# *WATER ENERGY & FOOD NEXUS*

# *From model to Policy framework, towards the realization of SDGs-Case Study of Pakistan*

*"So many people today – and even professional scientists – seem to me like somebody who has seen thousands of trees but has never seen a forest."*

*-Einstein (1944)*

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*Abstract*

*Though not very sudden, but incremental spike in the resources-usage, coupled with "climate change" over last few decades, particularly in the emerging economies of China, India, Brazil and to an extent Pakistan, lead us all the way to resource scarcity. If, BAU (Business as Usual) has not been harnessed, more resonating impact of the resources unavailability will not be very far in future rather colloquial of "no water", "no energy" and "hungry stomachs" are already common place. There is need for moving away from silo thinking in policy making parlance, towards more holistic framework i.e. Water, Energy and Food-Nexus. All of these natural resources are inseparably linked. Water as an input for producing agriculture goods & entire agro-food supply. Energy is needed to distribute and make water available, to pump it, to irrigate it. In reverse order, water makes (via dams) energy available, availability of food ensures human development, hence along with their sectoral importance, their linkages and a nexus among themselves makes strong case for policymaking to be in that frame too. Now, there are many synergies and trade-offs between water and energy use and food production. Using water to irrigate crops might promote food production but it can also reduce river flows and hydropower potential. Growing bioenergy crops under irrigated agriculture can increase overall water withdrawals and jeopardize food security. Converting surface irrigation into high efficiency pressurized irrigation may save water but may also result in higher energy use. Recognizing these synergies and balancing these trade-offs is central to the nexus concept, which has been inquired here. It is inquired in this paper that, post IWRM (Integrated Water Resource Management) models, are leading towards maturity with the inclusion of "Food" to the dimension. This joined up approaches to policy and practice lies at the heart of nexus thinking. It's an approach which applies at all levels of society; from local competition over access to water for irrigation or livestock, to global connections between policy on biofuels, food and water security. Inquiring and probing the model further makes it evident that its not often that synergies that exist among Water-Energy-Food but the trade-offs are negative at times i.e. increased use of fertilizer to enhance food production leads to high energy usage & greenhouse emissions along with pollution of surface and underground water. Such trade-offs are often poorly understood, unanticipated or overlooked because of no "coherent" understanding of the nexus. Further, the nexus model has been used as a suggestive framework for the policy-making for the realization of UN-SDGs. For this paper, Pakistan has been the case study.*

Key words: Water-Energy-Food, Nexus, Natural Resources, Climate Change, National Policies.

## List of Acronyms

ADB………………………………………………………………. Asian Development Bank

MDG………………………………………………………………Millennium Development Goal

NPP………………………………………………………………National Power Policy

SDG………………………………………………………………Sustainable Development Goal

UN………………………………………………………………..United Nations

WB……………………………………………………………......World Bank

WEF………………………………………………………………Water Energy & Food

WEF………………………………………………………………World Economic Forum

# Contents

## Introduction

Nexus Model, came to horizon, following the World Economic Forum (WEF 2011)[1] to sought the attention of academia and the policy-makers of the inherent and inseparable links between the use of resources to provide basic and universal rights to food, water and energy security. Whilst the World Economic Forum (2011) presented the nexus framework from a securities perspective (water–energy–food security), subsequent versions have taken on various facets with alternative components, such as water resources as a central component (Hoff, 2011)[2], land use–water– energy (Howells et al., 2013)[3] and food as a core component with land–water–energy linkages (Anik et al., 2013)[4]. Nexus thinking is advocated as an advance on current and often sector-specific governance of natural resource use.

The model incremented on thinking that natural resources are beginning to limit to a substantial degree, and this can have serious repercussions for economic growth and human well-being goals. As the Bonn Nexus Conference 2011 website succinctly describes 'this pressure on resources could finally result in shortages which may put water, energy and food security for the people at risk, hamper economic development, lead to social and geopolitical tensions and cause lasting irreparable environmental damage'(WEF 2011)[5] Focussing on the interconnectedness across key natural resource sectors, and improving their efficiency in entirety was considered to be a "win-win-win strategy for human well-being" and environmental sustainability for both current and, even more importantly, future generations. The model has gained momentum because of the past economic and natural resource development that have shown to adversely impact the environment and thus are compromising human well-being goals, as highlighted in many popular, scientific publications and policy outreach efforts such as the reports of the

[1] *Water Security: Water-Food-Energy-Climate Nexus World Economic Forum, 2011* http://www3.weforum.org/docs/WEF_WI_WaterSecurity_WaterFoodEnergyClimateNexus_2011.pdf
[2] *Understanding the Nexus: Background paper for the Bonn2011 Nexus Conference, Hoff, 2011* http://wef-conference.gwsp.org/fileadmin/documents_news/understanding_the_nexus.pdf
[3] *Integrated analysis of climate change, land-use, energy and water strategies, Howells et al, 2013* http://www.nature.com/nclimate/journal/v3/n7/full/nclimate1789.html
[4] *The nexus across water, energy, land and food (WELF): potential for improved resource use efficiency? Anik et al, 2013* http://www.sciencedirect.com/science/article/pii/S1877343513001504
[5] *Water Security: Water-Food-Energy-Climate Nexus , WEF, 2011* http://www3.weforum.org/docs/WEF_WI_WaterSecurity_WaterFoodEnergyClimateNexus_2011.pdf

Intergovernmental Panel on Climate Change (IPCC)[6], the Millennium Ecosystem Assessment (2005)[7], or the Planetary Boundaries paper[8]. The nexus concept also benefited from efforts to conceptualize the Green Economy and Sustainable Development Goals (SDGs) that rose to prominence during the preparation phase of the United. Nations Conference on Sustainable Development, held in Rio de Janeiro in June, 2012 or Rio+20[9]. It was also popularized in several wide-reaching events and reports, including, in particular, the Bonn 2011 Nexus conference[10] and its supporting background paper as well as the Global Risks 2011 report of the World Economic Forum( WEF 2011).[11]

## The "*What*" of Nexus-Model

Water, energy, and food are critical[basic] needs for humanity (Maslow 1943)[12]. Whilst this is an "*objective"* statement, a reality check vividly says that not every geographical region has an equitable and adequate supply. An arid/semi-arid region will have energy but might lack water and domestic food production capabilities (Middle East). Some regions have water but lack food production infrastructure (Bangladesh-South East Asia), while other countries have the capability to produce food but lack access to adequate energy (Central Europe). Other countries without natural reserves of fossil fuels are compelled (China)to purchase costly oil and gas and need to produce food for export to maintain their balance of payments (Anik et al 2014).[13] So the equation is not harmonized globally.

In order to comprehend the model, first we need to understand the very basis of each sector i.e. Water, Energy & Food not in the epistemological context but in the sphere of "*Governance"* and their availability in a sustainable way,

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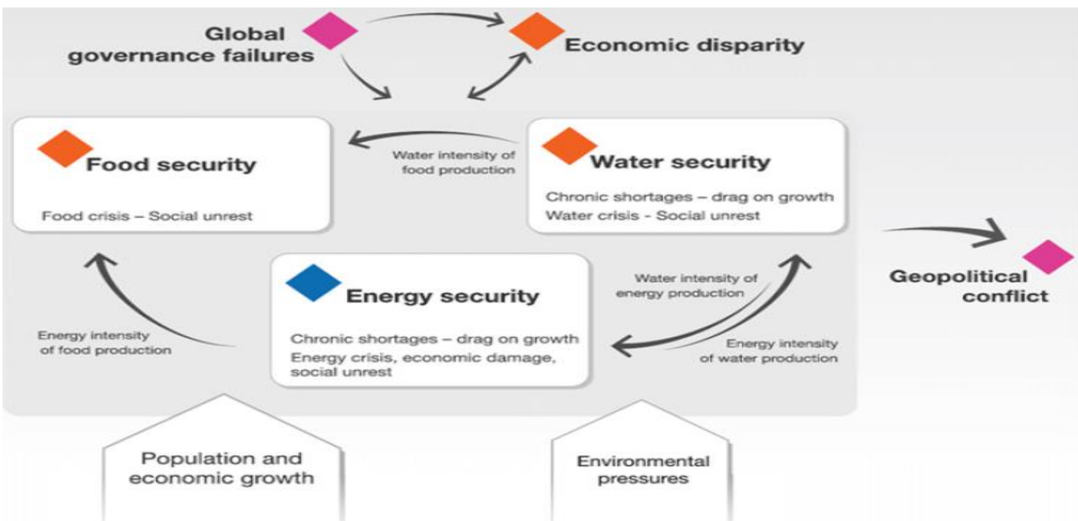
[6] *Intergovernmental Panel on Climate Change* http://www.ipcc.ch/
[7] *The Current Stats and Trends assessment, 2005* http://www.millenniumassessment.org/en/Condition.html#download
[8] *The nine planetary boundaries , 2015* http://www.stockholmresilience.org/research/planetary-boundaries/planetary-boundaries/about-the-research/the-nine-planetary-boundaries.html
[9] *UN-Sustainable Development* https://sustainabledevelopment.un.org/
[10] *Water Energy Food Nexus model: Literature and publications site* http://www.water-energy-food.org/en/
[11] *Global Risks, 2011 Edition, WEF* http://reports.weforum.org/wp-content/blogs.dir/1/mp/uploads/pages/files/global-risks-2011.pdf
[12] *Theory of human motivation, Maslow. A.H, 1943* http://psychclassics.yorku.ca/Maslow/motivation.htm
[13] *Water-Energy-Food Nexus: Moving towards sustainability, Anik et al, 2014* http://www.gwsp.org/fileadmin/documents_news/Newsletter_for_the_web.pdf

Water goal is defined in the Sustainable Development Goals (SDGs) as "access to safe drinking water and sanitation" both of which have recently become a human right. While not part of most water security definitions yet, availability of and access to water for other human and ecosystem uses is also very important from a nexus perspective.

Energy goal has been defined as "access to clean, reliable and affordable energy services for cooking and heating, lighting, communications and productive uses" and as "uninterrupted physical availability [of energy] at a price which is affordable, while respecting environment concerns".

Food goal is defined as "availability and access to sufficient, safe and nutritious food to meet the dietary needs and food preferences for an active and healthy life". Adequate food has also been defined as a human right(UN Sustainable Development 2015 ).[14]




The emphasis on access in these definitions also implies that security is not so much about average (e.g., annual) availability of resources; it has to encompass variability and extreme situations such as droughts or price shocks, and the resilience.

Water security, energy security, and food security are intimately linked. In simple terms, food production demands water; water extraction, treatment and redistribution demand energy; and energy production requires water. Energy inputs via fertilizers, tillage, harvest, transport,

[14] *UN Sustainable Development* https://sustainabledevelopment.un.org/

irrigation and processing have their influence on food prices. Environmental pressures and climatic changes, as well as growing economies and populations both intensify the existent relations between the three sectors (Mohtar, Daher, 2012)[15]

Founded on a series of understandings that nature is inherently connected in all its entirety, the resources must be affecting each other directly/indirectly, the integrated approaches to resource use emerged. The emphasis is longer-term social and ecological sustainability while offering operational means to internalize externalities, foresee and mitigate unintended consequences, and above all, strengthen resilience through outcome-oriented and institutional change. Yet this is a tall order, and while specific transition pathways that often emerge gradually must be seized rapidly, the conceptual development and tools application processes have benefitted from a decade or more of innovation and experimentation. The 'nexus' of multiple resources, in essence, means, governance and policy frameworks, that are embedded in broader political processes. The nexus conceptually links multiple resource-use practices and serves paradigmatically to understand interrelations among such practices that were previously considered in isolation (Scot et al (2015)[16].

## The Linkages

| Resource Element | Resource Dimension | Context |
|---|---|---|
| Water | Energy Challenges from Water Perspective | |
| | | Water footprint of multiple energy portfolio<br>Energy generation degrades Water quality<br>Dry cooled, thermo-generation potential/limits<br>Low water footprint solar PV and wind |
| | Food Challenges from Water Perspective | |

[15] *Strengthening the Interface between Science and Policy Communities through Inclusive Tools, Mohtar et al, 2012* https://sustainabledevelopment.un.org/content/documents/3796daher.pdf

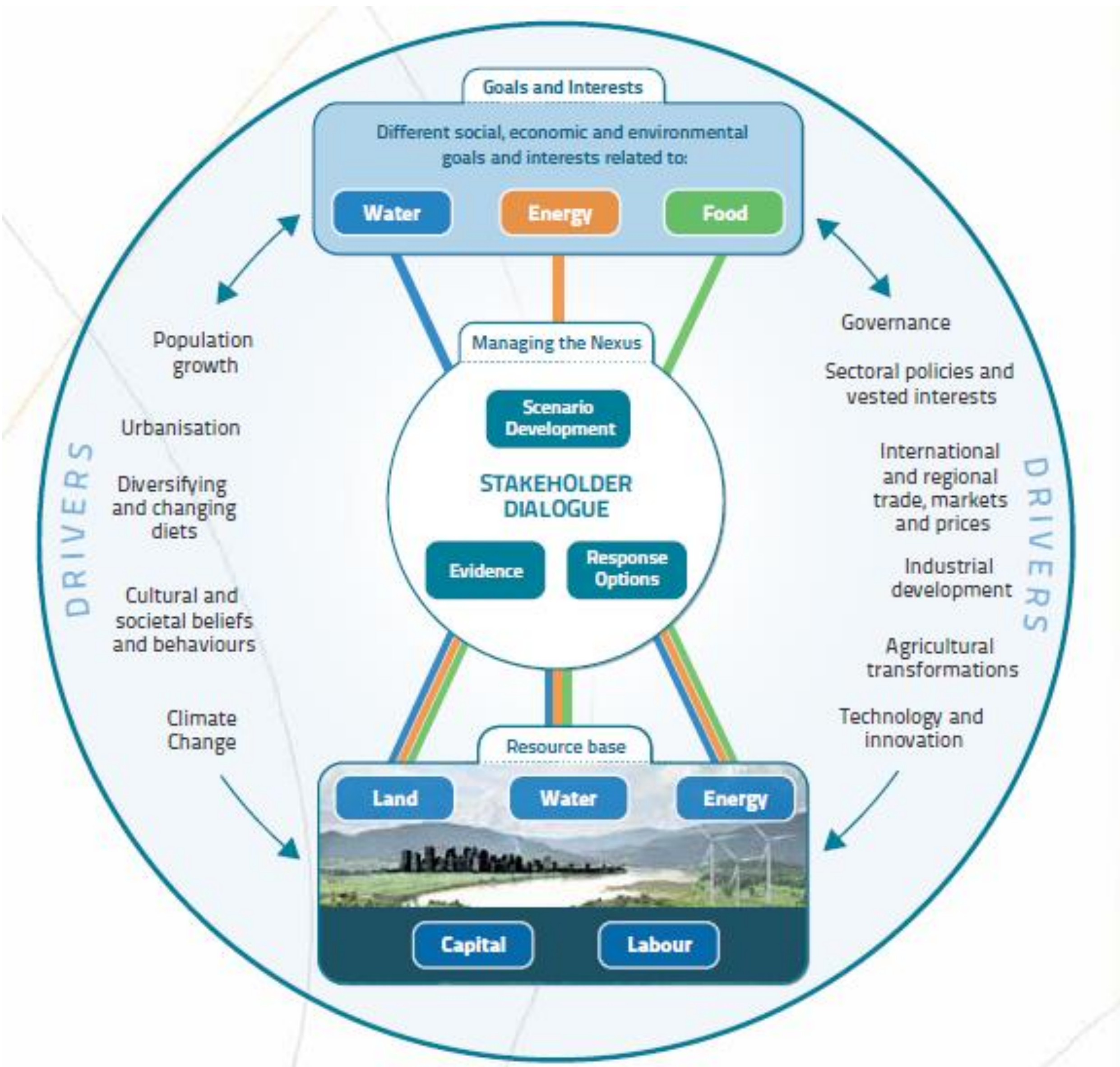
[16] *The water energy food nexus, Enhancing adaptive capacity to complex global challenges , UNU-FLOORS, 2015* https://flores.unu.edu/wp-content/uploads/2013/11/04-Scott-The-Water-Energy-Food-Nexus-Enhancing-Adaptive-Capacity-to-Complex-Global-Challenges.pdf

| | | |
|---|---|---|
| | | Production shifts polar ward, higher elevations<br>Climate change raises irrigation demand<br>More ground water pumped w/varied demand<br>Diminishing institutional influence of irrigation |
| Energy | Food Challenges from Energy Perspective | |
| | | Local food chains minimize transport energy<br>intensity of farm operations<br>Climate change increase food cooling needs<br>Extended crop season, night time operations |
| | Water Challenges from Energy Perspective | |
| | | Climate change raises water needs of energy<br>Ensure water allocation for energy generation<br>Rising demand of carbon free hydropower<br>Energy intensity of water desalination, water reuse |
| Food | Water Challenges from Food Perspective | |
| | | Higher water footprint of agriculture<br>Ensure water allocation to irrigation<br>Supplemental irrigation of rain fed land<br>Water land degradation e.g. salinization<br>Waste water use for food production |
| | Energy Challenges from Food Perspective | |
| | | Biofuel must not compete w/ food production<br>Energy intensification of agriculture<br>Energy intensification of food transport<br>Mitigation hydropower-farming trade-offs |

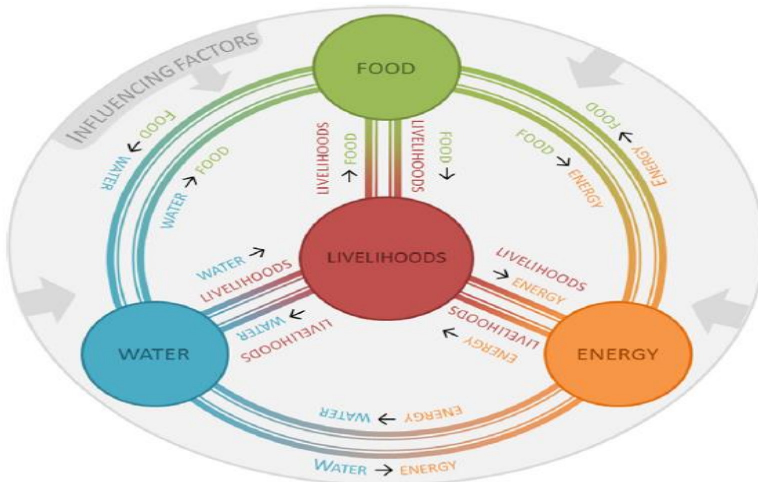
Model has been analysed in the context of “interconnectivity” and “linkage-ness”. First, lets visit the bases of nexus and its inter dependability.

The model has evolved graphically, following its conceptual inception over last couple of years. All these infographics depicts the theme of “connectivity”, though the nucleus move from water to energy to food, depending on the emphasis of the argument.

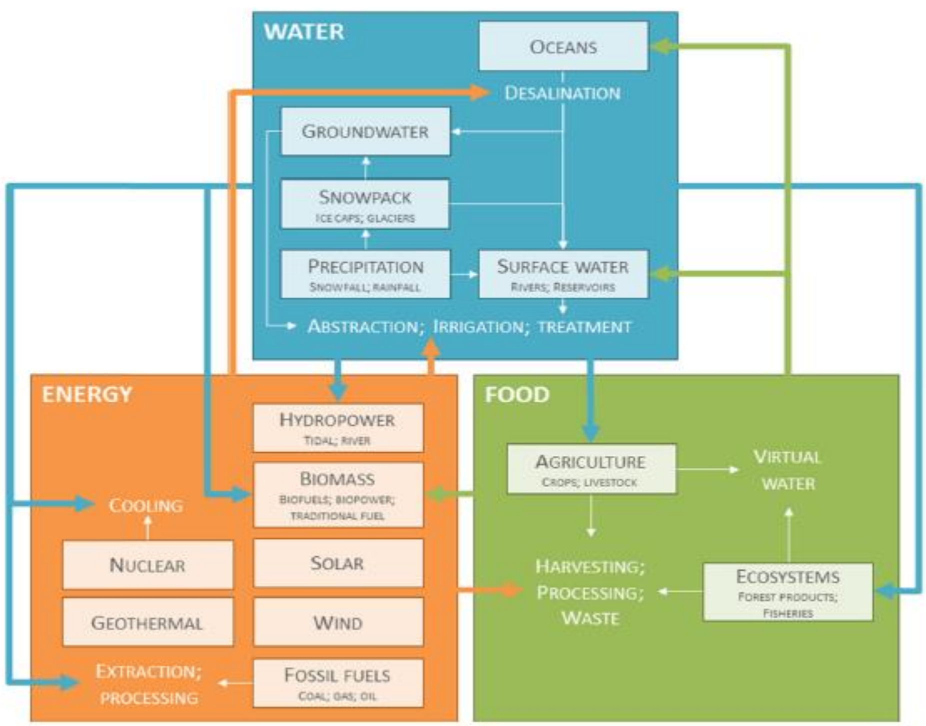
Few of them has been reproduced, from the available literature.



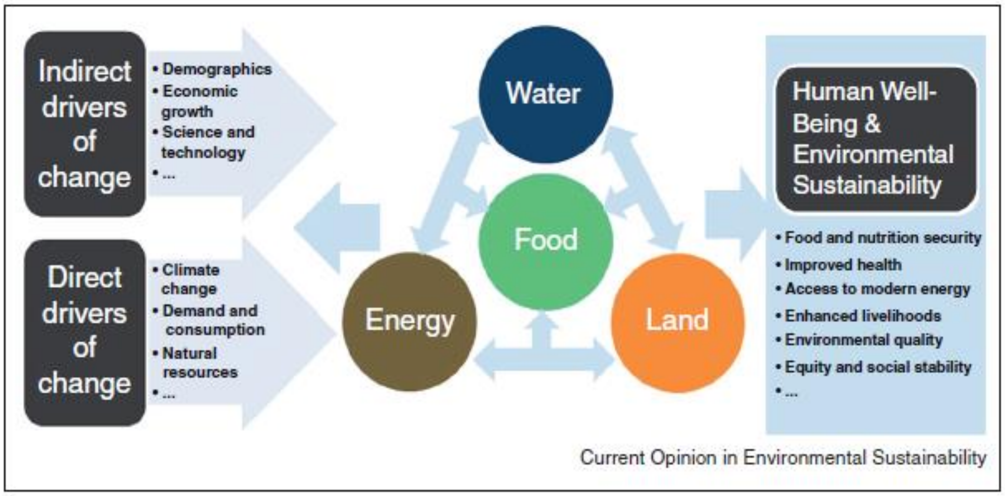

FAO Nexus Model. Courtesy FAO-Water Energy-Food Nexus 2014



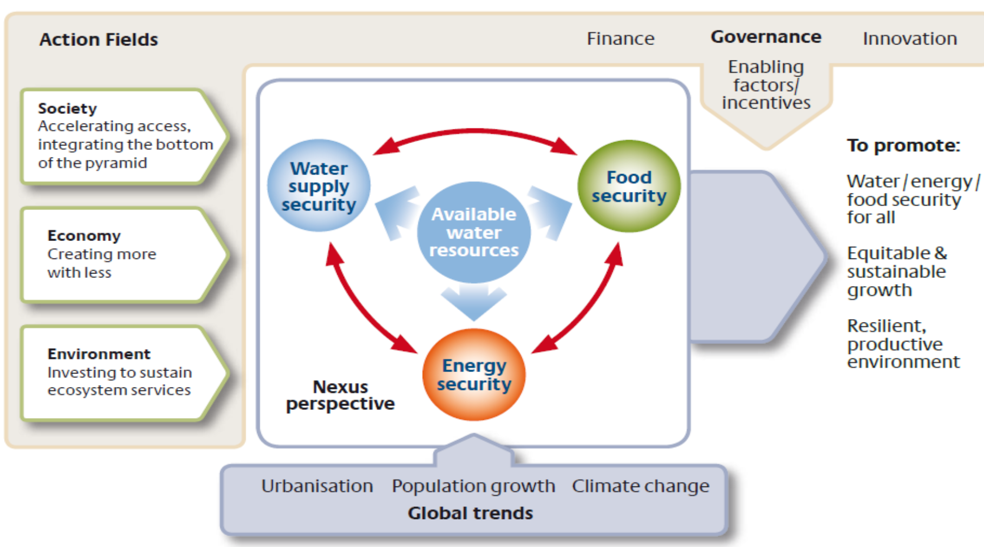

Nexus & Livelihood Perspective: Eloise et al (2015), Sustainable development and WEF Nexus.




Nexus & Environmental Perspective: Eloise et al (2015)




Having "Land" in the equation. Claudia et al (2013)




Bonn conference 2011 conceptualization with water centricity

## Having *IWRM*, do we need *Nexus*?

Association of water with "nexus" model is nothing new. "Water" has been an "aquatic-centricity" through the Integrated Water Resource Management (IWRM) concept. Although the Global Water Partnership defines IWRM as 'a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems'(GWP 2010)[17] and thus includes 'land and related resources' in the definition, the concept seldom went beyond the water sector within river basins(GWP 2010)[18], but IWRM concept never gained much traction in sustainability discourse. Also, IWRM requires cooperative behavior among actors, whereas the nexus approach focuses on increasing resource use efficiency through seeking to maximize the benefits of the scarcest resource and produces cross-sector benefits, which could be enhanced through cooperation.

IWRM (Integrated Water Resource Management), as the name suggests, is an environmental piloted paradigm ushering explicit complex nature of the water system and its interdependencies, at the same time not encompassing the intended and undesirable consequences engendered by isolated management interventions. Same is the case of other sectors e.g. Food and Energy, they, have adopted integrated pesticide management; the energy sector struggled to adopt an integrated energy planning and management paradigm; and the waste sector has adopted the integrated waste management paradigm. However, these paradigms developed from within each sector, and were unable to engage other sectors. This was because each sector/issue operated governance in isolation within line ministries. (Claudia 2014)[19]

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[17] *What is IWRM, 2010* http://www.gwp.org/the-challenge/what-is-iwrm/

[18] *What is IWRM, 2010* http://www.gwp.org/the-challenge/what-is-iwrm/

[19] cpahlwos@uni-osnabrueck.de *GWSP Co-Chair Director of the Institute for Environmental Systems Research (USF) at the University of Osnabrück, Germany. Published in* www.gwp.org *No. 14, May 14 2014 Water-Food-Energy Nexus*

Now, the objectivity of these integrated models will be nullified without cross-sectorial linkages that are the very basis of their objectivity, constraints and possibilities, because they are unable to bypass the *political correctness* of sectoral decision-making.

As the world population striving towards 8 billion, more grounded and wholesome approach of the requisite resources required, has become significant. Food security (because of prices and climate change) events implies the general vulnerability of resource production systems and the overexploitation of water in particular. To address it, the 2008 World Economic Forum (WEF) Annual Meeting agreed upon a Call to Action on Water aimed at re-examining the relationship between water and economic growth. Business leaders and policy makers subsequently developed the nexus concept, resulting in the WEF's 2011 report (WEF, 2011)[20], which provides a major source of guidance. Following that, Bonn 2011 Nexus Conference then became the first internationally recognised event held on the water, energy and food security nexus. Aftermath of that was, The Mekong2Rio Conference[21] which explored the water, energy and food security nexus in a trans-boundary context, moving from rhetoric to practice (Bach et al., 2012)[22].

Major differences can be found in terms of, how nexus model is approached, what is the *centrality of theme* or what is the *foci*, accordingly neologisms and arguments will follow. These include the 'water-food-energy-climate nexus' (WEF, 2011; Beck and Villarroel Walker, 2013)[23]; the 'water and food nexus' (Mu and Khan, 2009)[24]; the 'water-energy nexus' (Scott et al., 2011; see also Perrone et al., 2011; Hussey and Pittock 2012); the 'energy-water nexus' (Marsh and Sharma, 2007[25]; Murphy and Allen, 2011[26]; Stillwell et al., 2011[27]); the 'bioenergy and water

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[20] *Water Security: Water Food Energy and Climate Nexus, WEF, 2011* http://www3.weforum.org/docs/WEF_WI_WaterSecurity_WaterFoodEnergyClimateNexus_2011.pdf

[21] *Mekong2Rio Conference, 2012* http://www.mrcmekong.org/assets/Events/Mekong2Rio/Mekong2Rio-Conference-Brief-Final.pdf

[22] *Transboundary River Basin Management: Addressing Water, Energy and Food Security, 2012* http://www.mrcmekong.org/assets/Uploads/M2R-report-address-water-energy-food-security.pdf

[23] *On water security, sustainability, and the water-food-energy-climate nexus,* Walker et al,2013 http://link.springer.com/article/10.1007/s11783-013-0548-6

[24] *Pathways to reduce the environmental footprints of water and energy inputs in food production, Mu et al, 2009* http://www.sciencedirect.com/science/article/pii/S0306919208001000

[25] *The nexus approach to water–energy–food security: an option for adaptation to climate change, Sharma et al, 2007* http://www.tandfonline.com/doi/full/10.1080/14693062.2015.1029865

[26] *Energy-Water Nexus for Mass Cultivation of Algae, Murphy& Allen, 2011* http://pubs.acs.org/doi/abs/10.1021/es200109z

[27] *The energy-water nexus in Texas, Stillwell et all, 2011* http://www.ecologyandsociety.org/vol16/iss1/art2/

nexus' (UNEP, 2011)[28]; the 'energy-irrigation nexus' (Shah et al., 2003)[29]; 'water-energy-food security nexus' (Bazilian et al., 2011; ICIMOD, 2012; Bizikova et al., 2013; Lawford et al., 2013)[30]; and related concepts such as 'land use-climate change-energy nexus' (Dale et al., 2011)[31] and a range of development-related nexus approaches (Groenfeldt, 2010)[32]. The nexus concept is therefore far from unified and seemingly varies according to the focus of sectoral integration studied and the geopolitical context. (Middleton C, et al, 2015)[33]

## Sustainable Development and its Goals

United Nations (UN) defines the "Sustainable Development" as "The development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It calls for concerted efforts towards building an inclusive, sustainable and resilient future for people and planet. For sustainable development to be achieved, it is crucial to harmonize three core elements: economic growth, social inclusion and environmental protection. These elements are interconnected and all are crucial for the well-being of individuals and societies. Eradicating poverty in all its forms and dimensions is an indispensable requirement for sustainable development. To this end, there must be promotion of sustainable, inclusive and equitable economic growth, creating greater opportunities for all, reducing inequalities, raising basic standards of living, fostering equitable social development and inclusion, and promoting integrated and sustainable management of natural resources and ecosystems."(UN Sustainable Development Agenda)[34]

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[28] *Water and bioenergy, UNEP, 2011*http://www.unep.org/pdf/water/Water_Bioenergy_FINAL_WEB_VERSION.pdf

[29] *Energy-Irrigation Nexus in South Asia Improving Groundwater Conservation and Power Sector Viability, Shah et al, 2003* http://www.iwmi.cgiar.org/wp-content/uploads/2013/02/Report70.pdf

[30] *The nexus across water, energy, land and food (WELF): potential for improved resource use efficiency? Anik et al, 2013* http://www.sciencedirect.com/science/article/pii/S1877343513001504

[31] *Interactions among bioenergy feedstock choices, landscape dynamics, and land use, Dale et al, 2011* http://onlinelibrary.wiley.com/

[32] *Ethics and water governance, Groenfedlt et al, 2013* http://www.ecologyandsociety.org/vol18/iss1/art14/

[33] *The rise and implications of the water-energy-food nexus in Southeast Asia through an environmental justice Lens , Middleton C et al, 2015* http://www.water-alternatives.org/index.php/alldoc/articles/vol8/v8issue1

[34] *UN-Sustainable Development Agenda* http://www.un.org/sustainabledevelopment/development-agenda/

On 1 January 2016, the 17 Sustainable Development Goals (SDGs)[35] of the 2030 Agenda for Sustainable Development — adopted by world leaders in September 2015 at an historic UN Summit — officially came into force. Over the next fifteen years, with these new Goals that universally apply to all, countries will mobilize efforts to end all forms of poverty, fight inequalities and tackle climate change, while ensuring that no one is left behind.

The SDGs build on the success of the Millennium Development Goals (MDGs)[36] and aim to go further to end all forms of poverty. The new Goals are unique in that they call for action by all countries, poor, rich and middle-income to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with strategies that build economic growth and addresses a range of social needs including education, health, social protection, and job opportunities, while tackling climate change and environmental protection.

For the purpose of this paper, I will be dwelling on three goals of SDGs, i.e. Water, Energy & Food for the development of policy framework and its realization using nexus model.

## SDGs for Water, Energy & Food against the respective Global Status Quo

### Water Goals

| SDG-Water | Global Status Quo |
|---|---|
| • By 2030, achieve universal and equitable access to safe and affordable drinking water for all<br><br>• By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations<br><br>• By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally<br><br>• By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable | • 2.6 billion people have gained access to improved drinking water sources since 1990, but 663 million people are still without<br><br>• At least 1.8 billion people globally use a source of drinking water that is fecally contaminated<br><br>• Between 1990 and 2015, the proportion of the global population using an improved drinking water source has increased from 76 per cent to 91 per cent<br><br>• Water scarcity affects more than 40 per cent of the global population and is projected to rise. Over 1.7 billion people are currently living in river basins where water use exceeds recharge |

[35] *While the SDGs are not legally binding, governments are expected to take ownership and establish national frameworks for the achievement of the 17 Goals. Countries have the primary responsibility for follow-up and review of the progress made in implementing the Goals, which will require quality, accessible and timely data collection. Regional follow-up and review will be based on national-level analyses and contribute to follow-up and review at the global level.* http://www.un.org/sustainabledevelopment/development-agenda/

[36] *Millennium Development Goals (MDGs)* http://www.un.org/millenniumgoals/

| | |
|---|---|
| withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity<br>• By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate<br>• By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes<br>• By 2030, expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programs, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies<br>• Support and strengthen the participation of local communities in improving water and sanitation management | • 2.4 billion people lack access to basic sanitation services, such as toilets or latrines<br>• More than 80 per cent of wastewater resulting from human activities is discharged into rivers or sea without any pollution removal<br>• Each day, nearly 1,000 children die due to preventable water and sanitation-related diarrheal diseases<br>• Hydropower is the most important and widely-used renewable source of energy and as of 2011, represented 16 per cent of total electricity production worldwide<br>• Approximately 70 per cent of all water abstracted from rivers, lakes and aquifers is used for irrigation<br>• Floods and other water-related disasters account for 70 per cent of all deaths related to natural disasters[37] |

## Goals for Energy

| SDG-Energy | Global Status Quo |
|---|---|
| • By 2030, ensure universal access to affordable, reliable and modern energy services<br>• By 2030, increase substantially the share of renewable energy in the global energy mix<br>• By 2030, double the global rate of improvement in energy efficiency<br>• By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology<br>• By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States, and land-locked developing countries, in accordance with their respective programs of support[38] | • One in five people still lacks access to modern electricity<br>• 3 billion people rely on wood, coal, charcoal or animal waste for cooking and heating<br>• Energy is the dominant contributor to climate change, accounting for around 60 per cent of total global greenhouse gas emissions<br>• Reducing the carbon intensity of energy is a key objective in long-term climate goals. |

[37] *Sustainable Development Goals(SDGs)* http://www.un.org/sustainabledevelopment/water-and-sanitation/
[38] SDGs http://www.un.org/sustainabledevelopment/energy/

## Food Goals

| SDG-Food | Global Status Quo |
| --- | --- |
| • By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round<br>• By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons<br>• By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment<br>• By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality<br>• By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed<br>• Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries<br>• Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round.<br>• Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, | • Globally, one in nine people in the world today (795 million) are undernourished<br>• The vast majority of the world's hungry people live in developing countries, where 12.9 per cent of the population is undernourished.<br>• Asia is the continent with the most hungry people – two thirds of the total. The percentage in southern Asia has fallen in recent years but in western Asia it has increased slightly.<br>• Southern Asia faces the greatest hunger burden, with about 281 million undernourished people. In sub-Saharan Africa, projections for the 2014-2016 period indicate a rate of undernourishment of almost 23 per cent.<br>• Poor nutrition causes nearly half (45 per cent) of deaths in children under five – 3.1 million children each year.<br>• One in four of the world's children suffer stunted growth. In developing countries, the proportion can rise to one in three.<br>• 66 million primary school-age children attend classes hungry across the developing world, with 23 million in Africa alone.<br>• Agriculture is the single largest employer in the world, providing livelihoods for 40 per cent of today's global population. It is the largest source of income and jobs for poor rural households.<br>• 500 million small farms worldwide, most still rainfed, provide up to 80 per cent of food consumed in a large part of the developing world. Investing in smallholder women and men is an important way to increase food security and nutrition for the poorest, as well as food production for local and global markets.<br>• Since the 1900s, some 75 per cent of crop diversity has been lost from farmers' fields. Better use of agricultural biodiversity can contribute to more nutritious diets, enhanced livelihoods for farming communities and more resilient and sustainable farming systems.<br>• If women farmers had the same access to resources as men, the number of hungry in the world could be reduced by up to 150 million. |

| | |
|---|---|
| including on food reserves, in order to help limit extreme food price volatility.[39] | • 1.4 billion people have no access to electricity worldwide – most of whom live in rural areas of the developing world. Energy poverty in many regions is a fundamental barrier to reducing hunger and ensuring that the world can produce enough food to meet future demand. |

Global human society must now attempt to solve a set of complex, interrelated problems that Diamond (2005)[40] characterises as “fundamental threats to human civilisation”. Many of these issues are directly related to the areas of energy, water and food(WEF) production, distribution, and use—especially in developing countries.

## Pakistan Vision 2025

Announced in November 2013, after the new government was installed following general elections in May 2013. The vision tabulates(Pakistan Vison, 2025),[41]

- Meeting the basic needs of this growing population, including in particular their access to essential services—health, education, energy, water, and sanitation.
- Providing the social, legal, and physical infrastructure needed to empower people and ensure that they are able to live their lives with dignity, and that human rights are protected, lives are secure, there is full employment (i.e., over 1.5 million additional decent jobs are created every year), women are empowered, and that poverty and hunger are eliminated. A responsible and accountable government and public sector
- An entrepreneurial private sector that can generate the required number of jobs.
- Ensuring that the economy can engage effectively with and benefit from the opportunities emerging outside the borders, especially regional opportunities.
- Ensuring competitiveness in the modern world that has shifted towards a knowledge economy.
- Protecting natural resources and addressing climate change.

[39] SDGs http://www.un.org/sustainabledevelopment/hunger/
[40] *‘How Societies Choose to Fail or Succeed’ by Diamond* http://www.e-reading.by/bookreader.php/133781/Collapse:_How_Societies_Choose_to_Fail_or_Succeed.pdf
[41] *Pakistan Vision 2025* http://www.pc.gov.pk/wp-content/uploads/2015/05/Pakistan-Vision-2025.pdf

- Perhaps most importantly, ensuring rapid growth of the GDP in order to generate the required number of jobs, with an emphasis on 'inclusive growth', mindful of the regional and social inequalities which exist in our economy. A concerted effort to create balanced growth and provide equal opportunities to all Pakistanis.[42]

Pakistan Vision 2025 infographic has "Water-Food-Energy", as one of the pillar.


Source: Pakistan Vision 2025[43]

Here, for brevity and for purpose of this paper, we will inquire and develop the policy frame work for its realization of W-E-F. Believing that nexus model be the most optimized model not only achieving the vision, but also, can set forth the journey for UN-SDGs.

For W-E-F, vision 2025 elaborates,

### Energy, Water & Food Security

13. Energy: double power generation to over 45,000 MW to provide uninterrupted and affordable electricity, and increase electricity access from 67% to over 90% of the population
14. Energy: (a) reduce average cost per unit by over 25% by improving generation mix (15%) and reducing distribution losses (10%); (b) increase percentage of indigenous sources of power generation to over 50%; and (c) Address demand management by increasing usage of energy efficient appliances/products to 80%
15. Water: increase storage capacity to 90 days, improve efficiency of usage in agriculture by 20%, and ensure access to clean drinking water for all Pakistanis
16. Food: Reduce food insecure population from 60% to 30%

[42] Ibid

[43] *Pakistan Vision 2025* http://www.pc.gov.pk/wp-content/uploads/2015/05/Pakistan-Vision-2025.pdf

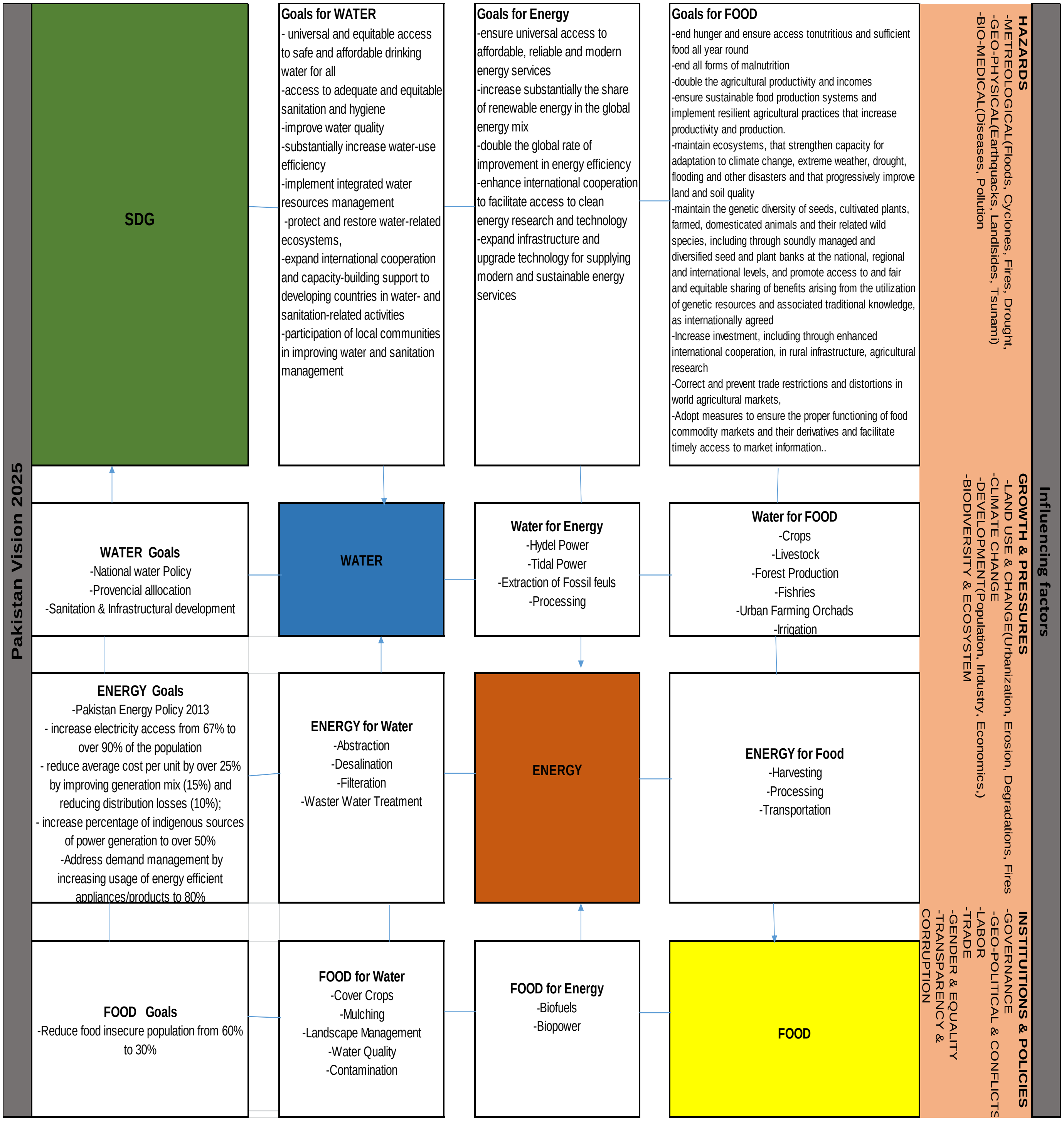
W-E-F have been mentioned very objectively in the vision charter, but have been acknowledge from "silo's" concept and the emphasis is on their security [ resources], not on the inter-dependencies.

"In Pakistan, water and energy have traditionally been interlinked through hydropower plants and large multipurpose dams. However, new interactions have emerged between water, energy and agriculture sectors that are poorly understood. Crop production in the heartlands of Pakistan — served by a massive network of canals — now increasingly relies on energy consuming groundwater pumps to meet irrigation needs. A million tube wells are reportedly installed in Punjab alone, and energy use in pumping and farm operations may account for up to one-fifth of the province's energy consumption. This link between energy, irrigation water and agriculture needs to be investigated with improved data collection and policy action. The coal deposits of Thar in Sindh promise energy supply on one hand, but will place demands on water resources in the arid region on the other. The new hydropower plants, currently under development in Khyber-Pakhtunkhwa, will further enmesh energy and water. For systems that are expected to function for decades to come, the implications of water and of energy must be evaluated if future water supplies in the Indus and its tributaries get affected due to climate change or face disruptions in flow across national boundaries. The use of multipurpose dams should be assessed for the economic tradeoffs that result between ensuring food security (by prioritizing supply for irrigation demands) versus cheap hydroelectric power that is desperately needed in the industrial and domestic sectors. Managing each resource separately can lead to decisions that seemingly improve supply in one sector, but in reality, create problems in others. If the linkages are incorporated in policy evaluation, then unintended consequences may be avoided while multiple problems may simultaneously get addressed. Says Afreen Siddiqi( Siddiqi, 2014)[44]

## The Framework

To address the argument further, here, a framework has been worked out.

[44]*The Water-Energy-Food Nexus of Pakistan, Siddqi, February, 2014*
http://belfercenter.ksg.harvard.edu/publication/23886/waterenergyfood_nexus_of_pakistan.html?breadcrumb=%2Fexperts%2F2298%2Fafreen_siddiqi




SDGs-Pakistan Vision 2025 and W-E-F Nexus

## Framework Analysis

Enabling conditions for horizontal and vertical policy coherence includes institutional capacity building, political will, change agents and awareness-raising (all implies to Vision 2025). This can be realized if the nexus is addressed coherently across all scales through multi-level governance.

Frame work has been analysed and looked into, in the context of "Risk Analysis", since "resource scarcity" and the undercurrents of "*one's mickel is another's muckle"* i.e. how one sector effects another sector. And this is the central theme of the model. Unless risk is not full comprehended, the linkage would poorly be understood hence policy making will miss on the "wholeness". The risk analysis model has been conceptualized and popularized by IRENA (International Renewable Energy Agency 2015)[45] 2015 report.

### Water: In relation to Energy & Food

| Impacted Sectors | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Water Sector | | | Energy Sector | | | Food Sector | | | |
| Security Elements | Access | Safety | Affordability | Continue Supply to Demand | Physical Availablity of Supply | Sufficient Supply to satisfy demand at a given price | Physical Availability of food | Economic and Physical Access to Food | Food Utilization | Stability of these 3 dimensions over time |
| Water | x | x | x | • Shifts in water availability (changing precipitation patterns) and quality (pollution or salinity)<br>• Increasing energy demand for water production, treatment and | Legal/ regulatory restrictions on water use for energy production/ fuel extraction | Shifts in water availability affecting traditional generation, requiring expensive back-up supply | Increased variability in water availability for food production, particularly due to climate change | Disruptions in global food supply due to regional water variability, given geographic concentration of food production and consumption | Impact of water quality on food production and consumptio n | Climate change impacts on availability of water resources in long term |

45 *Renewable Energy in the water, energy & Food Nexus, IRENA, 2015*
http://www.irena.org/documentdownloads/publications/irena_water_energy_food_nexus_2015.pdf

Water security elements – access, safety and affordability – are affected by the energy and food sectors (IISD, 2013)[46]. Access to water can be marred and hindered if electricity supply is limited due to availability(demands) for daily use like pumping, conveying and its respective distribution. This is valid for other sectors too such as oil extraction (conventional and fracking both), since pollute ground water with heavy metals and hydrocarbons(Water in the West, 2013).[47] Then there is expansion of intensive agriculture practices, where use of chemical fertilisers and concentrated animal farming, resulted in polluted ground water with nutrients (FAO, 2008b).[48] Another important factor is the price volatility of energy products and its proportionate effect on water affordability, since the whole infrastructure is energy intensive.

## Energy: In relation to Water & Food

| | | Impacted Sectors | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Water Sector | | | Energy Sector | | | Food Sector | | | |
| | Security Elements | Access | Safety | Affordability | Continue Supply to Demand | Physical Availablity of Supply | Sufficient Supply to satisfy demand at a given price | Physical Availability of food | Economic and Physical Access to Food | Food Utilization | Stability of these 3 dimensions over time |
| Impecting Sectors | Energy | • Limited or unreliable access to energy necessary to extract, transport and treat water<br>• Reallocation of water from other end-uses to energy | Contamination of water resources due to energy extraction and transformation processes | Fluctuating costs of water supply due to variability in prices of energy inputs (in costreflective markets) | x | x | x | • Disruption in energy inputs at production stage: mainly livestock (low risk), mechanised (high risk)<br>• Potential trade-offs between bioenergy production and food crops | • Fossil fuel dependency of upstream and downstream (transport, storage, etc.) food supply chain<br>• Allocation of agricultural products and agricultural land for bioenergy production (impact on food prices) | Social, environmental and health impacts of traditional biomass cooking methods | • Economic and physical volatility of energy inputs<br>• Increasing wastage (lost productivity) due to limited energy access (e.g., storage)<br>• Increasing diversion of food crops for energy production |

[46] *The Water–Energy–Food Security Nexus: Towards a practical planning and decision-support framework for landscape investment and risk management, IISD, 2013* http://www.iisd.org/pdf/2013/wef_nexus_2013.pdf

[47] *Water and Energy Nexus: A literature Review* http://waterinthewest.stanford.edu/sites/default/files/Water-Energy_Lit_Review.pdf

[48] *Agriculture and water quality interaction: Global Overview, FAO, Thematic Report 2008* http://www.fao.org/fileadmin/templates/solaw/files/thematic_reports/TR_08.pdf

The energy security components, their continuity of supply, availability and affordability-all are effected by water and food sector. Key objective of any energy system and their respective operator is to meet the demand by uninterrupted supply. This can be hindered by, when there is decrease in water flow or increase in water temperature since this can limit the thermal, nuclear or hydro power plant resulting in-supply can't match demand. Apart from this linear system approach (of demand and supply of energy), what has been the case (and ignored) is the competing needs of water for agriculture and domestic use. This can potentially limit the amount of water that can be allocated for the extraction of natural resources instead of its production(food). Furthermore, the trade-offs of water and energy can be very pressurizing, since the limited availability of water can have effect on energy pricing.

## Food: In relation to Water & Energy

| | | Impacted Sectors | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Water Sector | | | Energy Sector | | | Food Sector | | | |
| | Security Elements | Access | Safety | Affordability | Continue Supply to Demand | Physical Availablity of Supply | Sufficient Supply to satisfy demand at a given price | Physical Availability of food | Economic and Physical Access to Food | Food Utilization | Stability of these 3 dimensions over time |
| Impacting Sectors | Food | • Water resource over-utilisation impacts of food security ambitions<br>• Poorly regulated agricultural foreign direct investments | Groundwater/surface run-off water contamination from food production and processing activities | Contamination and overexploitation lead to increase in water supply costs | Overall increase in food production and changing diets raises energy demand along the food supply chain | Lack of energy availability hinders food processing and irrigation | Variations in crop-based bioenergy feedstock prices. | x | x | x | x |

The availability of food is threatened when the life line of agriculture i.e. water, is allocated for the other competing needs. Sourcing water to respective agricultural needs is dependent on the energy intensive irrigation infrastructure, hence the *Domino Effect*[49]. Hence, water and energy resource stains can have economic fall out in terms of food affordability. Food utilization can be constrained by use of contaminated (because of hydrocarbons extraction for energy usage) water sources. There can be shortage of cooking fuel (LPG gas) supply (for cooking needs, or any household needs for that matter), which means effect on food utilization, where water can be un-ignorable factor in the whole system of linkages.

## The Status quo of WATER, ENERGY & FOOD in Pakistan.

Resilient economies require coherent and effective planning of water, energy and food that balances consumption, production and trade requirements against the country's natural resource endowments. To achieve this coherence, one crucial and neglected part of development planning is to forge a shared perspective within government on where a country stands within the framework of resource scarcity and abundance, and how this relates to the country's development goals.

### Water- Its Inclusivity as Available Resource in Pakistan

According to the Asian Development Bank (ADB 2013)[50], Pakistan is already one of the most water-stressed countries. This means only 1,000 cubic meters of water are available per person per year, which is approximately five times less than was available at the country's inception in 1947. By 2020, water availability will further reduce to less than five hundred cubic meters per capita per year, making Pakistan water-scarce (Mustafa D, et al 2013).[51] The amount of water Pakistan has stored for emergency purposes only lasts thirty days, compared to the international standard of 120 days and the recommended standard of 1,000 days for countries with similar climates.

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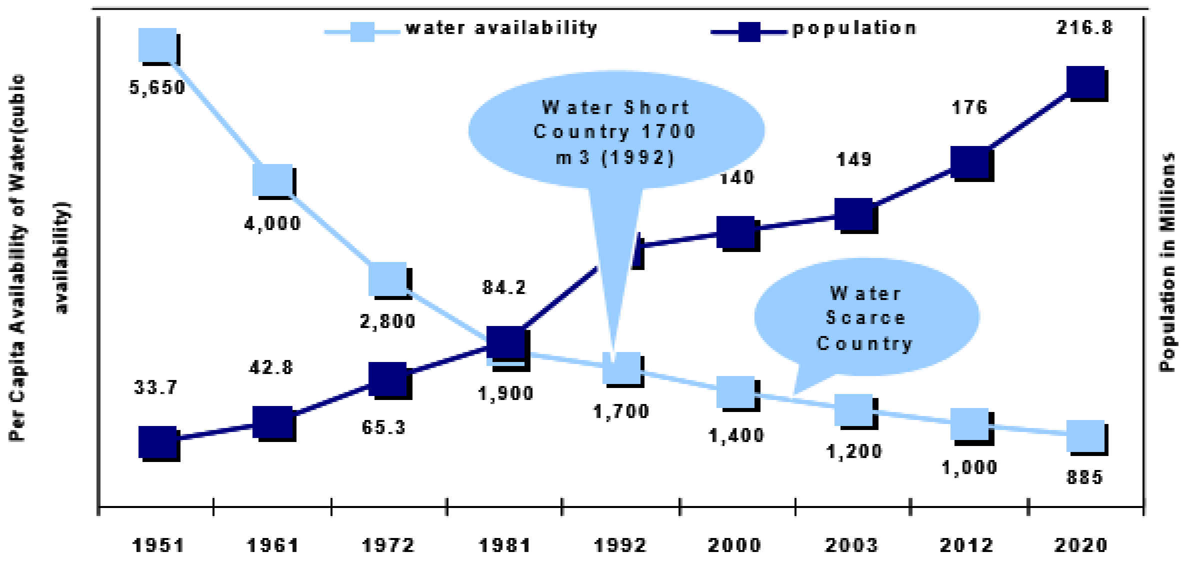
[49] "*Repercussion of an act or event under which every associated or connected entity is affected to a more or less the same degree. Named after the circular arrangement of dominos in which if any one domino falls, all fall*." Read more: http://www.businessdictionary.com/definition/domino-effect.html#ixzz4I5d5WWDs

[50] *Indus Basin Floods: Mechanisms, Impacts and Management, ADB, 2013* http://www.adb.org/publications/indus-basin-floods-mechanisms-impacts-and-management

[51] *Understanding Pakistan's Water and Security Nexus, Mustafa D et al, 2013* http://www.usip.org/sites/default/files/PW88_Understanding-Pakistan's-Water-Security-Nexus.pdf



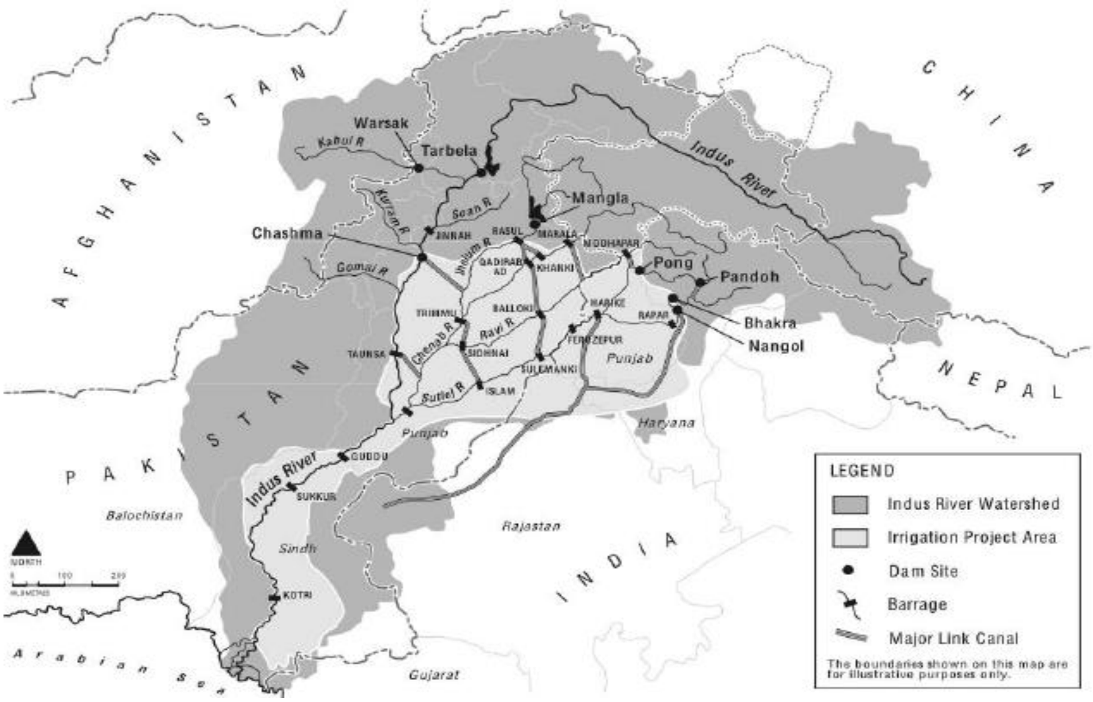

Source: World Bank Pakistan[52]

Over the last decade, Pakistan became a water-stressed country: The United Nations (UN) currently estimates an annual per capita availability of 1,090 cubic meters.9 The UN's Food and Agriculture Organization (FAO) measures the pressure on national water resources by calculating water withdrawal as a percentage of total renewable water resources (TRWR). Stresses are considered high if the TRWR value is above 25 percent. Pakistan's water pressure amounts to a staggering 74 percent. This pressure is exorbitant even compared with neighboring high-pressured countries, including India at 34 percent and Afghanistan at 31 percent (FAO Database).[53]

Water supply, as understood universally (though linearly) is not just the amount of melted snow or the rainfall in per year, rather it's a whole governance system involving technology that is developed from ancient civilizations hitherto for the access to the water resources. No doubt, the available water quantity is an important statistic but the governance of it, over region, how it reaches to dwellers is of much more importance. Pakistan 's water scarcity and for that matter security problems means the inequality and lack of governance in its distributing it.

[52] *World Bank Pakistan* http://siteresources.worldbank.org/PAKISTANEXTN/Resources/293051-1146639350561/CGA-Companion-Paper-3.pdf
[53] *FAO Database* http://www.fao.org/nr/water/aquastat/data/query/index.html

About 80 % of cultivated land in Pakistan is irrigated, of which about 33 % is affected by waterlogging and soil salinity, leading to significant declines (an estimated 25 percent) in crop yields, especially downstream. These issues will remain problematic until more sustainable irrigation practices are put in place (Mustafa D et al 2013).[54]




Source: Google Images

Current water withdrawals in Pakistan total about 142 MAF. Approximately 71 % of withdrawals are from surface water and 29 % from subsurface groundwater. Withdrawals from surface water account for about 74 % of the total surface water available, and withdrawals from groundwater account for 83 % of total renewable groundwater available.

River flows in Pakistan are highly uneven temporally, and year-round agricultural requirements depend on adequate storage capacity (National Water Policy, Pakistan 2012).[55] However, the Indus' massive irrigation system has a storage capacity of only 121 MAF per year, or a thirty-

[54] *Understanding Pakistan's Water-Security Nexus, Mustafa D et al, 2013* https://www.usip.org/sites/default/files/PW88_Understanding-Pakistan's-Water-Security-Nexus.pdf

[55] *Pakistan's National Water Policy* http://www.salmanmasalman.org/wp-content/uploads/2012/12/IndusWaterPolicyArticle.pdf *This is a draft version of National water policy of Pakistan, which have hit a political conundrum among provinces, and has not been signed and ratified yet. For more, please read here* http://www.futuredirections.org.au/publication/pakistan-new-national-water-policy-faces-scrutiny/

day supply. This capacity is extremely low given that India can store for 120 to 220 days, Egypt up to 700 days, and the United States for 900 days(Wilson Center 2009).[56]
The UN estimates that water demand in Pakistan is growing at an annual rate of 10 percent(UN-WATER 2016).[57] That is, demand is projected to rise to 274 MAF by 2025. This said, total water availability by 2025 is not likely to change from the current 191 MAF. This gap of about 81 MAF is almost two-thirds of the entire Indus River system's current annual average flow (Akhtar 2010).[58]

In terms of water supply and sanitation, the situation in Pakistan remains dismal. 16 million people have no choice but to collect unsafe water from unsafe sources. 68 million people don't have access to adequate sanitation in Pakistan (Water-Aid 2015).[59] And the main reason, apart from institutional governance is the crumbling old infrastructure. Appropriate technologies can address it, but there hangs the tale because developmental agencies funded projects cover the Capital expenditure, when it comes to, operational and maintenance of these systems, lack of trained staff leads to insufficiencies in capacity building.

Keeping in view the water-related Sustainable Development Goals, as well as Pakistan's growing population, water scarcity, and increasing demands on water resources, Question arises: Can Pakistan meet its challenges through a continuation of conventional reforms and interventions? The answer is not through business as usual. A paradigm shift will be required to reframe the whole discourse on water i.e. what effects water, what is effected by water and here enters the W-E-F nexus approach.

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[56] *Running on Empty: Pakistan 's Waster Crisis, 2009*
https://www.wilsoncenter.org/sites/default/files/ASIA_090422_Running%20on%20Empty_web.pdf
[57] *Water & Jobs: The UN World water Development Report, 2016*
http://unesdoc.unesco.org/images/0024/002439/243938e.pdf
[58] *Shaheen Akhtar, "Emerging Challenges to Indus Waters Treaty: Issues of Compliance and Transboundary Impacts of Indian Hydro projects on the Western River," available at* http://www.irs.org.pk/f310.pdf
[59] *Water Analysis in Pakistan by WaterAid* http://www.wateraid.org/where-we-work/page/pakistan

## Pakistan-The Energy Starved Country

In year 1994, that is when, the new Power Policy (alternatively used for Energy) was introduced by The government of the day (NPP 2014).[60] At the time, only 40% of the population had access to electricity, Pakistan was facing power shortages of about 2,000 MW during peak load times (Atfab, 2014).[61]. It offered an attractive package of incentives to foreign investors, including a tariff ceiling that resulted in returns on investment of 15-18%, a minimum required equity investment of just 20%, and a host of fiscal and security incentives (for details, see Pakistan, 1994). More importantly, the policy effectively transformed the fuel mix for energy generation in the country. In the 1980s a little over 60% of Pakistan's power was generated from hydropower(Aftab, 2014).[62] The government of the time considered this strategy to be the optimal one, not only because of the relative ease with which thermal power plants could be added to the generation mix compared to hydropower resources, which would take much longer, but also because key proposed hydropower projects, for which feasibility studies had been prepared, were controversial for political reasons(Aftab, 2014).[63] Hence the short sightedness of the policy makers two decades ago resulted in an energy starved country, not only with the gloomy current statistics, but a tremendous economic implications, the status quo is summarized in Pakistan Energy Policy ( 2013) as,

- A yawning supply-demand gap where the demand for electricity far outstrips the current generation capacity leading to gaps of up to 4,500 – 5,500 MW.
- Highly expensive generation of electricity (~Rs 12 / unit) due to an increased dependence on expensive thermal fuel sources (44% of total generation).
- A terribly inefficient power transmission and distribution system that currently records losses of 23-25% due to poor infrastructure, mismanagement, and theft of electricity. This in total estimated to be costing the national exchequer over Rs 140 billion annually.

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[60] *Pakistan's National Power Policy 2013* http://www.ppib.gov.pk/Power%20Policy%201994.pdf

[61] *Pakistan National Energy Crisis: Consequences and possible remedies, Safiya Aftab, January 2014* http://www.peacebuilding.no/var/ezflow_site/storage/original/application/ade59fba5daf67a11a1c217434abf440.pdf

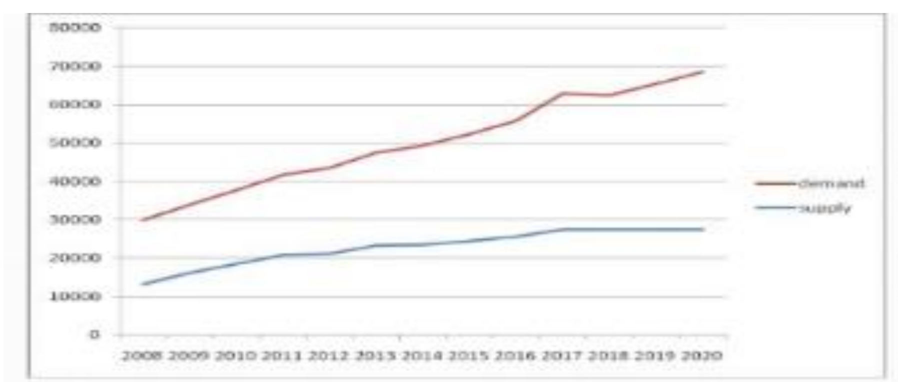
[62] *Pakistan National Energy Crisis: Consequences and possible remedies, Safiya Aftab, January 2014* http://www.peacebuilding.no/var/ezflow_site/storage/original/application/ade59fba5daf67a11a1c217434abf440.pdf

[63] Ibid

- Circular debt of almost Rs600 Billion. The debt—often described as "circular" in nature—is a consequence of cash flow problems. Energy generators, distributors, and transmitters lack funds.[64]

Having the whole vision based on "access" i.e. availability, which is politically correct, being energy starved country, there has been no comprehensive policy towards, the "how" of it, and at what cost of available natural and financial resources, this will be achieved. The trade-offs, not only involving environmental consideration (*vis-à-vis* fossil fuel, dams) but the effects on water (being already scarcest) and agriculture.

Having whole energy supply based on non-renewable source leaves "no" to "little" for environmental friendly practices in energy sector and sounds "sustainability" just a word, "signify nothing". On another note, in recent months, shale and tight gas have been championed as the only solution for all "*ills"* of Energy in Pakistan. Pakistan's reserves of these unconventional natural gas sources are estimated at more than four times the remaining reserves of conventional natural gas (which constitutes about half of Pakistan's overall mix). Michael Kugelman[65] says, "extraction requires a whole lot of water. In the US, an average of four million gallons of water is used for a single fracking job. In severely water-stressed Pakistan, large-scale extraction may be well-nigh impossible."[66]




Source: World Bank Data portal

[64] *Pakistan's National Power Policy 2013* http://www.ppib.gov.pk/National%20Power%20Policy%202013.pdf
[65] *Senior program associates for South Asia at the Woodrow Wilson in Washington, DC*
[66] *OPED: Energy Solutions, by Michael Kugelman, 2006* http://www.dawn.com/news/1198658

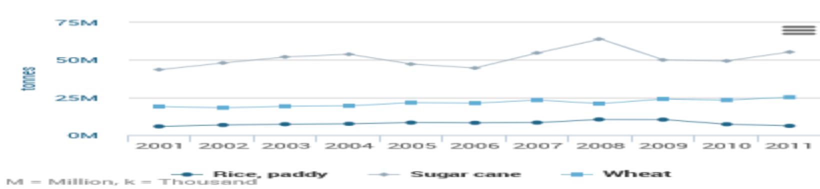
## Dying Agriculture in an Agrarian Economy

Pakistan’s agriculture sector consists of four subsectors:

- Food and fiber crops
- Horticulture and orchards
- Livestock and dairy
- Fisheries, and forestry[67]

Pakistan Agriculture sector output was at its peak during the early few decades of the country’s independence i.e. from 1960s to 1980s. High yield, expansion in land base and irrigation water supply were the enablers. With growing population, the agriculture policies were not in unison for the lack of governance or political will, which resulted, regardless of having more irrigable land, the food crop out put is still lower than some regional countries (USAID Pakistan 2009).[68]

Water productivity is another major concern. Crop outputs, both per hectare and per cubic meter of water, are much lower than international benchmarks, and much lower even than in neighboring areas of India. Output of sugarcane, a crop that needs four times as much water to produce a Rupee of output as wheat, has been growing almost twice as fast as the staple grain(USAID Pakistan 2009).[69] Government policies of food production has been very linear in approach and were mainly concerned to production. Policy makers never looked into the productivity from the lens of water required for the food production, even the water management models such as IWRM have never incorporated the crop productivity in its holistic models.




Source: FAO data portal

[67] Pakistan Agriculture Year Book ( 2013-2014), available at http://www.mnfsr.gov.pk/gop/index.php?q=aHR0cDovLzE5Mi4xNjguNzAuMTM2L21uZnNyL3VzZXJmaWxlczEvZmlsZS9ORlNSJTIwWUVBUiUyMEJPT0slMjAyMDEzLTE0LnBkZg%3D%3D

[68] *Pakistan Foods & Agriculture Systems, USAID 2009* http://pdf.usaid.gov/pdf_docs/Pnado507.pdf

[69] ibid

## The Challenge of 'Climate Change' & Pakistan's Water, Energy & Food Sector.

According to Global Climate Index(Kreft et al, 2015)[70] Pakistan is the 10th most vulnerable country to climate change though it produces less than 0.5pc of global emissions.

| **CRI 1994–2013** (1993–2012) | **Country** | **CRI score** | Death toll | Deaths per 100,000 inhabitants | Total losses in million US$ PPP | Losses per unit GDP in % | Number of Events (total 1994–2013) |
|---|---|---|---|---|---|---|---|
| **1** (1) | Honduras | 10.33 | 309.70 | 4.60 | 813.56 | 3.30 | 69 |
| **2** (2) | Myanmar | 14.00 | 7137.40 | 14.80 | 1256.20 | 0.87 | 41 |
| **3** (3) | Haiti | 16.17 | 307.80 | 3.41 | 261.41 | 1.86 | 61 |
| **4** (4) | Nicaragua | 16.67 | 160.15 | 2.98 | 301.75 | 1.71 | 49 |
| **5** (7) | Philippines | 19.50 | 933.85 | 1.13 | 2786.28 | 0.74 | 328 |
| **6** (5) | Bangladesh | 20.83 | 749.10 | 0.54 | 3128.80 | 1.20 | 228 |
| **7** (6) | Vietnam | 23.50 | 391.70 | 0.48 | 2918.12 | 1.01 | 216 |
| **8** (8) | Dominican Republic | 31.00 | 210.45 | 2.38 | 274.06 | 0.37 | 54 |
| **9** (10) | Guatemala | 31.17 | 83.20 | 0.68 | 477.79 | 0.62 | 80 |
| **10** (12) | Pakistan | 31.50 | 456.95 | 0.31 | 3988.92 | 0.77 | 141 |

Source: Global Climate Index:

The devastating floods of year 2010, which resulted in the death of thousands of human lives (apart from other losses of livestock), the economic consequences were amounted to be 7% of the GDP (Asian Development Bank 2010).[71] This implies that climate change threat is a global phenomenon, but effecting those countries more, which are not ready for the challenge it poses. Frequency of extreme weather events in Pakistan like cyclones, droughts and glacial lake outburst floods show that Pakistan is becoming increasingly vulnerable to climate change (UNDP Pakistan 2016).[72] Before dwelling into Water, Energy and Food sector of Pakistan, and how vulnerable they are, to climate change, first, a brief capture of

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[70] *Global Climate Risk Index, 2015 by Kreft et al, 2015* https://germanwatch.org/en/download/10333.pdf

[71] *Pakistan Floods 2010, Preliminary Damage Needs Assessments* http://www.adb.org/sites/default/files/linked-documents/44372-01-pak-oth-02.pdf

[72]*An opinion piece by UNDP Pakistan Chief Marc André Franche, Damaging Effects March , 2016* http://www.dawn.com/news/1246105/damaging-effects

Climate Change and its effects on W-E-F.

| Climate Change and W-E-F | | |
|---|---|---|
| Energy | Water | Food |
| *-Elevated water and air temperatures reduce the efficiency of power plant generation and pose risks for power plant operators of exceeding regulations on thermal pollution released to receiving water bodies. Electricity transmission is less efficient with higher air temperatures, weakening the capacity of grid infrastructure.*<br>*-Climate change is projected to decrease water availability in many semi-arid and arid regions (IPCC,2008)*[73]*, with shifting rainfall patterns and intensified droughts threatening water resources necessary for different inputs of energy supply.*<br>*-Increasingly numerous and intense floods in areas close to energy plants can cause severe harm to power production and energy delivery infrastructure, and can result in more frequent blackouts (Pakistan floods 2010)*[74] | *-Freshwater source all over the globe are glaciers. With unprecedented changes in the temperature due climate change resulted in its speedy melting. This give rise to risks of flooding and the fast paced vanishing of glaciers- an alarm for water scarcity.*<br>*-Glaciers are considered and understood as banks holding fresh water, but with climate change and global warming these banks are running out of cash(water) (David Suzuki)*[75]<br>*-Water infrastructure, to deal with supply of water, storm water system, sewerage system, the whole infrastructure is designed to deal with normal conditions. But with the advent of global warming, the in place infrastructure has been witnessed as incapable to deal with the anomaly, resulting in billions of loss to it and further billions for more investment into it, hence financing can be major and catastrophic burden on various urban communities around the globe.* | *-Impacts on food production will affect food supply at the global and local levels. In theory, higher yields in temperate regions could offset lower yields in tropical regions. However, because many low income countries have limited financial capacity to trade and depend largely on their own production to cover food requirements, it may not be possible to offset declines in the local food supply without increasing reliance on food aid.*<br>*-Impacts on all forms of agricultural production will affect livelihoods, incomes and therefore access to food. Producer that are less able to deal with negative effects from climate change, such as the rural poor in developing countries, risk having their safety and welfare compromised.*<br>*-Processing, distribution, acquisition, preparation and consumption of food, are similarly important for its security. (FAO 2008a)*[76] |

The year 2000 floods, agriculture has been the most severely affected sector, accounting for a full 50 % of the estimated cost of overall damages. The overall damages and losses to the sector

[73] *Climate Change and water: IPCC Technical Paper VI, 2008* http://ipcc.ch/pdf/technical-papers/climate-change-water-en.pdf
[74] *Pakistan Floods 2010, Preliminary Damage & Needs Assessment* http://www.adb.org/sites/default/files/linked-documents/44372-01-pak-oth-02.pdf
[75] *Water Impacts, David Suzuki Foundation* http://www.davidsuzuki.org/issues/climate-change/science/impacts/water-impacts/
[76] *Climate Change and Food Security: A Framework Document, FAO, 2008* http://www.fao.org/forestry/15538-079b31d45081fe9c3dbc6ff34de4807e4.pdf

were estimated to be around $ 4.29 billion most (89 %) of which are attributable to cropped agriculture. (Asian Development Bank, 2010)[77]

Pakistan's readiness to the Climate Change and its accompanying threats can be best described as *"Acknowledged-Yes, Ready-Probably Not"*.

Acknowledging Climate Change resulted in a National Climate Change Policy (NCCP) in 2012(UNDP Pakistan 2014)[78], outlining mitigation and adaptation actions. Pakistan is also one of the few countries in the developing world, that have undertaken 'Climate Public Expenditure and Institutional Review (CPEIR 2015)[79]

For 'Not' being 'Ready' to deal with Climate change can be attributed to many (rightfully though) factors such as being a developing country, with low literacy rate, marred with governance and political issues, lack of capacity building and financial capacity, hence the deficit of vision and action remains widespread. The INDCs (INDC 2015[80] put forward by Pakistan for the COP21 were considered limited and devoid of quantitative commitments and investment requirements for adaptation and mitigation. Strong institutional governance can be the way forward but what is striking here is the approach that has been taken, which, in its very ethos is a '*Silo'* one. Water, Energy and Food sectors have not been considered as *'consequential collateral damaged sectors',* in its all entirety.

Pakistan incurred $6bn climate change-related losses in 2012. It needs to invest 5.5% of GDP annually for mitigation and 1.5-3% for adaptation to address its effects (UNDP 2016).[81]

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[77] *Pakistan Floods 2010, Preliminary Damage & Needs Assessment* http://www.adb.org/sites/default/files/linked-documents/44372-01-pak-oth-02.pdf

[78] Framework for implementation of Climate Change Policy: UNDP Pakistan 2014 http://www.pk.undp.org/content/pakistan/en/home/library/hiv_aids/publication_1.html

[79] *Pakistan Climate Public Expenditure and Institutional Review (CPEIR) - April 2015* http://www.pk.undp.org/content/dam/pakistan/docs/Environment%20&%20Climate%20Change/UNDP%20Climate%20Report%20V10.pdf

[80] *Intended Nationally Determined Contributions (INDCs)* http://www4.unfccc.int/Submissions/INDC/Submission%20Pages/submissions.aspx

[81] *An opinion piece by UNDP Pakistan Chief Marc André Franche, Damaging Effects March, 2016* http://www.dawn.com/news/1246105/damaging-effects

Developing countries will be most affected. It is time to act together. As UN Secretary General Ban Ki-moon said, “there is no plan B, because there is no planet B”.[82]

Meanwhile heavy rainfall, high temperatures and major pest outbreaks have taken a heavy toll on Pakistan’s cotton growing districts of Punjab and Sindh province this year. Pakistan’s Ministry of Textile Industry has expressed concern over the 28% drop in cotton production during 2015-16 caused by climate change-induced phenomena. The weather has been complete totally unfavorable for the country’s only cash crops i.e. cotton. Year 2015 was the hottest season in the cotton growing regions in the past decade but unfortunately similar weather conditions predicted for next few year, which may, results into low cotton production (Baigel 2016).[83] and here lies the conundrum for policy making. System Linearity in policy making will make government follow the conventional way of addressing the issue by incentivizing it i.e. lower costs for fertilizer and pesticide, this will help farmers compensate their losses, but does it solve the problem, in the long term, it does not. Government policy maker should be looking at the problem source and how it effects the energy and agriculture sector in the long run, rather for short term gains. More pesticides usage more energy intensive practices, more generation of GHGs as a result and hence the problem, over decades, instead of getting quarantined becomes more robust.

According to the Pakistan Economic Survey 2015-16, cotton contributes 1% of Pakistan’s GDP (PES 2015-16)[84] and 5 % of the country’s agriculture value added. The survey shows cotton production has dropped dramatically with the industry missing its 5.5% growth target.

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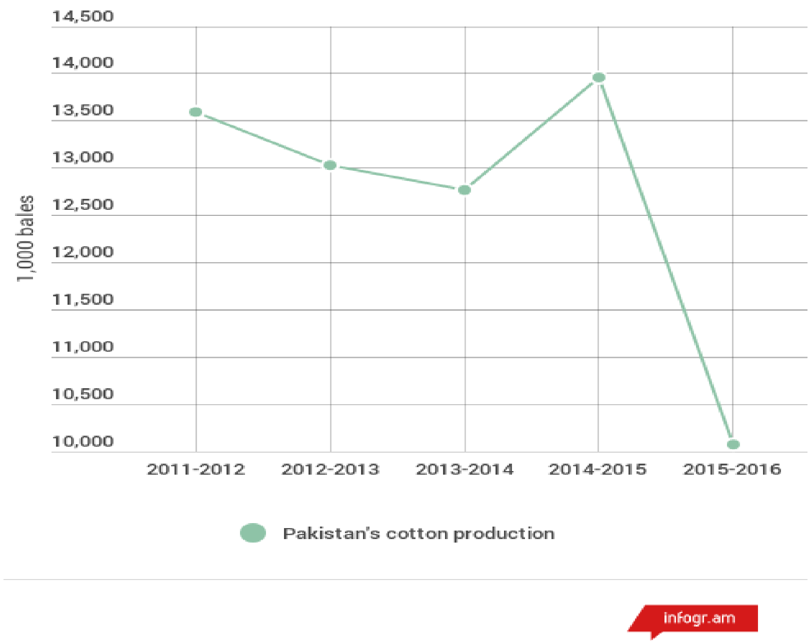
[82] *UN Sec-General Ban Ki Mon Address* http://www.un.org/climatechange/summit/2014/09/plan-b-climate-action-planet-b-says-un-chief/

[83] *An opinion piece by P.M Baigel, August 2016, “Climate change blamed for Pakistan’s steep drop in cotton production”* https://www.thethirdpole.net/2016/08/01/climate-change-blamed-for-pakistans-steep-drop-in-cotton-production/

[84] *PES 2015-16, Chapter 02* http://www.finance.gov.pk/survey/chapters_16/02_Agriculture.pdf




Data source: Pakistan Bureau of Statistics

Meanwhile, how water intensive is the cotton sector is cotton sector, can be judge from the fact that Just 2.4 % of the world's arable land is planted with cotton yet cotton accounts for 24 % of the world's insecticide market and 11 percent of the sale of global pesticides. 73 % of global cotton harvest comes from irrigated land, hence named as '*Thirsty Corp'* (WWF 2015).[85]

This is another example of where paradigm shift in policy making is required, but has never been addressed in Pakistan i.e. corps cost benefit analysis has never been done against the respective resource intensiveness.

## Nexus Approach Adaptation

Given the complex interplay of water, energy, and food demand and supply, numerous challenges and opportunities exist to minimize trade-offs and promote synergies to formulate effective adaptation options. The nexus approach provides a framework for addressing competition for resources and enhancing resource use efficiency. The goals and principles of the

[85] *Living Waters: Conserving the source of Life: Thirsty Corps : Our Food and clothes: Eating Up Nature and Wearing out Environment, WWF 2015* http://www.wwf.org.uk/filelibrary/pdf/thirstycrops.pdf

nexus approach and of climate change adaptation are closely linked and interconnected, as are the focus and strategies. Effective adaptation and nexus approaches share many common features. Management of water, energy, and food security has an impact on adaptation, and the strategies and policies aimed at climate mitigation and adaptation have significant implications for nexus challenges. While some adaptation measures such as water-use efficiency, renewable energy, and growing biofuels on wasteland might have positive implications for water, energy, and food resources, other measures for adaptation and mitigation such as extensive groundwater pumping, desalination plants, inter-basin transfers of water to deal with water scarcity, and growing biofuels to deal with fuel scarcity, may increase nexus challenges.

For example, micro-irrigation technologies such as drip and sprinkler irrigation reduce water demand by increasing efficiency, but increase energy demand. Similarly, growing biofuels on wasteland can enhance the energy supply and reduce dependence on fossil fuels, but diverting cultivable land for biofuels can threaten food security and lead to social impacts in terms of higher food prices. Promoting large-scale bioenergy production is a prime example of a policy in which trade-offs have to be made between food security, biodiversity, and climate change (Scott, Kurian, & Wescoat, 2015).[86] The higher costs of clean energy systems generally have to be weighed against social and economic benefits. These trade-offs are strongest in developing countries where a large section of the population do not have access to adequate food, nutrition, drinking water, and energy. Trade-offs may also arise between efficiency of resource use and equity of access. Policy makers have to make choices between food and energy, and efficiency and equity. Managing trade-offs across the three sectors of water, energy, and food is a daunting task and significant challenges remain.

[86] *The nexus approach to water-energy-food security: An option for adaptation for climate change ,by Golam Rasul et al Apr, 2015* http://www.tandfonline.com/doi/pdf/10.1080/14693062.2015.1029865

## Recommendations

- Despite the strong linkages among Water, Energy and Food, a continuity of approach in the developmental sector (Academia & Practitioners) over the decades, has always been in the "silos". To maximize W-E-F in its output from resource perspective, a mechanism of awareness on part of policy makers is very important. After 2007/2008 food prices crisis (UN-DESA 2011)[87], governments re-evaluated the agricultural investments. This paradigm shift, in its essence, is reactionary in approach, but it paved way for thinking in the interconnectivity of resources and the complexity of linkages of food with energy, land and water. The SDGs will be the first litmus test for the nexus model and the resources linkages.
- Curbing subsidies in all the resource sectors i.e. Water, Food, and Energy, instead paving way for accessibility of it. For example, the International Energy Agency reports that global fossil fuel subsidies in 2010 amounted to US$409 billion, whereas renewable energy subsidies totaled US$66 billion (IEA 2011).[88] The poorest 20 % of the population received approximately 8 % of the global fuel subsidies, and the more than 1 billion poor people without access to modern forms of energy were fully excluded from this support. Apart from the fact the subsidies are directly proportionate to the resource it often leads to unintended consequences for other sectors. e.g. with large-scale groundwater depletion as a result of free electricity access for irrigators in India (Shruti Sharma et al 2015).[89] Thus, a nexus approach is to review, identify and scrutinize the trade offs in the context of "*At the cost of what*".
- Water pricing is a major factor. Most irrigators, who use about 70 percent of global freshwater resources either do not pay at all or only nominal amounts for water and payments are in most cases not linked to the volumes of water used. In the domestic and industrial sectors, accounting for about 30 percent of water withdrawn and 20 percent of water depleted, payments are generally volumetric, but even here water charges are often

[87] *The Global Food Crisis: Chapter IV , 2011* http://www.un.org/esa/socdev/rwss/docs/2011/chapter4.pdf
[88] *IEA analysis of fossil-fuel subsidies: October 2011* https://www.iea.org/media/weowebsite/energysubsidies/ff_subsidies_slides.pdf
[89] *Rationalizing Energy Subsidies in Agriculture: A scoping study of agriculture subsidies in Haryana , India by Shruti Sharma et al September 2015* https://www.iisd.org/sites/default/files/publications/rationalizing-energy-subsidies-agriculture-in-haryana-india.pdf

too low to affect behavior(Pimentel et al, 2004).[90] For more than a decade, the concept of virtual water has been used to relate water, food and trade(Allan J.A 1998).[91] Water-scarce countries can substitute food imports for domestic irrigated production (so-called imports of virtual water) and allocate these resources to other, higher-valued uses. For example, Cereal trade from water-abundant to water-deficit areas is expected to grow to 38 percent by 2025 from just 23 percent in 1995, because food demand growth outstrips food production growth in water-deficit areas.[92] Hence, the whole science of relevancy in policy making, rests on the choices made, and that can rightly be done if priorities are set right and its far sighted. This possibility is more explicit in the nexus model of the W-E-F resources.

- The lesson in Reisner's "Cadillac Desert"(Reisner 1986)[93] about the over- development of water resources in the American West has documented it very well, how the shift can be negative. Reforming water institutions and adopting more efficient irrigation technologies are usually perceived as good substitutes for water-infrastructure investments across the globe(Xie et al 2016)[94] This leads to very deductive conclusion that the answer is not always building on more water reservoirs rather the efficient use of it, the governance of water infrastructures.
- Use trade, regional integration and foreign policy to manage nexus trade-offs more effectively, and contribute further to resilience at both country and global levels. (WWF 2014)[95]. Energy trade has been now sought out at regional level between Pakistan and Central Asian Countries for 1000 MW of energy. This trade in energy will have long term effects on food and water. Fore mostly, trade in energy means, being less on fossil

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[90] *Water Resources: Agricultural and Environmental Issues*: *Pimentel D, 2004* http://bioscience.oxfordjournals.org/content/54/10/909.full

[91] *Virtual Water: A Strategic Resource Global Solutions to Regional Deficits Allan, J.A July 1998* http://onlinelibrary.wiley.com/doi/10.1111/j.1745-6584.1998.tb02825.x/abstract;jsessionid=6B33401AF910CA4BC67DAA32447918BA.f04t01

[92] ibid

[93] *Reisner, Marc, Cadillac Desert — The American West and Its Disappearing Water, Penguin Books, New York, 1986.* http://www.psych.utah.edu/psych4130/Reading2.pdf

[94] *"Theoretical implications of institutional, environmental, and technological changes for capacity choices of water projects" (Xie et al 2016)* http://sciencedirect.nk022.com/science/article/pii/S2212428415300062

[95] *"The water food energy nexus: Insight into resilient development" WWF 2014* https://www.sabmiller.com/docs/default-source/investor-documents/reports/2014/sustainability-reports/water-food-energy-nexus-2014.pdf?sfvrsn=4

fuel for 1000 MW of energy, which could have been produced using fossil fuel or for which a hydro project would have been required. In both cases, a big effect on ecology and environment can't be ignored. By-product of trade i.e. regional peace and stability is another important contributing factor. This thinking can only instill, when integrated model of natural resources usage and its governance has been at priority to the policy makers.

- More than ever, Pakistan's policy makers and government institutions needs to think and devise policies in the resource scarce county, where lack and absence of water and energy can sooner than later will have catastrophic effect on its agriculture and food sector.
- The policy tilt has always been towards '*Supply'*, it has never looked into conservation. Conservation can be key to green economy in future and the resource sustainability can be assured, which is a national and global goal. With the advent of renewable technologies in energy sector and the technological adaptation mechanisms in agriculture sector (drip irrigation instead of canal water) can be useful tools in achieving the resources sustainability.

## Conclusion

Water-Energy & Food Nexus Model, in its actuality as a concept, has not been very old, but with the announcement of SDGs in September 2015 subsequently COP21 in November 2015, has made academicians and policy makers to think more on integrated modelling of natural resources. Hitherto, results have shown that model have some vivid deliverables for decision makers e.g. In Qatar, the implications of increasing food security (independence from imports) from 10 to 20 % was analyzed by quantifying the increased food production, considering the costs of energy, carbon, and water footprints. The study determined that a 10 % increase in food production would require more than 150 % additional land, which was simply not available (Mohtar and Daher 2014).[96] The water-energy-transportation nexus in Texas is analyzed using a scenario-based approach by examining sustainability indices to create an economic-environmental-social index because the sustainability of energy production in the state is of high priority. The approach has implications for policy, regulation, subsidy, the development and

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[96] *"Nexus Dialogue on water infrastructure Solutions"* http://www.waternexussolutions.org/ContentSuite/upload/wns/all/Case%20study_WEF%20nexus%20research%20team(1).pdf

transfer of new technology and changing behaviors regarding how these issues are approached (WEF Nexus Research Group 2015).[97] Study shows that the nexus is a very relevant approach in the Mekong River Basin, as the nexus components form the basis for social and economic development in the riparian countries and are closely interlinked. The results also show that with the time scale used in the model (up to the year 2042), the impacts from hydropower development are likely to be much more severe than those from changing climate. Such impacts are likely to lead to radical reductions in ecosystem productivity and, consequently, in the Tonle Sap (In Cambodia) fisheries (UN ESCAPE 2013)[98]

With the advent of ICT (Information Communication Technology), data availability, and further analysis of nexus model, a now software tools are available, which can give, using scenario modeling and other required data input, to give the best possible results for the descion makers.[99] SDGs when announced, did managed to have its very sound full critics, who were in unison in attributing them as '*Catch All',*[100] but lessons learnt from MDGs were, the journey must began now, there is no other option.

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[97] *A platform for Nexus Publications* http://wefnexus.tamu.edu/publications/

[98] *Water Food and Energy Nexus: In Asia and The Pacific-A Discussion paper 2013)* http://www.unescap.org/sites/default/files/Water-Food-Nexus%20Report.pdf

[99] *"Isd Planning Models"*https://www.water-energy-food.org/news/2016-08-18-tools-new-version-of-integrated-sdg-planning-model-isdg/

[100] *Johannes Mengel-International Council for Science* http://www.icsu.org/news-centre/press-releases/press-releases-2015/sustainable-development-goals-need-clearer-more-measurable-targets-say-scientists