Examples of WEF Nexus Approach from Different Regions of the World

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Introduction

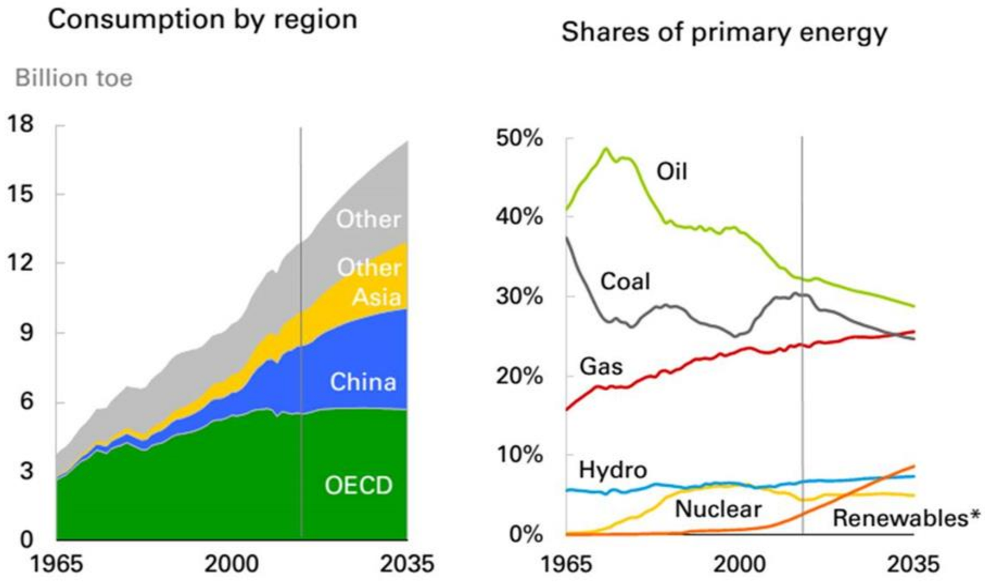
- Water, energy and food resources share a lot in common:
  - inaccessibility to billions of people
  - rapidly growing demand
  - strong interdependencies with climate change
  - different regional availability
  - variations in supply and demand
- Bonn 2011 Nexus Conference acknowledged the need for the integrated water, energy and food related policies in the face of growing concerns over the future availability and sustainability of these resources.
- A nexus approach is based on three guiding principles:
  - placing people and their basic human rights as the basis of the nexus
  - creating public awareness and the political will for successful implementation
  - involving local communities in the planning and implementation processes in order to have sense of participation and ownership

Availability and Consumption Trends: Water

- There are 1.2 billion people living in areas of physical water scarcity, another 1.6 billion people facing economic water shortage, and there are 748 million people who lack access to an improved drinking water source.
- The shortage in both quantity and quality may likely spread and become more acute due to growing demands, unsustainable withdrawal rates, degradation of source water quality and changing climate patterns.
- The global water withdrawals in 2009 stood at 4,500 billion m^3 (BCM) of which 70% were used for agriculture, 17% for industry and 13% for municipal and domestic purposes.
- The projected demand for 2030 and 2050 will be 40% and 55 % more than the currently assessed water supplies, respectively. This is mainly attributed to growing demands in the manufacturing sector, thermal power plants and domestic use.
- Effective demand-side management including effective policy interventions are needed to close the gap between future availability and demand.

Availability and Consumption Trends: Energy

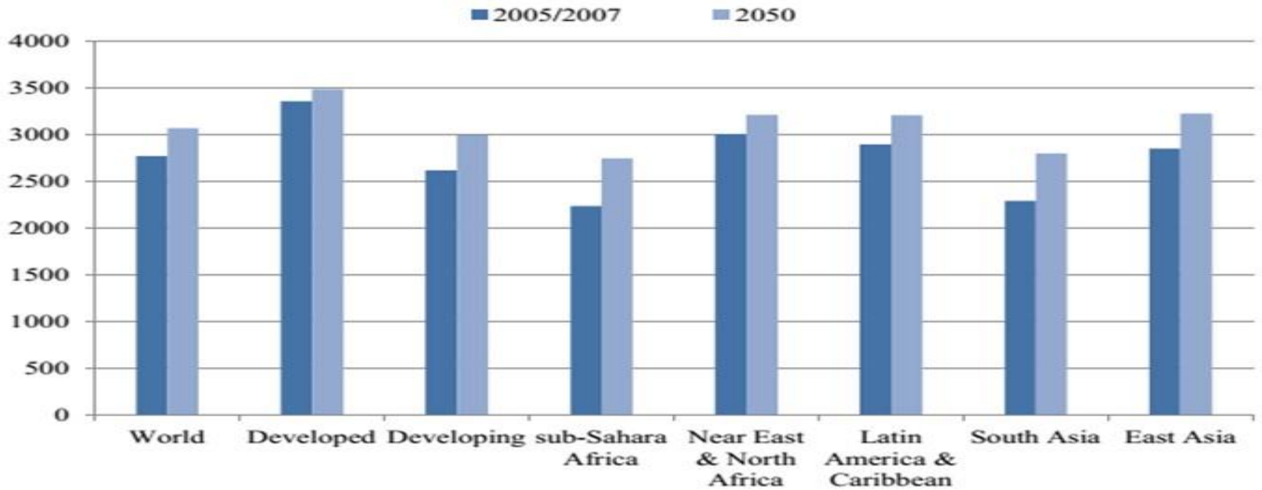
- There are 1.2 billion people without access to electricity and 2.6 billion people use the traditional cookstoves.
- Energy demand is increasing primarily due to population growth and increase in Gross Domestic Product (GDP).
- There are many international initiatives which look at reducing the demand and dependency on fossil fuels. Example: Sustainable Energy for All (SE4ALL) which was launched by the UN Secretary-General in 2011.
- The SE4ALL has three main objectives by 2030:
  - ensure universal access to modern energy services,
  - double the global rate of improvement in energy efficiency and
  - double the share of renewable energy in the global context.



Projected growth in energy consumption (Source: IRENA, 2015)

Availability and Consumption Trends: Food

- The world average available food for direct human consumption was 2,770 kcal/person/day in 2005/2007.
- By 2050, food production in the global context and for developing countries need to be increased by 60% and 100%, respectively, from 2005/2007 figures. This means 1.1% annual growth rate of total world consumption.
- The increase will be mainly due to increasing population and income as well as structural changes in diet (i.e. shifting to a meat based diet) and over-nutrition.

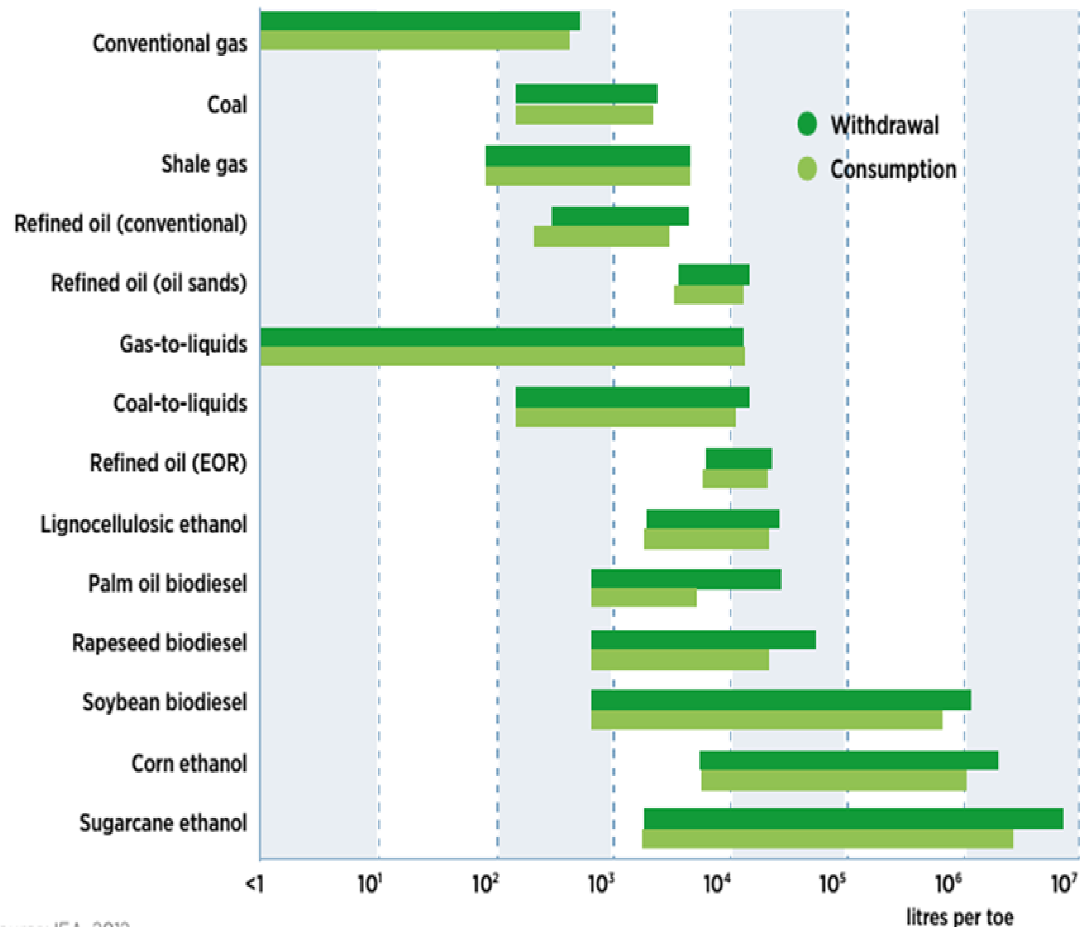


Per-capita food consumption (kcal/person/day)

Sectoral Interactions: Water - Energy

- Water is used for growing of biomass related fuel stocks (biofuel), generation of electricity, cooling tower etc.
- The water requirement for renewable energy generation such as biofuel is much higher than that required for fossil fuel based products.
- The promotion of biofuels in the transport sector through subsidies has led to the greater competition for land and water use.

Water withdrawal and consumption for primary fuel extraction, processing and transportation (litres/toe)

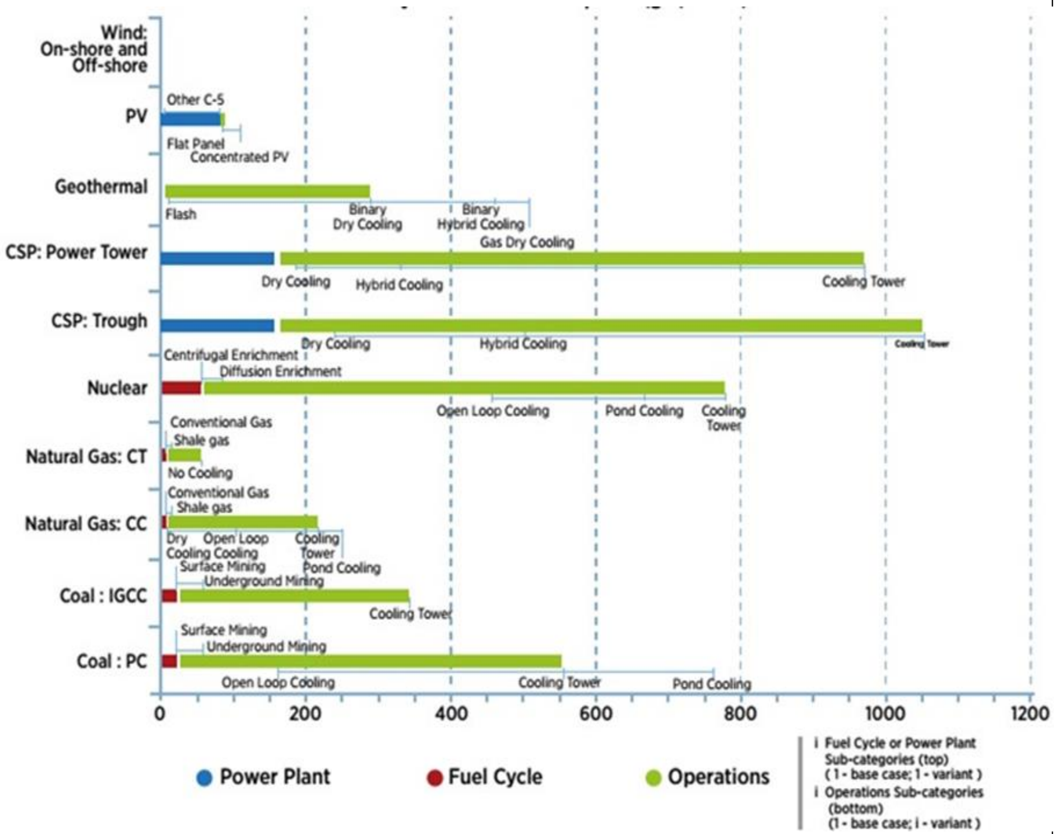


(Source: IRENA 2015)

Sectoral Interactions: Water - Energy

- Energy is required for the extraction, transportation and treatment of water.
- In 2010, energy generation accounted for 15% (580 BCM) of global freshwater withdrawals. In USA 41%.
- The global energy demand is projected to increase by 35% in 2035 which would increase water withdrawal in the energy sector by 20%.
- About 55% of water utilities operating budget being attributed to the energy cost.

Lifecycle water consumption for selected electricity generation technologies (gal/MWh)



(Source: IRENA 2015)

Sectoral Interactions: Water - Food

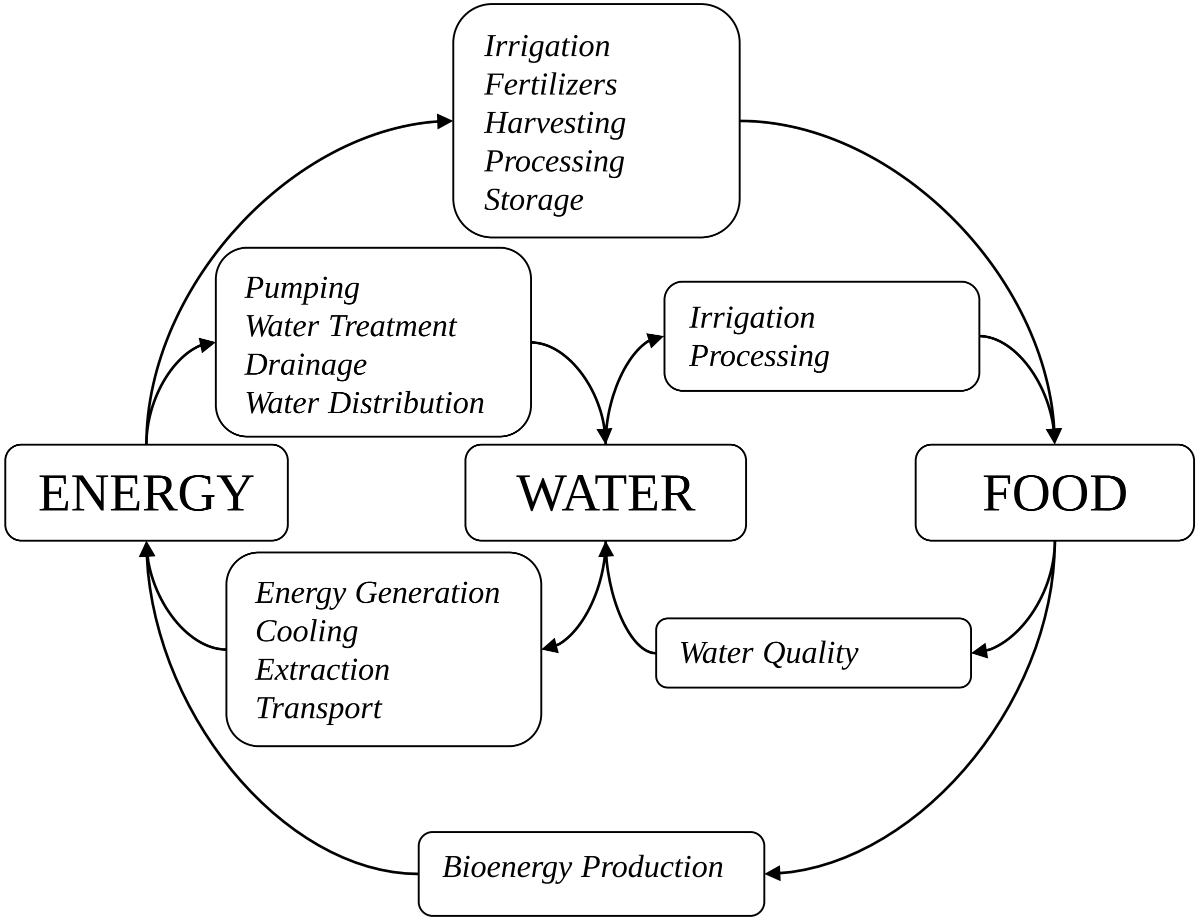
- Water is necessary for food production, preparation and consumption while changes in food consumption patterns or agricultural practices can create a strain on water security.
- Agriculture is the largest consumer of freshwater supplies accounting for approximately 70% of consumption but most of the water is returned back to the surface or groundwater along with pollutants.
- Water is not only used for irrigation but also for the processing, distribution, retailing and consumption.
- Water resources polluted through the fertilizers and pesticides which in turn affect agriculture itself thus forming a vicious cycle.
- The generation of waste or polluted water is unavoidable whenever food is handled, processed, packed, distributed or stored.

Sectoral Interactions: Energy - Food

- The energy-food interaction is more visible and easily felt as the variations in food prices are strongly linked to oil price variations.
- Agri-food supply chain accounts for 30% of the world's energy consumption and mainly used for processing, distribution, preparation and cooking. Also for producing pesticides and fertilizers.
- The main challenge in the food sector in meeting the growing demand is not actually an increase in food production but rather reducing food wastages.
- **Approximately one-third of edible food produced for human consumption is lost or wasted. This means loss in embedded energy and water, and contribution to greenhouse gas (GHG) emissions.**
- Food processing industries consume energy for heating and cooling during processing and storage of food products. For example, 20% of energy in the dairy industry is used for cooling and 80% for heating purposes.

Interactions of the Water-Energy-Food Nexus

- The Sustainable Development Goals (SDGs) have set targets for each of the nexus sectors explicitly:
  - SDG 2 (zero hunger)
  - SDG 6 (clean water and sanitation)
  - SDG 7 (affordable and clean energy).
- The interconnection between SDGs emphasizes the need for a nexus approach in achieving the individual goals.



(Source: IRENA 2015)

The Need for Water-Energy-Food Nexus

- There are still 1.2 billion people who lack access to electricity, 783 million people without access to potable water and 842 million people who suffer from chronic hunger.
- By 2050, it is expected that global energy demand will double, with water and food demand to increase by over 50%.
- Climate change impacts such as global temperature increase and extreme weather conditions, further compound the challenge of meeting the growing demand.
- There is a likely possibility that economic growth will soon be constrained by shortages of one or more of these resources.
- The amalgamation of water, energy and food in a ‘nexus’ framework in order to increase resource efficiency is necessary and the way forward in achieving SDGs.

(Source: Abdul Salam et al. (2017)). The need for the Nexus Approach.

Tools and Models in Practice for WEF Nexus

- There have been a number of tools developed to assess, and implement the water energy food nexus approach.
- Some of these tools and models are:

  i. Water-Energy-Food Nexus Rapid Appraisal Tool: Developed by FAO

  ii. Integrated WEAP and LEAP Tool: Developed by Stockholm Environment Institute

  iii. Foreseer Tool: Developed by University of Cambridge, UK

  iv. IRENA's Preliminary Nexus Assessment Tool: Developed by the International Renewable Energy Agency.

(Source: Shinde VR (2017), Water-Energy-Food Nexus: Selected Tools and Models in Practice)

(i) Water-Energy-Food Nexus Rapid Appraisal Tool: Developed by FAO

- The tool uses a WEF nexus assessment approach in order to:
  - Understand the interactions between water, energy and food systems in a particular context.
  - Evaluate the performance of a technical or policy intervention in the given context.
- The structure of the WEF Nexus Rapid Appraisal Tool has three distinct components
  - **Context analysis:** focuses on using a systems approach to develop a site-specific understanding of the issues surrounding water, energy and food securities.
  - **Quantitative assessment:** focuses on evaluating the performance of technical or policy interventions. Specific interventions are identified and discussed and their nexus links are quantified.
  - **Response Options:** focuses on engaging different stakeholders in an open and participatory policy dialogue to build consensus on specific policy issues related to effects of interventions, and strategizing the way forward.

(ii) Integrated WEAP and LEAP Tool: Developed by Stockholm Environment Institute (SEI)

- Water Evaluation and Planning (WEAP) model is capable of simulating real time situations in terms of policies, plans, priorities to model both the water demand and its main drivers, and used to evaluate various water management measures.

- The Long-range Energy Alternatives Planning (LEAP) system is a model for integrated energy and climate change mitigation planning. A number of countries use LEAP for conducting their climate change mitigation assessments and creating Low Emission Development Strategies LEDs.

- WEAP and LEAP can individually address aspects of water and energy planning; however, they were not originally designed to have synergies with each other.

- SEI has now integrated WEAP and LEAP through a common “wizard” that connects them. WEAP and LEAP can now exchange key model parameters and results, and can represent evolving conditions in both water and energy systems simultaneously.

- Using this integrated model, planners can examine the impact of individual water or energy management choices on both the water and energy systems

(iii) Foreseer Tool: Developed by University of Cambridge, UK

- The tool is used to investigate the influence of future demand scenarios on requirements for energy, water and land resources.
- The Tool comprises of a set of physical models for energy, water and land which are interconnected. It also considers the technologies that transform these resources into final services – e.g. housing, food, transport and goods.
- The tool allows the user to generate different scenarios of natural resource supply and use, and apart from the final services, also calculates greenhouse gas emissions and other measures of stress, such as groundwater depletion.
- The user can explore various future scenarios by choosing different parameters such as estimated population growth, climate change scenarios and others.
- The inputs to the Foreseer Tool include forecasts of demand for final services and technology scenarios to predict how technology performance and may evolve over time.

(iv) IRENA's Preliminary Nexus Assessment Tool: Developed by the International Renewable Energy Agency.

- This tool uses energy as the entry point. The framework uses a country's energy balance as the main input to develop various scenarios. The tool is used to investigate the influence of future demand scenarios on requirements for energy, water and land resources.
- The scenarios are developed by modifying the energy balance associated with different policy choices (e.g., a greater use of renewable energy), and to analyze the resulting nexus impacts.
- The first step in the use of the tool is establishing a baseline, i.e., current energy scenario that is the year in which the analysis is carried out or a future reference case.
- The second step is to provide an alternative energy balance. This involves developing different policy scenarios that will then be analyzed from a nexus perspective.
- The third step is to estimate the water, land, emissions and cost implications of the incremental energy balance.
- The final step is to assess whether the incremental use of resources or emissions are acceptable.

Example of Nexus Approach: Nepal

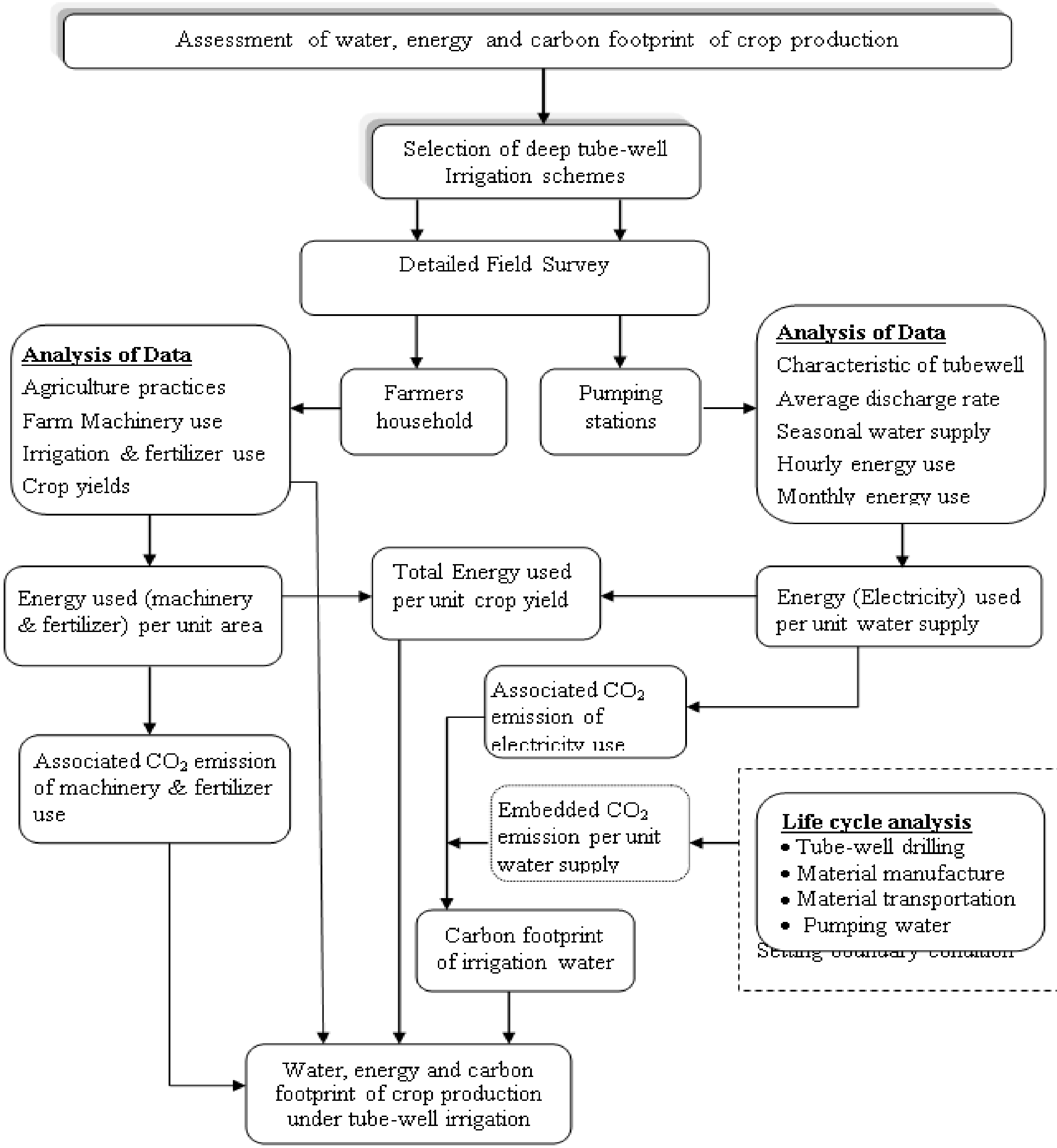
Assessment of Water, Energy, and Carbon Footprints of Crop Production: A Case Study from Southeast Nepal:

- This study assessed the water, energy, and carbon footprint of crop production under the groundwater irrigation system in Raniganj Nepal.

- Methodology:
  - Set of field level data was collected through a designed survey approach.
  - The energy and carbon auditing approach was used to examine the energy use efficiency and environmental footprints of major crop production.
  - Two deep tube wells having different capacity of pumps and the most commonly grown crops rice, wheat and maize were selected for the detailed study purpose.

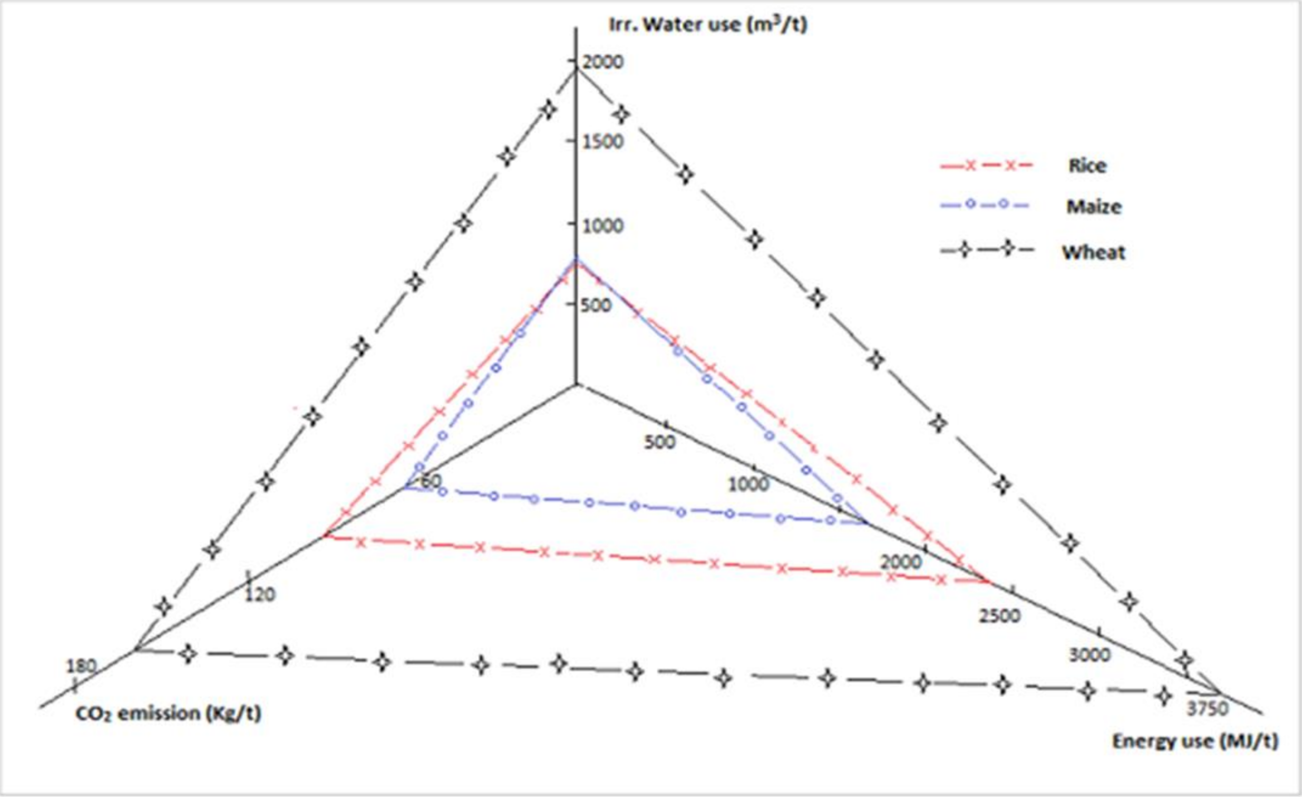
(Source: Shrestha and Adhikari (2017)). Assessment of Water, Energy, and Carbon Footprints of Crop Production: A Case Study from Southeast Nepal

The detailed methodology adopted for the study



Findings

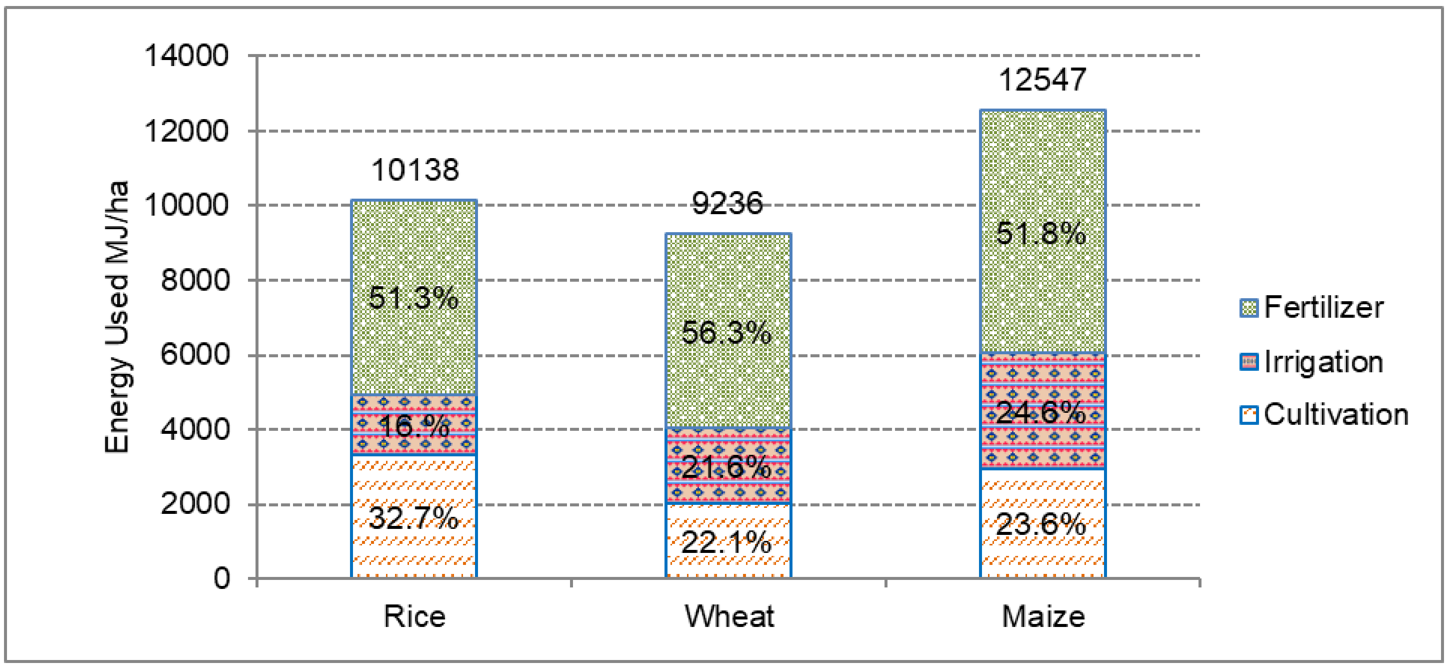
- The maize and rice production showed relatively better yields per unit of water and energy inputs, whereas wheat showed poor performance.
- Maize production seems to be the most water- and energy-efficient farm business; it requires almost half of the resources used in wheat production for each ton of yield. Also the carbon emission per ton of maize yield showed a significantly low value of 65.7 kg/ton.



Web diagram showing Comparative use of irrigation water, energy and associated carbon emission

Findings

- The wheat crop required the largest quantity of water (1938 m3) and energy (3734 MJ) resources to produce 1 ton of wheat. The carbon emission rate was also the highest (153.8 kg/ton).
- However, rice is the most water-intensive crop but requires the least irrigation water and associated energy input due to excess water from monsoon rainfall during the season.



Proportion of energy used for different operations

Example of Nexus Approach: USA

Case I: Water-Energy Nexus in Texas

- Texas is the largest generator and consumer of electricity in the United States and has extreme variability in water availability. The study assessed the amount of water used for generating electricity in Texas.
- The water needed to produce electricity varies based on a number of factors, including the fuel used, efficiency of the power plant, and cooling method.
- About 157,000 million gallons of water consumed annually for cooling Texas' thermoelectric power plants while generating about 400 TWh of electricity. This amount of water is enough for over 3 million people for a year, each using 140 gallons/person/day.
- Texas uses an estimated 2.1–2.7 TWh of electricity for water systems and 1.1–2.2 TWh for wastewater systems annually.
- The amount of energy used in wastewater systems can generate enough electricity for about 100,000 people for a year.

(Source: Pradhanang SM (2017)). Water-Energy-Food Nexus: Examples from USA)

Example of Nexus Approach: USA

Case II: Energy and Water Associated with Food Wastes

- Animal products require more energy than other foods. Ex: producing the 43 million tons of meat, poultry, and fish that Americans consumed in 2004 required 800 TJ of energy, whereas only 75 TJ was needed to supply 74 million tons of grains.
- Food is also a water-intensive resource, and there is a strong nexus between food and water consumption. Any discarded food is directly attributable to wasted water. About 2.5% of the U.S. energy budget is "thrown away" annually as food waste. In addition, about 25% of all freshwater consumed annually in the US is associated with discarded food.
- Per capita food waste in the United States has increased by 50% since 1974. In 2010, discarded food represented the single largest component of the municipal solid waste stream reaching landfills and incinerators.

Water Requirements for Food Commodities

Product	Unit	Equivalent water (m^3/unit)
Cattle	Head	4000
Sheep and goats	Head	500
Fresh beef	kg	15
Fresh lamb	kg	10
Fresh poultry	kg	6
Cereals	kg	1.5
Citrus fruits	kg	1
Palm oils	kg	2
Pulses, roots, and tubers	kg	1

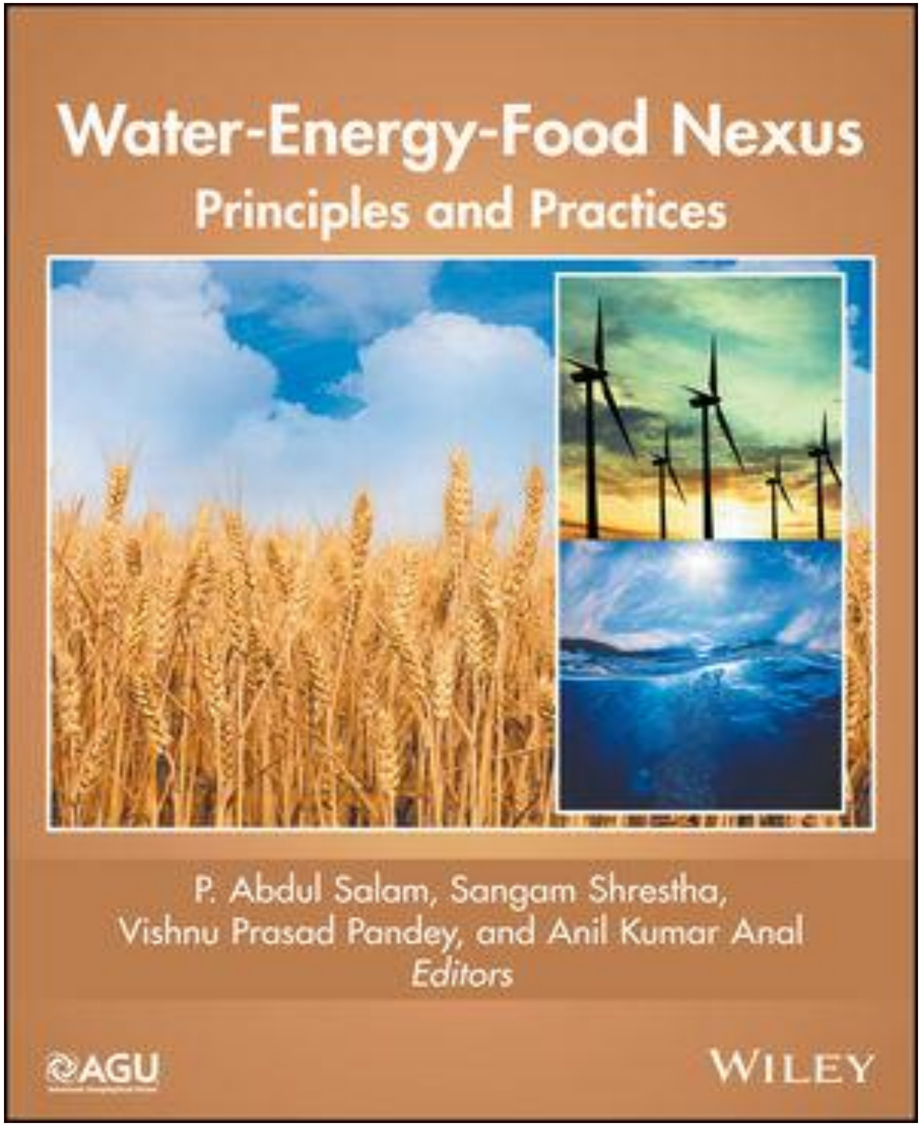
(Source: Pradhanang SM (2017)). Water-Energy-Food Nexus: Examples from USA)

Example of Nexus Approach: South Africa

- South Africa is a water-scarce country where about 13% of the land is arable and the population experiences significant disparities in equitable access to water, energy, and food.
- A Case Study of the Karoo Region in Central South Africa on the possibility of generating electricity from new resources.
- The Karoo is a semi-desert environment, has historically served a rural population with an economy based on agriculture, livestock production, and some tourism. No large-scale electricity is generated in the area, except for small solar farms. Water resource systems and the supporting infrastructure are severely constrained.
- There is a critical need to quantify the baseline conditions, socioeconomic factors, and land use changes along with projections of future population growth and climate variability to provide a better understanding of water security and its linkages with food and energy securities.
- A stepwise approach to incorporate the WEF nexus could provide insights into the sustainability of various energy alternatives and the types of governance and investments that are needed for success.

(Source: Ololade et al.,(2017)). The Water-Energy-Food Nexus from a South African Perspective)

Upcoming Book on WEF



- P. Abdul Salam, Sangam Shrestha, Vishnu Prasad Pandey and Anil K. Anal (Editors)
- 19 Chapters and 272 pages
- Available in August 2017
- Published by WILEY and American Geophysical Union
- Price = $169.95

Volume highlights include:

- Contributions to the global debate on water-energy-food nexus
- Examples of the nexus approach in practice from different regions of the world
- Perspectives on the future of the nexus agenda

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