journal of legal and economic research | Volume: 7 / N°: 2 (2024), p 964 -983

Environmental Technology's Contribution to Sustainable Development in Desert Regions-Sahara Forest Project as a model

Amel Hafnaoui*
Echahid Cheikh Larbi Tebessi University- Tebessa
amel.hafnaoui@univ-tebessa.dz
Environmental Studies and Sustainable Development Laboratory

Send Article Date: 10 / 02 /2024 Date of acceptance of the article: 03 / 05 /2024

****

Abstract:

This study aims to present the role of environmental technology in meeting the requirements for achieving sustainable development in desert and arid regions. The Sahara Forest Project model was presented with the environmental technologies it depends on, and what distinguishes it as a comprehensive, innovative system that would contribute effectively to facing global challenges. It was concluded that the experiences of implementing the project in Qatar and Jordan showed good capabilities that contribute to achieving true sustainable development in desert areas. It enables the production of much-needed resources and provides valuable jobs while preserving the ecosystem.

keywords:Environmental technology,Sustainable Development, Desert Regions, Environmental Protection, Sahara Forest Project.

Introduction:

Sustainable development is a comprehensive initiative addressing the most pressing global challenges to build healthy communities characterized by justice, equality, and prosperity. Among these challenges are achieving food security, providing clean water and energy for all while protecting the environment, and facing climate

*Amel Hafnaoui.

change. It's worth mentioning that innovative and successful solutions are offered for each challenge. However, the problem lies in responding to one challenge at the expense of others. Therefore, the difficult equation now is how to find a solution that can address these challenges simultaneously or address one challenge without sacrificing another in return.

Statistics indicate that the world's population is expected to reach around 9.3 billion by the year 2050(Sahara Forest Project, 2015, p. 4). The Food and Agriculture Organization (FAO) estimates the need to increase global food production by at least 50% to meet the needs of this expected population. However, achieving this goal is challenging due to the scarcity of arable land and freshwater, and climate change threats(FAO, 2014). Therefore, attention has turned to desert lands in an attempt to use them to address this global challenge.

This promising proposal faces the harsh characteristics of the desert, which include its dry and harsh climate, water scarcity, and management issues, as well as environmental, economic, and social problems, all of which pose development challenges.

This research, using a descriptive-analytical method, aims to present the solutions offered by the Sahara Forest Project and to what extent these solutions can ensure sustainable development in desert regions. It also examines whether these proposed solutions maintain the desired balance to address the aforementioned global challenges.

SECTION I: THEORETICAL FRAMEWORK

First Requirement: Environmental technology

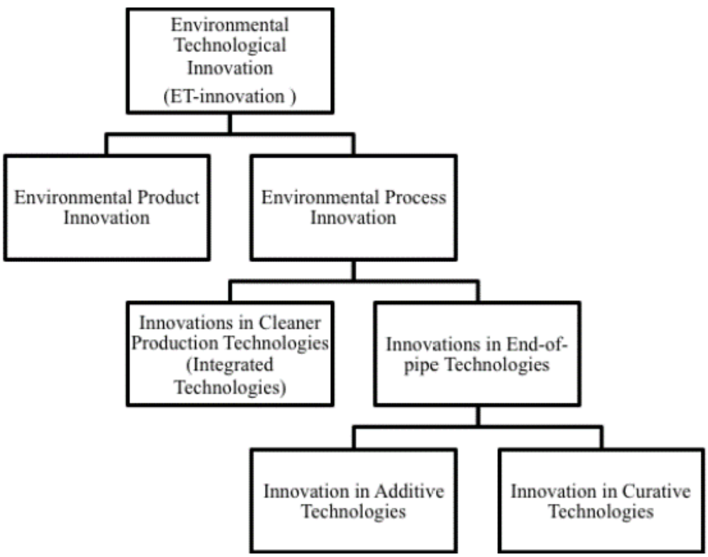
Technology is considered one of the most important means relied upon to find effective mechanisms for achieving development while preserving environmental safety and as innovative solutions to address environmental challenges.

There are many terms used by researchers and specialists to express environmental technology, such as green technology, clean technology, and sustainable technology. Environmental technology can be defined as products, services, organizational models, and large-scale technological systems, the development and use of which contribute to achieving better environmental performance from a life cycle perspective compared to related alternatives.(Kanda, Sakao, & Hjelm, 2014).

This technology aims to instill a greater sense of environmental protection in production processes. It includes specific measures such as using fewer polluting inputs, redesigning production processes to have less environmental impact, and recycling products. (Salem, Shawtari, Hussain, & Shamsudin, 2020, p. 2)

Environmental technological innovation is defined as "the invention, creation, and dissemination of new sets of products and processes that are more environmentally friendly by nature than currently manufactured and used sets." There are three important components to defining environmental technological innovation: innovation must be based on new technological knowledge; it must be a new innovation; and it must involve reducing environmental impacts compared to current technologies.(Yusuf, Ashari, & Razalli, 2018, p. 1572)

Classification of environmental technology innovations



Source:(Yusuf, Ashari, & Razalli, 2018)

Environmental technology innovations are divided, as illustrated in the figure, into two main categories: Environmental Product Innovations and Environmental Process Innovations, which are further classified into end-of-pipe innovations and integrated (or cleaner production) technologies. End-of-pipe technologies include preventative measures, i.e., additive technologies (such as pollution control and remediation). The other component of end-of-pipe technologies includes treatment technologies (such as treating polluted water).

Second Requirement: Sustainable Development

Sustainable development was defined, as stated in the 1987 report of the World Commission on Environment and Development, entitled "Our Common Future," as: "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs"(Tracey strange, 2008, p. 26). According to this concept, sustainable development is a development that aims to meet the needs of current generations efficiently without compromising the rights of future generations to do the same. It is a continuous and renewable process, where achieving a certain level of growth or development leads directly to pursuing a higher level for the next stage of development, giving the concept of development the advantage of sustainability.

This concept was further clarified and enhanced in the same report, stating: "(…especially the basic needs of the neediest people, who are given the highest priority. Sustainable development aims to prefer a state of harmony between humans among themselves, and between them and nature...)"(Souyet, 2009, p. 30). This definition is the first to clearly outline the three basic pillars of sustainable development (economic, social, and environmental). It is evident from this definition that sustainable development means achieving economic development environmentally secure, and socially beneficial and involves everyone everywhere in the world.

In this regard, the historic summit of the United Nations General Assembly in September 2015 adopted the 2030 Sustainable

Development Agenda by the United Nations member states, numbering 193 countries. The Sustainable Development Goals were formulated, consisting of 17 goals branching into 169 targets. These goals represented a global agreement to eliminate poverty and hunger and achieve prosperity in a fair and equitable world for people and the planet.

Sustainable Development Goals are: (UNITED NATIONS, 2015)

- End poverty in all its forms everywhere.
- End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.
- Ensure healthy lives and promote well-being for all at all ages.
- Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all.
- Achieve gender equality and empower all women and girls.
- Ensure availability and sustainable management of water and sanitation for all.
- Ensure access to affordable, reliable, sustainable, and modern energy for all.
- Promote sustained, inclusive, and sustainable economic growth, full and productive employment, and decent work for all.
- Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation.
- Reduce inequality within and among countries.
- Make cities and human settlements inclusive, safe, resilient, and sustainable.
- Ensure sustainable consumption and production patterns.
- Take urgent action to combat climate change and its impacts.
- Conserve and sustainably use the oceans, seas, and marine resources for sustainable development.
- Protect, restore, and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, halt and reverse land degradation, and halt biodiversity loss.

- Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.
- Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Third Requirement: Sustainability in desert

Deserts serve as a livelihood for millions of people,nevertheless, agricultural systems and biodiversity in desert regions are at risk. It is noteworthy that 44% of the world's food, including half of its livestock, is produced in dry areas. Among the 2.7 billion people living in drylands, estimates suggest that around 40 million reside in deserts that typically receive less than 100 mm of rainfall annually (ICARDA Communication Team, 2021).

The sustainability of fragile desert agriculture is severely threatened by several factors, including climate change, population pressures, inappropriate land management practices, extreme temperatures, declining soil fertility, limited availability of organic matter, water scarcity and salinity, wind erosion, high evaporation rates, and isolation from energy sources and markets (ICARDA Communication Team, 2021)

SECTIONII:Sahara Forest Project as a Model

The Sahara Forest Project (SFP) is an innovative Norwegian project established through two entities: the Sahara Forest Project Foundation, aimed at promoting the concept of regenerative growth and serving as a creative platform for launching new initiatives, and the Sahara Forest Project AS, aimed at creating profitable innovations and environmental solutions. Its goal is to cultivate and green the desert and provide fresh water, food, and renewable energy in arid and barren areas, prioritizing environmental protection first and foremost. It relies on modern and innovative technology to combat desertification and climate change. Additionally, the project involves storing carbon dioxide from the atmosphere in soil and new biomass, offering a feasible and profitable method for establishing a negative carbon value chain.(SFP, n.d.)

The Sahara Forest Project is primarily designed to leverage existing resources to produce what we need more of, using desert lands, seawater, and emitted carbon dioxide to generate food, freshwater, and clean energy. This is achieved through the employment of proven environmental technologies.

The project serves as a distinctive experiment to demonstrate the effectiveness and importance of environmental technologies in restoring vegetation cover and creating new job opportunities through profitable production of food, water, biomass, and electricity, employing simple solutions and mimicking designs and principles from nature. This integrated system allows for harnessing beneficial synergies and increasing the efficiency of individual technologies. Thus, the Sahara Forest Project advocates for an environmentally friendly, beneficial to people, and economically viable regenerative growth approach. It offers a clear vision and effective solutions for harnessing the potential of regenerative growth and green innovation to enhance sustainable food, water, and energy security.

key objectives of this project are:(FAO, 2014, p. 90)

- Enhancing the efficiency of electricity generation from solar energy.
- Operating greenhouse cooling with high efficiency using seawater.
- Utilizing energy and water for cultivating high-value crops in the desert.
- Producing freshwater for irrigation or drinking purposes.
- Safely managing saline water and harvesting beneficial compounds from the resulting salt.
- Replanting desert lands.
- Providing commodity outputs of food, energy, and salt.
- Obtaining climatic benefits by sequestering carbon dioxide from the plant and soil.

- Mitigating desertification by restoring vegetation cover in arid areas.

First Requirement: Sahara Forest Project pilot in Qatar

1. Project Implementation:

The SFP pilot facility in Qatar serves as a distinguished research platform for applying and testing environmental technologies aimed at achieving sustainable growth in desert regions worldwide. This initiative marks the initial step in developing the project on the ground.

The first feasibility study for the SFP was presented at the United Nations Climate Summit in 2009. Three years later, the first experimental facility was inaugurated in Qatar and showcased at the United Nations Climate Conference in 2012. Covering an area of 10,000 square meters outside Doha, the capital of Qatar, a pilot station was established to transform the barren desert into a thriving forest that produces food, renewable energy, and freshwater. This project, which harnesses modern innovations, resulted from a cooperation agreement between the Norwegian Sahara Forest Project (SFP) and Qatar Fertilizer Company (Qafco), the world's largest producer of urea and ammonia, along with its partner Yara International ASA, the largest fertilizer supplier globally. The station began operating in December 2012,(Al-Bia Wal-Tanmia, 2012, p. 49) providing a research framework to demonstrate the feasibility of environmental technology in achieving sustainable development in desert regions worldwide, making it socially beneficial, environmentally sound, and economically viable.

Subsequently, the Norwegian non-profit environmental foundation "Bellona" joined the project, contributing its expertise in cultivating algae and other crops for biofuel production.(Al-Bia Wal-Tanmia, 2012)

The concept of this project relies on using solar energy in the process of evaporating seawater to produce cold air and fresh water. This enables cultivation inside greenhouses in the deserts, as well as the production of freshwater and clean energy.

2. Environmental technology of the Sahara Forest Project:

The goal of the SFP is to vaporize very large amounts of seawater using locations below sea level, thus overcoming the problem of pumping costs. The large greenhouses will include a CSP station that uses mirrors to focus sunlight to create the steam needed to power turbines that generate electricity.

The project relies on innovative environmental technologies that have contributed to its success and achieving sustainable development in desert areas. These include:(Sahara Forest Project, 2015, pp. 9-11)

- **Concentrated Solar Power (CSP):** The project utilizes an innovative cooling system for CSP, allowing low-cost use of saline water to achieve cooling efficiencies without depleting freshwater resources. The heat emitted from CSP mirrors is used to operate a multi-stage evaporation desalination system to produce distilled water for greenhouse plants and beyond. The wasted heat is utilized to heat the greenhouses in winter and renew the used dryer to remove moisture from the air. The project also provides a testing ground to examine the effects of CSP arrays alongside vegetative covers, which can reduce dust levels in the air, thereby potentially enhancing solar power system performance and partially protecting valuable CSP mirrors from harsh desert winds.

  This technology relies on using mirrors to concentrate sunlight onto water pipes and boilers, producing high-temperature steam inside the pipes, which provides sufficient energy to operate steam turbines for electricity generation. Excess energy is sent to local community use.(Al-Bia Wal-Tanmia, 2012, p. 50)
- **Greenhouses Cooled by Saline Water:**Greenhouses cooled by saline water enable the cultivation of high-value vegetable cropsover the year in Qatar's desert. The air will be cooled and humidified with seawater before entering the greenhouses. This humidified air will nourish crops inside the greenhouses before passing through a dryer, where the heated seawater streams through the greenhouse. When humidified air encounters a series

of channels containing cold seawater, freshwater condenses and drips off the outer sides of the channels for collection. Only 10 to 15% of the humidified air condenses into freshwater, while the rest flows out to irrigate surrounding trees, thus creating a green environment around the greenhouse. Through this process, water usage and carbon footprint are minimized.

- **External Vegetative Cover and Evaporation Fences:** Water coming from the greenhouse will have a salinity concentration of about 15%, and for higher concentrations, it will pass through external vertical evaporation devices installed in a row to create protected and humid environments. These areas are cultivated to take advantage of conducive growth conditions for food and forage crops and a wide range of desert species. New species have been identified and distinguished for use as harvested fodder and grazing for livestock and as raw materials for bioenergy, among other local desert plants.
- **Photovoltaic Solar Energy:** The facility is supported by the latest photovoltaic technologies, ensuring efficient absorption of dust from surrounding plants and water for cleaning photovoltaic panels and effective electricity generation.
- **Salt Production:** As seawater evaporates, its salinity concentration increases to the point where salt precipitates. The final stage of this process takes place in traditional evaporative basins. SFP does not return highly saline wastewater to the sea. When the water evaporates, the salts remain, which can be extracted and used as table salt or for industrial purposes.
- **Salt-Tolerant Plants:**Salt-tolerant plants - halophytes - are grown in saline water. These robust plants are very promising sources of fodder and feedstock for bioenergy that can thrive in highly saline environments. However, direct irrigation with saline water into the soil can cause significant environmental damage. Therefore, the experimental station in Qatar is implementing and testing a variety of modern agricultural techniques for growing low-cost salt-tolerant plants, ensuring

that saline water does not leak into surrounding soil or groundwater layers.

- **Algae Production:** The modern algae test facility, the only one of its kind in Qatar and the region, allows for commercial research on the cultivation of native marine algae species in the Gulf and the Red Sea for use as nutrients, biofuel, and feed for animals and fish. Plans have been made to cultivate algae in open ponds containing seawater to produce biofuel by converting algal oil into energy fuel. Studies conducted at the National Renewable Energy Laboratory have shown that one hectare of algae grown in the lab can produce 30 times more fuel oil than other plants used for biofuel production.

3. key findings of Qatari pilot assessment:(FAO, 2014, p. 94)

- Each plant in the greenhouse uses 2.3 liters of water per day and yields up to 25 kg/m^2 of cucumber, indicating a productivity of 75 kg/m^2 per year of high-quality cucumbers. This output competes with leading European greenhouse operations.
- With 8 hectares of greenhouse production, the SFP matches Qatar's annual cucumber imports. With 60 hectares, it equals annual imports of cucumber, tomato, pepper, and eggplant to Qatar, where over 90% of food consumption is imported.
- Over 19 desert plant species and crops have been successfully grown outdoors year-round in areas with evaporative fogging nets relying on saline water.
- By using seawater for greenhouse evaporative panels and fan cooling systems, the project reduces water usage by over 50% compared to traditional freshwater systems.
- Vegetables can be produced in protected greenhouses year-round despite summer heat.
- Water usage varies seasonally, with freshwater use at 2-3 m^3 per day in a 600 m^2 greenhouse during crop production periods, with 1.5 m^3 generated daily from nutrient-rich runoff. This water can be recycled for greenhouse use or external crop irrigation and fertilization.

- Cooling CSP stations with seawater infrastructure provides nearly 100% efficiency, with 2-2.5 units of seawater needed per unit of fresh water produced through desalination. This saline solution is then used for solar power and external evaporative cooling. The 600 m^2 greenhouse requires about 2-3 m^3 of saline solution daily, with the five external nets evaporating the remaining saline solution to near saturation.
- The project's technologies have successfully operated throughout the summer, showing significant advantages in integrating food production, vegetation cover, and energy production using saline water.
- Seawater-cooled greenhouses support high-quality vegetable production year-round even in harsh desert environments. Seawater cooling can reduce temperatures by up to 15°C on hot dry summer days, enabling commercial vegetable yields comparable to those in moderate European climates.
- Cooling has increased electricity production efficiency at CSP stations by up to 10%. Waste heat from solar power or other systems can be effectively used, with greenhouse surfaces used to distill seawater into fresh water.
- Useful desert plants have rapidly grown with minimal water and nutrients. Salt production has occurred in large evaporative basins as a final product of the saline water value chain.
- The Sahara Forest Project in Qatar provides clear societal benefits, producing food, fresh water for local use, and sourced energy, while creating various jobs, from engineers to farmers.
- The system also provides climate benefits by sequestering carbon dioxide in plants and soil and by mitigating desertification through re-vegetation efforts.

Second Requirement: Sahara Forest Project in Jordan

The Sahara Forest Project pilot in Qatar ended successfully in 2016, immediately afterward, a pilot project was launched in Jordan.

1. Project Implementation:

The launch site for the Sahara Forest Project in Jordan is located approximately 12 kilometers north of the center of Aqaba city and the Red Sea, just a few kilometers from Aqaba International Airport. (Sahara Forest Project, 2019, p. 5)Construction of the project facility began on 07/10/2016, and the facility was officially opened on 07/09/2017. The project had a budget of approximately $3.7 million, financially supported by the Norwegian government, the European Union, the Grieg Foundation, and Yara International. Additionally, USAID provided funding for shipping materials and equipment from the pilot project in Qatar.(Sahara Forest Project, 2019, p. 7)

The goal of the Sahara Forest Project station in Jordan is to demonstrate the ability to generate profit through sustainable development and to provide production opportunities that contribute to environmental protection and improve social conditions in desert areas. This station serves as an initial step toward the completion of a project spanning 20 hectares in Aqaba, integrating production with a specialized technology innovation and development center for environmental technology to increase green space in the desert.

2. Environmental Technology ofSFP in Aqaba:

The Jordanian Sahara Forest Project employs the same innovative technologies used in the Qatari experiment, which have proven effective. The project's concept involves bringing seawater to land, evaporating it in an agricultural greenhouse, then condensing the vapor to produce freshwater, creating a humid and cool indoor environment suitable for crop cultivation. Algae are cultivated in open ponds containing seawater to produce biofuel. The project also includes establishing a solar panel farm to produce clean energy. The Jordan project includes two agricultural greenhouses totaling 1350 m^2, cooled by saline water, providing a conducive environment for high-quality vegetable production. Solar panels provide electricity to the facility with a capacity of 39 kilowatts. Additionally, there are areas outside the facility for cultivating various crops totaling 3200 m^2, as well as carbon dioxide sequestration in desert vegetation cover. The facility also contains a water purification unit capable of processing 10,000 liters of freshwater daily, meeting the needs of greenhouses and vegetation cover in surrounding lands. Furthermore, the facility spans an area of 3 hectares, containing salt ponds for salt production, as well as a laboratory equipped with state-of-the-art technology and specialized research and development facilities.(Sahara Forest Project, 2019, p. 7)

The technology used in the Sahara Forest Project has been developed through a series of scientific and operational studies and experiments, along with research, development, and data modeling programs. The project's experience in Qatar has demonstrated good competitiveness in crop production, with half the water consumption of other greenhouses in the Middle East and North Africa.

3. The key findings of the Sahara Forest Project in Jordan:

The principal findings of the assessment of the Sahara Forest Project in Jordan are:(Sahara Forest Project, 2019, pp. 7-12)

- Annual vegetable production yields of up to 130,000 kilograms.
- The project has contributed to the production of 220 tons of climatically adaptive vegetables, with approximately 300 kilograms exported to Norway since its inception in 2017.(Sahara forest project, 2022)
- Daily freshwater production amounts to 20,000 liters.
- The garnered returns from the trial phase are markedly competitive.
- Agricultural greenhouses are effectively cooled by up to 15 degrees Celsius compared to external ambient temperatures.
- Water consumption is significantly curtailed, approximately one-tenth in comparison to conventional agricultural practices prevalent in the region.

- Utilization of saline water-cooled greenhouses facilitates year-round cultivation of high-quality crops, even amidst periods of extreme external temperatures.
- Successful cultivation of over 50 distinct varieties of desert flora, vegetables, and cereal crops outdoors in the desert environment throughout the annual cycle.
- A total of 120 graduates from Al-Hussein Technical University have been proficiently trained over the preceding two years in agricultural technology, aimed at ensuring employment prospects in this domain and contributing towards achieving food security, given the project's exemplification of viable agricultural technological solutions adaptable to the Jordanian context.
- The "She Grows" initiative was launched, to augment the skills and competencies of young Jordanian female graduates interested in pursuing careers in agricultural technology and innovative, sustainable food production, aligning with prevailing work priorities about water, energy, and climate in Jordan.Collaboratively between 2020 and 2021, this initiative targeted 30 female engineers through a partnership established between Al-Hussein Technical University and Sahara Forest Project in Aqaba.
- The project was cited in a report by the prominent international governmental body on climate change, highlighting it as a future-oriented solution to address climate change and meet the challenges of water, food, and energy scarcity.

Third Requirement: Global Prospects of Sahara Forest Project

The Sahara Forest Project aims to tackle global challenges and offer solutions to worldwide issues, contributing significantly to Sustainable Development Goals. Its success in one or two regions serves as a springboard to spread the experiment globally, aiming to achieve sustainable development in desert areas, providing food, water, and energy everywhere, while also combating desertification and climate change.

1. Project Requirements:

The Sahara Forest Project can be effectively implemented in any desert region worldwide, contingent upon six essential elements:(SFP, n.d.)

- **High Radiation and Low Humidity:** To optimize solar power and greenhouse production, high direct natural irradiance (DNI) and low humidity are crucial, allowing for efficient cooling inside greenhouses.Renewable energy production requires solar radiation exceeding 2000 kWh/m^2.
- **Access to Saline Water:** Utilizing saline water, particularly seawater, is key, with elevation and proximity to the sea influencing energy needs for seawater pumping.As a general rule, the project can be applied to lands up to 200 meters high.
- **Land Size and Type:** Suitable land areas, ranging from 10 to over 20 hectares, are needed, with various arid land types suitable for sustainable feedstock program facilities.
- **Wind Direction:** While not mandatory, stable wind directions are beneficial for project techniques.
- **Proximity to Other Industries:** Being close to industrial facilities utilizing carbon dioxide emissions, heat, or saline water, and to the recipient of salt produced in the project, enhances project feasibility.
- **Social and Financial Factors:** Success also hinges on social factors like local support and access to skilled labor, along with financial considerations such as funding availability, construction costs, market access, and incentives.

2. Expansion Proposal for the Project in Jordan:

The Sahara Forest Project station in Jordan serves as a platform for international collaboration in food, water, and energy production in desert regions. It also acts as a tool for value engineering and cost improvement for future project stages, providing an opportunity to understand market characteristics. Therefore, an expansion proposal for the project in Jordan has been introduced to achieve greater economic returns.

This station marks the initial step towards the comprehensive Sahara Forest Project, covering an area of 20 hectares. Sahara Forest Project and Aqaba Special Economic Zone Authority have secured a total of 200 hectares of additional land in Aqaba for this purpose.

The Sahara Forest Project involves partnerships between the public and private sectors to develop a 20-hectare facility for producing high-quality vegetables for various markets in and outside Jordan. Private investments will be sought for vegetable production, while public investments will be allocated to infrastructure projects like the saline water pipeline. After the successful operation of the launch station, the innovative farm spanning 20 hectares will gradually be established in two main phases. It's noteworthy that the feasibility study demonstrates competitive returns for the project on all three main fronts - environmental, social, and economic.(Sahara Forest Project, 2019, p. 14)

3. Broad-Scale Proposal for the Sahara Forest Project:

The concept and techniques of the Sahara Forest Project can be implemented in numerous deserts and arid regions worldwide. Expanding the project's implementation will lead to sustainable increases in food, water, and energy security, providing a powerful tool to combat climate change.

The project foundation has proposed a scenario for the large-scale SFP, spanning over 4000 hectares in northern Africa. This massive facility is expected to deliver remarkable results. Notable expected outcomes include:(Sahara Forest Project, 2015)

- CSPpowering all Oasis needs and exporting 325GWh/year.
- Thermal desalination of freshwater meeting all irrigation needs.
- 300 hectares of water-cooled greenhouses producing 190,000 tons annually of tomatoes and watermelons.
- 2000 hectares of new outdoor plants and crops producing 30,000 tons annually of fodder crops.

- 150 hectares of algae cultivation capable of producing 7,500 tons annually of algae oils ready for biofuel.
- The project can employ up to 20,000 people directly and support five times that number.
- This project achieves a closed-loop system that restores vegetation to desert lands and provides carbon sequestration of 50,000 tons annually. (Sahara Forest Project, 2015)

Conclusion:

Achieving Sustainable Development Goals (SDGs) is the long-awaited hope agreed upon by most countries worldwide, viewed as an effective solution to achieve prosperity and address the problems faced by all peoples of the world in a fair manner that ensures equality for all and preserves the environment and various resources. Achieving development in the desert poses a greater challenge due to the characteristics that distinguish these regions; however, sustainable development in deserts can contribute to addressing current and future global challenges.

The Sahara Forest Project offers promising and innovative solutions to restorative growth and the most pressing current global challenges, primarily focusing on providing food, water, clean and renewable energy, protecting the environment, and confronting climate change. This is accomplished through an integrated technological system that adheres to the three basic pillars of sustainable development (environmental, economic, and social). This system not only addresses the harsh features typical of deserts but also turns them into resources for development. It combines technologies that collectively address each challenge, utilizing waste from one technology as a resource for another, which is a key factor in the success of this system with the concept of restorative growth. The results of Qatari and Jordanian experiments were outstanding on all economic, social, and environmental levels.

Based on the above, here are some recommendations:

- Countries that encompass desert lands should work on exploiting those areas, through the use of environmental technologies and relying on achieving integration between the technologies used to ensure compliance with the three pillars of sustainable development (environmental, economic, and social).

- Providing more global support for these initiatives and replicating their implementation or transferring them to various deserts worldwide to value their results and expand their scope to benefit more countries concerned.
- Encouraging countries to adopt the project and the initiative by requesting feasibility studies to assess the potential and benefits of implementing the project on their lands.
- Conducting larger studies and expanding research to find more effective solutions to some of the project's requirements that are difficult to meet in some world's largest deserts, such as the problem of the cost mechanisms of transporting seawater to the desert.
- Increasing courses and training programs on the project and its technologies, even outside the countries where it has been implemented, to prepare specialists who contribute to creating the conditions and overcoming obstacles to project implementation in their countries.
- Working on integrating the Sahara Forest Project facility effectively into local communities to maximize its benefits, especially in terms of mitigating the effects of climate change, reducing conflicts caused by resource scarcity, and providing job opportunities.

Bibliographie

- Al-Bia Wal-Tanmia. (2012, June). Ghaba fi Sahara Qatar. *Al-Bia Wal-Tanmia Environment & Development, 17*(171), 48-51. Retrieved from http://www.afedmag.com/
- FAO. (2014). *Walking the Nexus Talk: Assessing the Water-Energy-Food Nexus in the Context of the Sustainable Energy for All Initiative.* Rome: FAO.
- ICARDA Communication Team. (2021, 04 21). *THE AGRICULTURAL GOLDMINES OF DESERTS*. Retrieved from ICARDA: https://www.icarda.org/media/blog/agricultural-goldmines-deserts

- Kanda, W., Sakao, T., & Hjelm, O. (2014, July). Design of business concept with environmental technology. *Journal of Cleaner Production – special issue*.
- Sahara Forest Project. (2015). *The Sahara Forest Project From vision to reality, QATAR PILOT PLANT.* Retrieved from Sahara Forest Project: https://www.saharaforestproject.com
- Sahara Forest Project. (2019). *Enabling Restorative Growth.* Retrieved from Sahara Forest Project: www.saharaforestproject.com
- Sahara forest project. (2022, November 8). *From Aqaba to COP27: Is it possible to globalize the experience?* Retrieved from Sahara forest project: https://www.saharaforestproject.com/from-aqaba-to-cop27-is-it-possible-to-globalize-the-experience/
- Sahara forest project. (n.d.). *Qatar*. Retrieved 11 01, 2022, from https://www-saharaforestproject-com: https://www.saharaforestproject.com
- Salem, M. A., Shawtari, F., Hussain, H. B., & Shamsudin, M. F. (2020). Environmental technology and a multiple approach of competitiveness. *Future Business Journal, 6*(1), 1-14. doi:10.1186/s43093-020-00012-1
- SFP. (n.d.). Retrieved from Sahara Forest Project: www.saharaforestproject.com
- Souyet, Y. E. (2009). *La responsabilité Sociétale de l'entreprise Sous le prisme de développement durable.* Canada: Arnaud franel Editions.
- Tracey strange, A. b. (2008). *Le développement durable à la croisée de l'économie de la société et l'environnement.* Paris: Organisation de Coopération et de Développement Economiques.
- UNITED NATIONS. (2015, October 15). *Transforming our world: the 2030 Agenda for Sustainable Development.* Retrieved from UNITED NATIONS: https://sustainabledevelopment.un.org
- Yusuf, M. F., Ashari, H., & Razalli, M. R. (2018, December). Environmental Technological Innovation and Its Contribution to Sustainable Development. *International Journal of Technology, 9*(8), 1569-1578.