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Dr. Renu Singh, IARI, New Delhi, India
Dr. Anil Kumar, PSU, Thailand
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A Holistic Comprehensive Concept for Energy, Water and Food Security: Environmentally Friendly and Sustainable Economic Development Plan

Hossana Solomon*

University of the Virgin Islands (UVI), St. Thomas, US. Virgin Islands hsolomo@uvi.edu

Corresponding author's mail: hsolomo@uvi.edu

Abstract

The Holistic Comprehensive Approach for Energy, Water and Food Security explores the feasibility of using small, renewable-integrated power units to create hydroelectric power and clean water to achieve environmentally sustainable food production system. Humanity faces complex problems of sustainability, environmental degradation, resource depletion and the global warming phenomenon that has been caused in global population growth resulting in a complex problem. There are a number of anomalies in the present energy, food and water system. This holistic system calls for "Paradigm Shift' in global food production from relying on weather changes of rain and dry season and fossil based energy , which has increasingly unpredictable and risky condition in food production, to a different system that can easily be manageable using renewable energy of the sun. The Sun provides the largest primary source of energy to the planet, and the water in the oceans and seas is Earth's most abundant resource. This system will harness the energy of the Sun by using solar power and wind power to pump seawater up a hill to a storage facility near the coast, creating pumped-storage hydroelectricity (PSH). PSH is a type of hydroelectric energy storage method that pumps water from a lower elevation reservoir to a higher elevation, storing energy in the form of gravitational potential energy of water. The seawater then generates electricity as it flows back to the sea. The renewable energy sources will also be used to desalinate part of the seawater to produce potable fresh water in a process called reverse osmosis. This potable fresh water will be used within the domestic agriculture production system. Seawater plants can also be utilized to produce a biodiesel source for industrial uses. The concept combines seawater and freshwater aquaculture farming systems to produce fresh fish and vegetables, as well as fodder crops as a source of feed for small, ruminant animals such as sheep, goat, and poultry.

Key Words; Holistic system. Sustainable, Integrated, Clean Energy, Water, Food, Sea farming and Hydroponic farm.

1. Introduction

The Holistic Concept to continental coastal regions and Island nations of the tropics shall explore the interplay between energy, water and food production systems and the feasibility, of how a combined small smart renewable power units that can provide electrical energy and clean water using solar or wind, as well as hydropower, generating system from the sea and oceans.

Many countries in the tropics receives abundant solar, wind and tidal wave energy year round. The Solar, Wave and Wind sources as well as Seawater are the most abundant natural resources of the planet earth. Many countries in most tropical countries face similar complex problems of sustainability, environmental degradation, resource depletion and the global warming phenomenon that has been caused by global population growth resulting in a complex problem for humanity. Presently, a number countries imports almost all of their energy and food supplies at increasingly higher cost. Potable water using rainwater harvesting, fresh water inland lakes and rivers are increasingly dwindling and same story for ground water supply being depleted rapidly. As a result of dwindling fresh water resource many affluent countries in the Middle East and East Asian countries rely on desalination of seawater that consume considerable fossil resources. Alternative energy is becoming a much talked about idea and countries are poised to take advantage of a number of alternative forms of energy. Solar, wind, tidal wave are all within the realm of possibility for energy production. Solar and wind energy have started to make inroad as the leading source of renewable energy.

2. Research Focuses: Problem identification for Research.

With information technology and the media, it is difficult not to hear problems near and far places. El Nino and La Nina have become part of our modern vernaculars. The seesaw game played by Mother Nature of drought and flood have become so

common in recent times and worsened by Climate Change pattern of global warming phenomenon. It is hard not to hear disasters management teams appealing for government help or private donations to mitigate the effects of the alternating disasters. If we glean disaster news from around the globe for 2016 the pattern is gloomy for many countries situated in tropical climate zones [1-6].

"Drought-hit Pacific island nation of Palau could dry up totally this month, appeals for aid". Reported by AFP April 2016 The United Nations estimates as many as 4.7 million people are at risk from water shortages, food insecurity and disease across the Pacific region due to El Niño. December 15, 2015

."Drought in Zambia Cuts Electricity and Cripples Economy, New York Time April 13, 2016

"Africa Drought Fears Grip Malawi and Mozambique; Food shortage fears over a drought in southern Africa have prompted Malawi to declare a state of national disaster and Mozambique to issue a "red alert". Reported by Leadership Newspaper — *Apr 14,*

Ethiopia is currently dealing with the worst drought in the region in decades. 10 Million People are at risk. April 16, 2016

"A water crisis is developing in central and southern Vietnam as the region is hit by its worst drought in recent history. The United Nations says 1.5 million people face an acute shortage of drinking water. April 4, 2016.

This paper focuses on three main areas to make solar and wind energy practical for relatively small-scale applications: to meet the specific demands of a location, energy water and food production, by utilizing the abundant local resources.

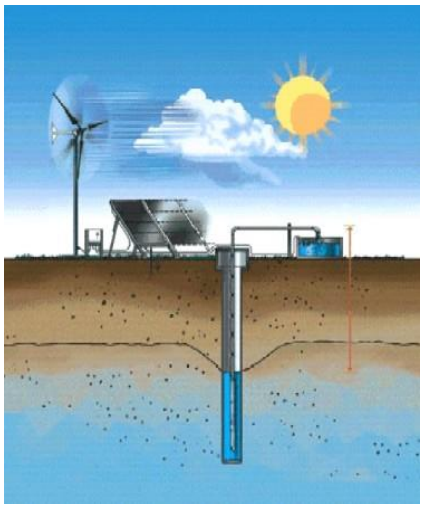

Fig 1. Solar and Wind Energy Sources:

3. Literature Review:

(i) Transforming Sun's Heat Energy to Wind and Hydro Energy:

The Sun is the ultimate source of most Energy for our planet earth. Modern Scientists believe deep in the core of our sun, hydrogen atoms react by nuclear fusion, producing a massive amount of energy. This massive energy is streamed to all the solar systems revolving around the Sun. The suns energy travels to earth at speed of light of 186,000 miles per second and enters the earth in 8 minutes covering 93 million miles. The Sun's energy reaches the earth surface in the form of heat and light energy. Every hour the sun beams onto earth more than enough energy to satisfy global energy needs for an entire year. All forms of energy, chemical, and kinetic, fossils energy or electrical energy can be traced back to the sun, with the exception of thermal energy from heat of volcano and tidal wave energy magnetic forces of the earth and the moon. The law of conservation of energy says that energy can't be created or destroyed, but can change its form and that's what happens with energy from the sun—it changes into lots of different forms:

Heat energy from the sun causes uneven heat exchange between the land and water surfaces creating changing weather patterns that produce wind (movement of air causing evapotranspiration on the surface of the earth). Wind turbines convert the wind power into mechanical and electrical energy; Wind power is created by capturing the energy within wind and converting that into electricity. In many developed countries and few developing countries, large scale wind farms, either onshore or offshore, is common producing to supply energy to the electric grid.

Hydroelectricity is electrical energy is produced from moving water, as water flows because the heat energy from the sun which causes evaporation that keeps water moving through the water cycle, from gas to liquid and snow or glacier on surface of the earth. Hydroelectric Energy is one of the cheapest and safe methods of producing electricity this includes nuclear, gas or coal as it does not attract a carbon levy. However, manmade dams along a river may have a limited life span, due to silt accumulation behind the dam and also manmade dams often require a large tract of land be flooded behind the dam creating adverse ecological problems in the short and long run to the surrounding climate affecting wildlife and vegetation. Also artificial dams are subject to climatic changes and weather conditions such as prolonged drought and rainy seasons, causing fluctuation of the electrical generating capacities. Hydro energy for the production of electricity is the most efficient energy source and has advantages over direct wind systems in being storable and controllable. Many small Islands in such as Caribbean region do not have large rivers that could

be used as source of hydroelectric dams. Due to the limited size of small area, surface water cannot be harvested during the rainy seasons in large enough quantity to develop hydroelectric dams.

(a) Transformation of Sun's Light Energy:

Plants convert light energy from the sun into chemical energy by the process of photosynthesis. Animals eat plants and use that same chemical energy for all their growth and reproduction activities. Livestock can also be considered as resources that transform plant energy to high value energy as food for human consumption. They have a four-chambered stomach consisting of the rumen. With the help of bacteria in the rumen cattle, sheep and goats have the ability to transform energy from cellulose, to high value food resource meat and milk. Ruminant animals large and small have the unique natural ability to transfer cellulose into edible food through the help of living bacteria in their four chamber stomach converting it into fat and protein that can be digested by humans or other animals with simple stomach system such as poultry and swine. When Plants and animals die the chemical energy trapped in their body is converted into other forms of chemical energy. Fossil energy sources, including oil, coal and natural gas, are the non-renewable resources that formed when prehistoric plants and animals died and were gradually buried by layers of rock. Today, oil industries drill or mine for these energy sources, burn them to produce electricity, or refine them for use as fuel for heating or transportations. However, the use of fossil energy has some negative effect on the earth's atmosphere. Over the past 20 years, scientists believe much of human-caused emissions to the earth atmosphere came from the burning of fossil fuels which contribute to the global warming phenomena associated with increases weather changes causing drought and flooding problems of the earth.

(b) Solar Power

Solar energy is the modern technology used to harness the sun's energy and make it useable as heat or electrical energy. Solar power is created by capturing sunlight energy and converting that to electricity. Solar cells called photovoltaic cells, the cells are made of semiconductor materials like those found in computer chips. When sunlight hits the cells, it knocks electrons loose from their atoms. As the electrons flow through the cell, they generate electricity.

Solar panels also can be used for water heating. On a much larger scale, solar thermal power plants employ various techniques to concentrate the sun's energy as a heat source. The heat is then used to boil water to drive a steam turbine that generates electricity in much the same fashion as coal and nuclear power plants, supplying electricity. But solar energy doesn't work at night or even on a cloudy weather it can make the technology unreliable during the day without a storage device such as a battery.

(c) Pumped-storage Hydro System

For the past half century, countries including the United States have used excess electricity from fossil fuel and nuclear power plants during periods of low power demand to pump water uphill to be stored in reservoirs as potential energy. Then, when demand peaks the reservoirs are opened, allowing water to pass through hydroelectric facilities to generate the needed electricity to meet power demand. Traditional pumped-storage hydro systems require two reservoirs of fresh water (one upper and one lower), which are not always available at locations that might otherwise benefit from an energy storage system.

Pumped Seawater represents the new, sustainable energy form by moving sea water to higher ground or to a hilltop we would have a controllable hydro system similar to the Okinawa pumped storage systems but utilizing renewable energy of wind and solar and not fossil fuels to pump the water up to the head.

So how do we get water to run up hill? Solar and windmill or wave or tide energy pumps to lift seawater uphill to a storage facility using 100% clean, renewable energy to pump the seawater as stored or potential energy. Wave energy could be a good fit, especially for islands where tropical clouds impede solar power or where wind turbines that work when the wind blows. Given the ocean's power, wave energy seems a promising source of renewable energy. Over the past two decades, firms have developed various designs, but still wave energy remains largely experimental, because the equipment can easily be damaged by relentless waves and strong storms.

The holistic concept require only one on-land reservoir and the sea as the lower reservoir from which seawater is pumped to the land storage for the hydropower. Seawater pumped-storage hydro works similarly to traditional systems. Excess electricity from fossil fuel, nuclear or renewable hydroelectric energy power plants is used during periods of low power demand to pump water uphill to be stored in reservoirs as potential energy. Then, when demand peaks the reservoirs are opened, allowing water to pass through hydroelectric turbines to generate the electricity needed to meet power demand. The main difference for seawater pumped-storage is that instead of having a lake, river, or some other source of fresh water the sea or ocean serve as the lower reservoir, these systems pump salt water uphill from the ocean to a land reservoir above.

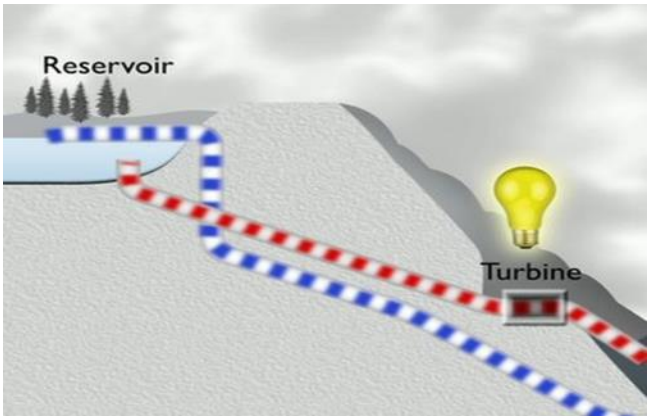

Fig. 2 Pumped Seawater Energy Storage System

(d) Water Production:

Potable water is a very scarce resource in the tropics and many Islands experience a definite wet and dry seasons. Historically, rain water during the wet season provided the only major sources of fresh water caught on the roofs and stored on cistern. But due to the irregularity of the rain fall, and high runoff associated with the hilly topography of the islands, there was a constant necessity for establishing a larger and more satisfactory supply to meet the demand of growing population lead to the distillation of seawater which is costly but readily available as the dependable alternative fresh water source. With the Reverse Osmosis (RO) method with renewable energies produces potable fresh water, for domestic and agriculture purpose. Wave energy also can also pumps high-pressure water through the desalination plant, without using fossil fuels. In contrast, many desalination plants use diesel fuel or electricity to pump saltwater at high pressure through membranes to yield fresh water.

Fig 3. Mobile solar powered reverse osmosis

(ii) Food Production:

(a) Freshwater and Saltwater Aquaculture and Aquaponics system and Seaweed farm:

The seawater pumped-up to produce hydroelectricity through gravitational force, before returning back to the sea can be used to capture more energy from the sun by processes of photosynthesis i.e. growing salt tolerant plants such as Salicornia. The seeds from *Salicornia* contain up to 30% vegetable oil which can be used for production of biofuel as well as for human consumption. The left over seed meal which is high in protein (~ 30%), can be used to supplement aquaculture and agricultural feeds. Biomass from the plant also has the potential to produce a number of useful resources including; sustainable building materials, paper pulp, and cellulosic ethanol. The concept also envisions an integrated fish, fresh fruits and vegetables farming systems utilizing seawater and/or fresh water Aquaponics systems.

Fig. 4.Integrated Seaweed and Aquaponics culture

Aquaponics is a food production system that combines conventional aquaculture (raising aquatic animals such as snails, fish, crayfish or prawns in tanks) with hydroponics (cultivating plants in water) in a symbiotic environment. In normal aquaculture, excretions from the animals being raised can accumulate in the water, increasing toxicity. In an Aquaponics system, water from an aquaculture system is fed to a hydroponic system where the by-products are broken down by nitrification bacteria into nitrates and nitrites, which are utilized by the plants as nutrients. The water is then re-circulated back to the aquaculture system.

Saltwater Edible seaweed culture in association with raising finfish and invertebrates such as shellfish shrimp and lobster production can be a nonpolluting and profitable agribusiness enterprise system using the most plentiful resource of the region the sea water. The production of fish in seawater piped from the sea to the shore based operation can produce fish and edible

seaweed from the fish waste. The seaweed can be grown for human foods, livestock fodder and for soil fertilizer. Aquaponics farms based in seaweed production make sense economically, environmentally and human health. Seaweeds produce Omega-3 oil for human nutrition.

(b) Integrated Animal Husbandry.

Livestock husbandry, Poultry and Bee Keeping can easily be incorporated to boost the nutritional quality and income for the holistic farmer. Sheep and goats are important small ruminants species kept by small farmers in the tropics as regular or emergency cash income sources.

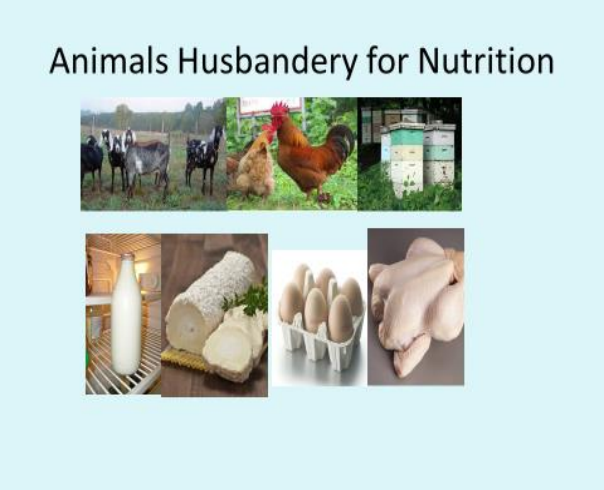

Fig. 5. Integrating, Goats, Poultry, and Bee Keeping

4. Conclusion and Recommendation.

This concept advocates the abundant resource saltwater as main source of energy, potable water and food system by lifting seawater using renewable Solar or Wind pumps to a storage facility up on a hill or elevated area close to the coast as potential energy. The stored seawater is essentially act a storage battery of the solar, wave and wind energy and when the stored water is allowed to flow back to the sea using gravity flow it converts its stored potential energy to a kinetic energy rotating a turbine to generate hydroelectricity. It also advocate to run desalination plant with renewable energy, solar, wind and/or wave energy to separate saltwater into fresh water and brine that could also generate rock salt from the sea using solar evaporation process. To use the brine and fresh water to run an integrated fish and vegetable farm for human consumption and livestock feeds, without contributing to global warming conditions. The 'Holistic system approach' advocates for a Transdisciplinary Research based developmental plan which allows scientists in various disciplines worldwide to work in tandem to solve the complex problems of energy, water and food problems for the planet, using the most abundant water resource in the oceans and seas .

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Commonwealth Energy and Sustainable Development Network (CESD-Net)

CESD-Net is a major global initiative in energy and sustainable development. The objective of network is to promote energy and sustainable development in commonwealth countries.
Focussing on Multidisciplinary Research, Promoting Future Low Carbon Innovations, Transferring Knowledge and Stimulating Networking among Stakeholders to Ensure the UK Achieves World Leading Status in Energy and Sustainable Development. https://www.weentech.co.uk/cesd-net/

The 1st International Conference on Energy, Environment and Economics (ICEEE 2016) was held at Heriot-Watt University, Edinburgh, EH14 4AS, UK, 16-18 August 2016. ICEEE2016 focused on energy, environment and economics of energy systems and their applications. More than fifty eight delegates from 31 countries with diverse expertise ranging from energy economics, solar thermal, water engineering, automotive, energy, economics and policy, sustainable development, bio fuels, Nano technologies, climate change, life cycle analysis etc. made conference true to its name and completely international. During conference total 51 oral presentations and six posters were shared between delegates. The presentations showed the depth and breadth of research across different research areas ranging from diverse background. ICEEE2016 aimed:

- To identify and share experiences, challenges and technical expertise on how to tackle growing energy use and greenhouse gas emissions and how to promote sustainability and economical, cost effective energy efficiency measures.

In total 11 technical sessions and two invited talks both from academia and industry provided insight into the recent development on the proposed theme of the conference. Preparation, organisation and delivery of the conference started from July 2015 and further co-ordinated by vibrant team of Conference Centre, Heriot Watt University. Conference organisers would like to acknowledge support from the sponsors particularly World Scientific Publication ltd and its team members for the delivery of the conference. Organisers are also thankful to all reviewers who contributed during peer review process and their contributions are well appreciated. At the end and during vote of thanks following awards have been announced and we would like to congratulate all well deserving delegates.

- Best Paper –Academia: Amela Ajanovic, EEG, TU Vienna, Austria
- Best Paper – Student : Christian Jenne,University of Duisburg-Essen, Germany
- Best Poster – Student: Yoann Guinard, University of New South Wales, Sydney, Australia
- Best Poster – Academia: E. Salleh, Universiti Kebangsaan Malaysia, Malaysia
- Active Participation Award - Yoann Guinard, University of New South Wales, Sydney, Australia

At the end we would like to extend our gratitude to all of you for your participation and hopefully welcome you again during ICEEE2017.

Editors:
Dr. Singh is Senior Scientist at Indian Agricultural Research Institute, New Delhi, India. Her area of expertise are bio energy and bio fuels, environmental engineering, carbon accounting and renewable energy integration for rural development.
Dr. Kumar is visiting faculty at Prince of Songkla University, Thailand. He have 16 years of research and teaching experience in the field of solar energy, drying and energy efficiency.

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