildup of sediment in the reservoir and dam also has consequences. The sediment buildup in the reservoir greatly reduces the amount of water that can be stored in Lake Nasser. Another consequence of sediment buildup is related to hydropower, which many dams like the High Aswan Dam generate. The hydropower valves, which are placed high on the dam, transport water down through the hydropower technology which then generates power. As the sediment buildup increases, it is reasonable to expect sediment will eventually interfere with the hydropower process and decrease the amount of energy generated.

This problem is getting worse. While the fishery industry has returned to an acceptable level, the situation is getting worse for all parties involved, even though it may not appear so. The increasing severity of the issue if very evident for poor farmers who are seeing the Nile Delta erode away while pumping tons of fertilizers into the ground. The situation is also getting worse for other people who use the dam, even though it may not appear so. Due to increasing sediment in the dam, the conditions in the Aswan High Dam are decreasing. While this may not be very clear now, at some point the dam will be overcome and will lose much of its functionality.

Proposal

The best way to address sediment buildup in the Aswan High Dam, and in most dams across the globe, involves reducing buildup through the improvement in the release and removal of sediment from reservoirs. Implementing this mission will relocate sediment from places that they are not needed above the dam to places where sediment is desired in the land used for agriculture. One proposal that could help address this problem is the re-design of dams that trap sediment to a new design where sediment is passed through the dam (Wiley Online Library). Unfortunately, many sediment management methods are not being implemented in the construction of modern dams. Designing and re-designing dams that manage sediment movement may be expensive, but will reduce the negative side effects of sedimentation like erosion and maintain the benefits of the river. Additionally, sediment buildup in reservoirs and dams reduces the life expectancy of the dams because the sediment interferes with hydropower and takes up space by collecting in reservoirs. One proposed sediment management method for diverting sediment around the reservoir is instituting sediment bypass tunnels. Bypass tunnels divert parts of incoming water filled with sediment around the reservoir and then the tunnels laden with sediment-filled water rejoin the river. The method diverts water when sediment levels are high and when the sediment levels are low, the water is allowed into the river. The use of sediment bypass tunnels has proven to be successful, especially in Japan in the Asahi Dam on the Shingu River. In 1998, after twenty years of maintenance, the Asahi Dam began to experience sedimentation problems. A tunnel that bypassed sediment was constructed in 2006 and since then has rerouted over 750,000 cubic meters of sediment. It is true that these tunnels are expensive to construct, but when you evaluate them in the context of the benefits that they provide such as increasing the fertilization of the Nile delta, preventing downstream erosion, and minimizing long-term operation costs, it is certainly a smart financial and agricultural move amortized over a long period of use (Wiley Online Library).

There are also ways to prevent sediment buildup in the Lake Nasser reservoir, and other reservoirs that are created around the world. One of these significantly less expensive ways is called drawdown routing, or *sluicing*, which is the discharge of high flows through the dam with the goal of transporting the sediment through the reservoir as quickly as possible to prevent sedimentation (Wiley Online Library). This leads to less water entering the dam and thus less power generated but it will preserve the long-term health of the dam so it can operate for a longer time. This also may lead to the transportation of pre-existing sediment in the reservoir. High amounts of water are usually passed through the dam when a controlled flood is released. If sluicing is instilled, sediment will be able to quickly pass through and exit the dam and continue downstream along with the flood. This will maximize the irrigation and agricultural benefits of the flood because nutrient-rich silt will be released into the environment and will fertilize the lands. This solution should be appealing to Egypt because it has positive environmental effects through the healthy fertilization of the farmlands, reduces the sedimentation in Lake Nasser so its volume can be utilized for water storage, preserves the long-term operating ability of the dam, and does not have any negative economic or environmental drawbacks

Another solution for lowering the amount of sediment buildup in Lake Nasser is through a practice referred to as "turbidity current venting". Turbidity currents are currents of water that have distinctly higher densities due to sediment in the water, like how sediment collects at the bottom layer of Lake Nasser. It is possible to allow the higher density water with sediment to exit the dam, referred to as "venting", through outlets on the bottom of the dam (Wiley Online Library). More benefits could be derived from this method because the sediment-laden water could be re-introduced into the river and could then fertilize land for agriculture. In the case of the High Awan Dam, this solution would be cost-ineffective because it would require the re-design of the dam. However, the lessons learned from the High Aswan Dam could be applied to the construction of future dams.

A final, last-resort solution to removing sediment levels in reservoirs is referred to as "drawdown flushing", which involves the emptying of the reservoir at a constant pace that does not disrupt the river flow (Wiley Online Library). This practice is most effective in reservoirs that are long and narrow, like Lake Nasser which is nearly 300 miles long and 10 miles wide (Encyclopedia.com). This method may not be the best solution since it is usually more effective with small reservoirs due to the lesser amount of water released and would lead to the complete vacancy of Lake Nasser, which currently supports an impressive fishing industry. This option obviously would best be avoided.

Because of the high initial capital costs, the Egyptian government, in association with NGOs and possibly the World Bank, will have to be the main force in implementing these solutions. NGOs specializing in engineering and technology will be helpful because they can be vital researchers and planners in the execution of this process. Additionally, if Egypt feels they need assistance in funding of this project, they should reach out to the World Bank.

Top-down solutions many times fail because they lack public support. The solutions proposed above are top-down solutions, and therefore require public support in order to be implemented effectively. Communication must be ample and clear between the government and local small-scale farmers, possibly through forms of media like newspapers, to get farmers on board with the government's actions. These actions will change how the river behaves and how healthy it is, so it is vital that the farmers are made aware of such changes, especially so they don't continue to use fertilizers. Overall, making the public aware will not only give the government more support, but will be more beneficial for the small-scale farmers in the Nile delta.

If the government of Egypt wishes to see these benefits take affect and acknowledges the positive impacts of dams with sediment management methods, they should invest in redesigning their dam and provide space for sediment to travel either through the dam or around the reservoir. Doing so will improve the efficiency of the dam and also nourish the farmlands and provide more sustainable water management to benefit agriculture.

Conclusion

The High Aswan Dam and Lake Nasser in Egypt have led to many benefits for the region, including the control of waterways, collection of water for human and industrial use, a large fishing industry, enormous amounts of hydropower being generated, and the manipulation of flooding from the Nile. However, sedimentation and sediment buildup in the High Aswan Dam and Lake Nasser reservoir in Egypt have also led to many negative side-effects, including downstream erosion in the Nile delta, disruption of maritime ecosystems, and decreased effectiveness of the dam and reservoir through reservoir storage being taken up by sediment and the hydropower process being interrupted by sediment. These consequences can be resolved through the implementation of a variety of methods that reduce the amount of sediment buildup in the Aswan High Dam and reduce the amount of sediment in Lake Nasser. These methods include rerouting sediment-laden water around the High Aswan Dam through bypass tunnels and lowering sediment levels in Lake Nasser by releasing high-density water through vents and permitting large currents through the reservoir to carry out some sediment. These methods, which will improve sedimentation in the dam and reservoir, will also have many other benefits such as combatting erosion in the Nile Delta and fertilizing farmland with natural nutrients instead of chemical fertilizers.

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