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ENERGY - WATER NEXUS: THE ESCALATING THREATS IN THE CONTEXT OF HIGH GDP GROWTH PARADIGM

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ABSTRACT

In the context of growing gap between the demand and the availability of energy and fresh water in India, the close relationship between the usage of energy and water needs a diligent focus for obvious reasons; especially in the context of fast looming Climate Change phenomenon. This nexus has a major impact on various associated issues of the natural world. The sustainability of our development policies will depend on how our society will treat this nexus. The importance of a holistic approach to the linkage between energy and water can be judged by an associated law in US: the 'Nexus of Energy and Water for Sustainability (NEWS) Act of 2014'. It defines the term energy-water nexus as the link between energy efficiency and the quantity of water needed to produce fuels and energy, and the quantity of energy needed to transport, reclaim, and treat water. High GDP growth rate paradigm in India has only aggravated the associated issues for a resource constrained country. This article analyses the associated issues and recommends few steps to address the problem in the medium to long term.

Key terms/words: energy and water nexus; GDP growth rate; efficiency; drought; industry; sustainability; equity; fresh water bodies; food and energy security; Climate Change; agriculture.

1.0 INTRODUCTION

In recent years the close relationship between the usage of energy and water are getting highlighted for obvious reasons. So much so, that in US the 'Nexus of Energy and Water for Sustainability (NEWS) Act of 2014' was enacted, and it defines the term energy-water nexus as the link between energy efficiency and the quantity of water needed to produce fuels and energy, and the quantity of energy needed to transport, reclaim, and treat water. As per an article in Scientific American on May 12, 2014, in the United States about 410 billion gallons of water are withdrawn for use each day from the fresh water bodies such as rivers, lakes and underground sources. Almost half (49%) of this water is used by the electric power sector. On the other side, more than 12% of the nation's energy use is used to meet the country's water and steam demand. As per another report from Government Accountability Office, US the energy sector has been the fastest growing water consumer in US in recent years and is projected to account for 85 percent of the growth in water consumption between 2005 -2030.

As far as the water energy nexus in India is concerned, although similar figures in Indian scenario are not available easily as in the case of US, it is safe to assume that the scenario cannot be vastly different to that in US. The fact that India is generally considered as a water deficit country, and that the per capita availability of fresh water is one of the lowest in the world, should make the energy-water nexus a priority issue to take into account in our developmental paradigm. According to industry estimates, India accounts for 17 per cent of the world's population and has just 4 per cent of the fresh water resources. India's rivers are reported to be carrying only 5 per cent of the world's fresh waters but an astounding 35 per cent of global sediments. There are probably no river stretches in India, except perhaps in the upper reaches of Himalayas or very few streams/rivers in Western Ghats, which can be said to be clean. As a recent article in India Water Portal has indicated, 'the major challenges of the 21st century in river water use is the increasing pollution in the rivers and the partial failure of the conventional methods of pollution control due to various reasons. The depletion in non-monsoon flow in rivers (more pronounced in peninsular rivers) is enhancing the pollution load and making the situation more difficult. Due to these challenges, the revival of the rivers in a holistic way has become a non-negotiable need of the day.' The Central Pollution Control Board (CPCB) has come out with yet another startling revelation recently about India's rivers—' the number of polluted stretches of the rivers has increased to 351 from 302 two years ago, and the number of critically polluted stretches has gone up to 45 from 34'. This scenario can be considered as a shame on the whole society, especially when we consider the glorious cultural heritage of worshiping rivers and other fresh water bodies as part of the overall family of natural resources. Irrigation consumes about 84 per cent of India's water. Industrial and domestic usage is just 12 per cent and 4 per cent, respectively. Ground water accounts for 62 per cent of the irrigation use. There is enormous dependence on ground water in India. Since almost all of the water usage needs energy to pump / transport, the seriousness of the water-energy nexus should become evident: higher usage of water will lead to higher demand for energy and vice-versa. There is a serious and legitimate concern that India will soon transform itself from a water-stressed country to a water-scarce country.

Water–Energy Nexus

As per an editorial in Current Science of April 2014 ("International World Water Day 2014, Focus: Water–Energy Nexus") 'Energy and water are closely intertwined. It takes a great deal of energy to supply water, and a great deal of water to supply energy'. This article also points out that water consumed for energy production, according to International Energy Agency (IEA, 2013), will increase from 66 billion cubic metres (bcm) at present to 135 bcm by 2035. Out of this global energy related water demand, it is estimated that more than half of this consumption will be by coal-fired thermal power plants, about 30% by bio fuel, whereas oil and gas-based production will account for 10%. Renewable energy generation, such as wind and solar photovoltaic power, accounts for less than 1% of water consumption for energy production. While power generation, as indicated above, requires large supply and utilization of water resources, energy itself is required for pumping, transporting, treatment and desalination of water. Agriculture, including irrigation, mining of coal and lignite, hydraulic-fracking, manufacturing and construction industries, use as much as 37% of the electrical energy produced.

As per UN Water, between 2013 and 2015, annual economic growth is estimated at about 6% in developing countries and 2% in higher income countries. As economies grow and diversify, they experience competing demands for water to meet the needs of more municipal and industrial uses, as well as agriculture. It also says that nowhere is the critical inter-relationship between water and energy more evident than in the Asia-Pacific region, which is home to 61% of the world's people and with its population expected to reach five billion by 2050. The Asian Development Bank (ADB) forecasts a massive rise in energy consumption in the Asia-Pacific region: from barely 33% of global consumption to 51-56% by 2035.

Because of the undisputed relationship between the usage of water and energy, there is a clear imperative of effectively managing both these aspects of our life keeping in view the impact of Climate Change in order to achieve the equitable development of all sections.

2.0 INDIA'S SCENARIO IN THE GLOBAL CONTEXT

The fact that India shares about 17% of the global population but is reported to have only about 4% of the total water resource should obviously indicate a water deficit scenario as an important geographical and climatic characteristic. Due to various constraints of topography there is also uneven distribution of precipitation over space and time within India. Precipitation varies from 100 millimetres (mm) in the western parts of Rajasthan to over 1,000 mm at Cherrapunji in Meghalaya. Further, extreme conditions of floods and droughts are a common feature, which affect the availability of water for various purposes.

Food, water, and energy are interlinked and there is deep interdependence. As per a report "India's Global Resource Footprint in Food, Energy and Water (FEW)" prepared for UK Aid, India is the largest groundwater user in the world and about 90 per cent of its ground water is used for food production. Energy is a vital input in agriculture for irrigation, harvesting, post harvesting, processing, value addition, storage, and transportation. Agriculture accounts for about 20% of total electricity consumption and 12% of total diesel consumption in India. Energy and water linkage is also critical as energy is needed for water extraction, transportation, distribution, and treatment and on the other hand water is required for energy generation from hydro and thermal power plants. Whereas due to Climate Change the total precipitation is projected to increase in few river valley areas, extreme conditions of floods and droughts are expected to be a common feature, which will affect the availability of water for various purposes. This report also has indicated that between 1950 and 2010 while there was a ten-fold increase in energy demand, a 25 fold increase in agricultural energy demand was recorded.

As per a notification of the Press Information Bureau on 25 April 2015, the per capita water availability in the country as a whole is reducing progressively due to increase in population. The average annual per capita availability of water in the country, taking into consideration the population of the country as per the 2001 census, was 1816 cubic meters which decreased to 1545 cubic meters as per the 2011 census. It is not difficult to project that this availability will be much less by 2050 when the population is expected to be about 1.6 Billion. To meet the demand for fresh water for such a large population in the context of Climate Change, which is projected to exacerbate the fresh water availability across the country, will be a major challenge.

As per World Bank ("Water Sector in India", September 29, 2011) more than 60 percent of India's irrigated agriculture and 85 percent of drinking water supplies are dependent on groundwater. Over exploitation of ground water is developing into a serious concern for the water security in India. The advent of electric pump sets and highly subsidised electricity supply to the farming community enabling withdrawal of water from deep underground has led to proliferation of the ground water extraction practices all over the country.

Such a scenario has not only resulted in the accelerated lowering of ground water table, but also in high electricity usage. Since most of the states in the union charge nil or very low price for supply of electricity to the farmers, there is no incentive for these farmers to become more efficient in energy/water usage resulting in huge inefficiencies. Indiscriminate exploitation of groundwater has led to alarming decline of water table in many parts of the country.

As per The Earth Institute many parts of India are consuming about 3 kWH of electricity to grow 1 kG of food which should indicate the enormity of the influence of food agriculture on water and energy.

A major consequence of the looming Climate Change will be the increase in average atmospheric temperatures in different regions of the country, including the hills, Western Ghats and Himalayas, which in turn is expected to lead to increase in energy demand, and consequently to the increased water demand too. The increase in average atmospheric temperature also means higher rates of water evaporation from fresh water bodies, which will reduce the total fresh water availability. It can be mentioned here that the preference of successive governments to construct more and more reservoirs, is leading to higher levels of total water evaporation at the national level, thus exacerbating the water availability scenario. Hence, there is a critical need to consider the future requirement of water and energy holistically, and to plan for extremely careful usage of these precious but scarce resources.

As per a survey report by Prayas Energy Group ("THERMAL POWER PLANTS ON THE ANVIL: Implications and Need for Rationalisation", 2011), if 700,000 MW of additional coal and gas power plants are to be set up in the country up as per the projects in pipeline in that year, the fresh water requirement of a huge quantity (about 4.6 billion cubic meters per year) additionally can be expected. The gravity of the situation becomes clear when we also realise that this much of fresh water can meet the drinking water needs of about 7 % of the population in India, or can provide irrigation to more than 900,000 hectares of land. In a country already having serious crises of fresh water, the rationality of such large additions to thermal power plants becomes highly questionable.

A recent Webinar program by ET Energy World under the title "Water demands, risks, and opportunities for India's power sector" recently has mentioned:

- 40 percent of India's freshwater-dependent thermal power plants experience high water stress
- Between 2013 and 2016, 14 of India's 20 largest thermal power utility companies experienced one or more shutdowns due to water shortages. Shutdowns cost these companies over Rs 91 billion ($1.4 billion) in potential revenue from the sale of power
- water shortages cancelled out more than 20 percent of India's growth in electricity generation between 2015 and 2016
- 12.4 billion cubic meters of fresh water withdrawals could be reduced from India's power sector needs, if proposed cooling mandates were fully implemented and aggressive renewable targets completely achieved.

Prioritizing installation of solar PV and wind projects in highly water stressed areas can help make India's electricity supply more resistant to water shortages while helping meet India's INDC to UNFCCC: a 40 percent cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030.

Similarly, the gas based and nuclear power plants also require vast quantities of water. Such an enormous impact of electric power generation sector on water availability for a water stressed country should drive our national energy policy away from over dependence of fossil fuel and nuclear power plants. In view of the maturity of wind and solar power technologies; their plunging costs; and their widespread usage across the world must make our policy makers in India to take all possible initiatives to minimise the dependence on thermal power projects, which has, anyway, become essential due to the need to minimise the GHG emissions.

The petroleum products (diesel, petrol and natural gas) used in various economic activities such as transportation, industry and agriculture also have considerable impacts on water; basically due to the cooling needs of the heated the engines.

All of the fossil fuels also have impact on the purity of fresh water sources because of the mining, transportation, usage and waste disposal. The mining and ash disposal in the case of coal, and the ground water contamination in the case of fracking are tow such evident examples.

Electricity being used for IP sets should be a major area of focus. At the national level about 20 % of the total electricity consumed is reported to be in irrigation pump (IP) sets. It is also well known that due to various technical and logistical reasons the overall efficiency of such IP sets is very low (of the order of about 50% as against technical feasibility of more than 80%). This scenario indicates that there is a vast scope for saving electricity usage in agriculture. Since agriculture mostly requires water supply during day time in summer months, and since solar power generation can be maximum during summer, the potential for meeting most of the agricultural electricity demand through solar power is not only enormous but also very attractive, if we consider various aspects of our power sector. Almost all of the IP set power requirements can be met by solar power, which will drastically reduce the pressure on the existing grid network, and on the need for additional conventional power plants. This solar technology is fairly mature, highly suitable to IP sets which are required to run during summer day time, and most suitable for the farmer's needs. The experience of Rajasthan, where thousands of such solar powered IP sets are performing satisfactorily, should settle the technical and economic issues.

As per an editorial in Current Science of April 2014, referred above, while the available utilizable water resource in India has remained nearly constant over decades, the demand for water is increasing and is influenced by steady growth of population, increasing urbanization, economic growth and changing life styles, resulting in per capita availability of water coming down from 1,816 m^3/year in 2001 to 1,545 m^3/year in 2011. It is expected to go down further to 1,340 m3/year by 2025 and 1,140 m^3/year by 2050. A per capita consumption of water less than 1,700 m^3/year is generally considered as an indication of water stressed condition and less than 1,000 m^3/year as water scarcity condition. This scenario of water stressed condition should be a major concern in our developmental paradigm.

In view of the fact that the country is facing serious issues with the supply of energy/electricity and water for its growing population, it becomes critical that all possible efforts should be focused on optimising the usage of these two precious resources. Effective rainwater harvesting and ground water recharging in all human settlements, and deployment of renewable energy resources across the length and breadth of the country can go a long way in this context.

3.0 IMPACT OF HIGH GDP GROWTH RATE PARADIGM ON ENERGY – WATER NEXUS

As a consequence of the obsession with a high Gross Domestic Product (GDP) growth rate paradigm as practiced by the successive governments since 1990s, the country has been recording high GDP growth rate for more than two decades. Since 1996 onwards the country has logged a high average GDP growth of more than 6% till 2005, and more than 7% since 2006 onwards. (ref: World Bank: http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG).

Such a high growth year after year can lead to the multiplication of the size of our economy as shown in the table below. Whereas a compounded annual growth rate (CAGR) of 4% of GDP will take about 19 years to double the size of our economy, 10% CAGR will increase the size of our economy by four times only in 18 years.

Time taken for the size of economy to get multiplied at constant CAGR

CAGR Growth Percentage	Increase by 100%	Increase by 200%	Increase by 300%	Increase by 400%
@ 4%	19 Years	29 Years	36 Years	40 Years
@ 6%	13 Years	20 Years	25 Years	29 Years
@ 8%	10 Years	15 Years	19 Years	22 Years
@ 10%	8 Years	13 Years	16 Years	18 Years

While vastly increasing the demand for water due to increased economic activities, the multiplication of the size of our economy in short durations will have many other serious concerns to bother the vulnerable sections of our society, while doubling the "financial wealth" of the country. The primary question should be whether such multiplication of the "financial wealth" in short span of time comes at a huge cost to some sections of our society, and by how much; and what will be the impact on demand for water and energy.

A sustained high GDP growth rate will mean the manufacture of products and provision of services at an unprecedented pace leading to: setting up of more factories/ manufacturing facilities; consumption of large quantities of raw materials such as iron, steel, cement, chemicals etc.; increasing an unsustainable demand for natural resources such as land, water, minerals, timber etc.; acute pressure on the Government to divert agricultural /forest lands; huge demand for various forms of energy (petroleum products, coal, electricity etc.); accelerated urban migration; clamour for more of airports, airlines, hotels, shopping malls, private vehicles, express highways etc. With such vastly increased economic activities, the demand for water and energy will obviously escalate.

The base line assumption in the Integrated Energy Policy of the erstwhile Planning Commission, 2008 that the country needs to sustain an economic growth of 8 - 9 % over next 20 years to eradicate poverty and to meet its human development goals, will lead to very many intractable problems for the society from social and environmental perspectives. Such a high growth rate projection for the country for the next 20-25 years has also resulted in the perceived need for enormous increase in electricity generation capacity in the form of thermal power plants, which in turn will escalate the demand for water also. Hence, the obsession with high GDP growth rate target should be diligently reviewed against a paradigm shift in our developmental objective, which will give priority for inclusive growth aimed at sustainable and responsible use of natural resources, and especially consider the impact on our vulnerable communities w.r.t their needs for water and clean environment.

4.0 FOOD, WATER, AND ENERGY NEXUS

Food, water and energy are interlinked and have deep interdependence too. India is the largest groundwater user in the world and about 90 per cent of ground water is used for food production. Energy is a vital input in agriculture for irrigation, harvesting, post harvesting, processing, value addition, storage, and transportation and agriculture accounts for 20% of total electricity consumption and 12% of total diesel consumption in India. The policies aiming at security in one sector often can have repercussions on resources in other sectors. Improved water, energy and food security can be achieved through a nexus approach - an approach that integrates management and governance across sectors and scales. A nexus approach can support the transition to a Green Economy, which aims, among other things, at resource use efficiency and greater policy coherence.

The UN water says: "The water-food-energy nexus is central to sustainable development. Demand for all three is increasing, driven by a rising global population, rapid urbanization, changing diets and economic growth. Agriculture is the largest consumer of the world's freshwater resources, and more than one-quarter of the energy used globally is expended on food production and supply. The inextricable linkages between these critical domains require a suitably integrated approach to ensuring water and food security, and sustainable agriculture and energy production worldwide."

Few other interesting facts posted on the website of UN water are:

- Agriculture accounts for 70% of global water withdrawal. (FAO)
- Roughly 75% of all industrial water withdrawals are used for energy production. (UNESCO, 2014)
- The food production and supply chain accounts for about 30% of total global energy consumption. (UNESCO, 2012)
- 90% of global power generation is water-intensive. (UNESCO, 2014)
- Power plant cooling is responsible for 43% of total freshwater withdrawals in Europe (more than 50% in several countries), nearly 50% in the United States of America, and more than 10% of the national water cap in China. (UNESCO, 2014)
- By 2035, water withdrawals for energy production could increase by 20% and consumption by 85%, driven via a shift towards higher efficiency power plants with more advanced cooling systems (that reduce water withdrawals but increase consumption) and increased production of biofuel. (UNESCO, 2014)
- There is clear evidence that groundwater supplies are diminishing, with an estimated 20% of the world's aquifers being over-exploited, some critically so. Deterioration of wetlands worldwide is reducing the capacity of ecosystems to purify water. (UNESCO, 2014)
- It typically takes 3,000 – 5,000 litres of water to produce 1 kg of rice, 2,000 litres for 1kg of soya, 900 litres for 1kg of wheat and 500 litres for 1kg of potatoes. (WWF).
- While almost 800 million people are currently hungry, by 2050 global food production would need to increase by 50% to feed the more than 9 billion people projected who live on our planet (FAO/IFAD/UNICEF/WFP/WHO, 2017).

A posting by World Watch Institute ("Is Meat Sustainable?") says:

- The standard diet of a person in the United States requires 4,200 gallons of water per day (for animals' drinking water, irrigation of crops, processing, washing, cooking, etc.). A person on a vegan diet requires only 300 gallons a day.
- A report from the International Water Management Institute, noting that 840 million of the world's people remain undernourished, recommends finding ways to produce more food using less water. The report notes that it takes 550 liters of water to produce enough flour for one loaf of bread in developing countries…but up to 7,000 liters of water to produce 100 grams of beef.

A recent WRI report ("Shifting Diets for a Sustainable Food Future"), it is estimated that a third of the global water may be needed for farm animal production by 2050, if the present trend continues. This eminently readable and well-researched report has recently suggested that people should reduce (if not abandon) eating beef. But the reasons for this suggestion are not belief-based but deeper and come from the angle of worrying about the methods to achieve a sustained future for feeding the growing population in the coming years.

Another publication by the title "Reducing food's environmental impacts through producers and consumers" published in the journal Science, states that more than 80% of farmland is used for livestock but it produces just 18% of food calories and 37% of protein. The study also indicates that on an average beef results in up to 105 kg of greenhouse gases per 100 g of meat, while nuts produces less than 3.5kg. In view of the deep interdependence of food, water and energy, the impact on the demand for water and energy from meat related food industry can only be enormous. The consequences on the Climate Change should become obvious.

India's agricultural energy demand for pumping water from the ground is enormous. At the national level the total electricity consumed in agricultural sector is estimated to be more than 25% of annual electricity consumption. In some states such as Karnataka, Telangana and Andhra Pradesh the annual electricity consumption in IP sets alone is estimated to be more than 30%.

The technology of solar powered water pumps has come as a great boon not only for the farmers, but for the whole electricity sector. Such pumps, which work optimally during the day time of summer months, also coincide very much with the water needs of the agricultural sector. They have the potential not only to eliminate the need for unreliable grid power supply, but they will also reduce the grid electricity demand by considerable margins. While minimising the need for farmers' subsidy, they can also provide a revenue earning opportunity for the farmers through the sale of excess electricity from such solar power panels back to the grid. Food and agriculture have major impact on the demand for fresh water. The kind of agricultural practices and the food habits are known to have considerable impacts of the demand for fresh water. In the context of Climate Change, a suitable food habit with less dependence on meat and based on fruits and vegetables can reduce the water demand by considerable margin, while also reducing the green house gas (GHG) emissions considerably.

Modifying diets to save water: The Hindu on 18.4.2017
{http://www.thehindu.com/sci-tech/energy-and-environment/modify-diet-to-save-the-planet/article17834580.ece}

India could save water and reduce planet-warming emissions if people added more vegetables and fruits like melon, oranges and papaya to their diet while reducing wheat and poultry, researchers said on Wednesday. India's population is forecast to rise to 1.6 billion by 2050, and to ensure there is enough available freshwater, water use will have to be cut by a third, according to a study published by *The Lancet Planetary Health* journal. But population growth will also lead to an increase in demand for food, putting more pressure on water through farming. By 2050, irrigation will account for 70% of total water use in India, up from the current 50%, unless farming methods change and diets shift towards food that needs less water to grow, the study said. "Modest dietary changes could help meet the challenge of developing a resilient food system in the country," said James Milner, the study's lead author from the London School of Hygiene & Tropical Medicine. The study, which Mr. Milner said was the first to look at changing food habits to save water, found that freshwater use could be reduced by up to 30% by lowering consumption of wheat, dairy and poultry in favour of fruits and vegetables. The best kind of diet would also include legumes, and swap fruits requiring more irrigation, like grapes, guava and mango, with more water-efficient crops such as melon, orange and papaya, the study said. The dietary changes would also lower the risk of cardiovascular diseases and cancer in humans, while protecting the planet by cutting greenhouse gas emissions.

4.1 Water needs of Energy production

In view of the vast demand for fresh water in electricity production processes of thermal and nuclear energy technologies, the criticality of attaining the optimal efficiency levels in all the associated processes has become evident. Additionally, the critical need for replacing such conventional technologies with renewable energy technologies based on sources such as wind, solar, bio-mass etc. in the medium to long term need not be emphasised. Such renewable energy technologies have already been well established since last 8 – 10 years, and are increasingly becoming popular not only from the perspective of economics and convenience, but also have become critical from the perspective of global warming.

4.2 Water demand of renewable energy sources

Large size land based solar PV systems, such as solar power parks, though seen as a renewable source of energy, can pose serious issue to a water stressed society. Regular cleaning of conventional solar power plants require significant amounts of water, which Council on Energy, Environment and Water (CEEW) estimates to average around 7,000 to 20,000 litres of water per megawatt (MW). If such large size solar power parks (of many hundreds of MW capacity) are to be set up in relatively drier regions such as Rajasthan and Gujarath, because of the consideration of higher solar insolation, arranging reliable water supply for such cleaning purpose in such regions will be an enormous challenge. In most case such solar power parks may result in reduced water supply to the local people.

4.3 Evaporation issues of dam based hydel power plants

Large hydro-power dams, such as Linganamakki (Karnataka), Idukki (Kerala),Tehri (Uttarakhand) etc. offer large water surface for evaporation, the percentage of which is not inconsiderable. Estimates indicate that the rates range between 5 to 10% depending on the local atmospheric conditions. India scenario, with probably the largest number of reservoirs, should be a matter of concern in this regard, and hence all proposal to build additional reservoirs should be carefully considered in this context.

4.4 Incompatibility of high GDP growth rate paradigm in the context of Water Energy nexus

When we objectively consider the limit of the nature to meet the increasing demand for water and energy, and when we also realise that a high GDP growth rate paradigm for a resource constrained and populous country like India can lead to intractable problems, the enormity of the situation confronting our country should become abundantly clear. There can be no escape from acknowledging the need for minimising the demand for not only for water and energy, but for all materials. A much simpler life style aiming at sustainability becomes obvious as the single choice. Keeping all these issues in proper perspective, the potential for saving of water and energy at the national level through efficiency improvement measures, including demand side management (DSM) and conservation, and hence the scope for effective reduction of electricity demand on the grid also is recognised as huge. Adequate efforts in this regard will result in vast savings to the nation perpetually, while bringing very many spin-off benefits. Proper choices and efficiency in the food sector will have major positive impact on energy water sectors.

5.0 THE CONTEXT OF CLIMATE CHANGE

Probably the most pressing issue of the 21st century is the phenomenon of Climate Change, which is threatening the very existence of life on this planet. Vast increase in various economic activities as a consequence of high GDP growth rate, while increasing the total greenhouse gas (GHG, responsible for global warming) emissions, will also add up to reduce the overall ability of natural carbon sinks such as forests and lands to absorb GHG emissions. As a consequence of such high GDP growth rate there will also be increased pollution of soil, air and water along with huge issues of managing the solid, liquid, gaseous, and radiological wastes.

Whereas, vast increase in the demand for water and energy, which are the direct consequence of high GDP growth rate paradigm, will lead to vastly increased GHG emissions, the phenomenon of Climate Change itself will have enormous impact on water, energy and food sectors. As per inter-governmental panel on Climate Change (IPCC), the phenomenon of Climate Change will be intricately related to vagaries of monsoon, un-seasonal rains, droughts and floods, heat & cold waves, increased average temperatures, forest fires, decreased food production etc. With such climate change events, there can be no doubt that sectors of water, energy and food will be impacted enormously, and can become unmanageable for the resource constrained and populous countries like India.

At a time when our natural resources are getting depleted at an alarming rate due to various reasons such as population growth, urbanisation etc. and when the pollution of air, water and land have become major health concerns, the above scenario cannot be ignored any longer, and hence needs a due diligence. The impact of Climate Change on the availability of water, energy and food; and the impact of higher demand for water and energy on the phenomenon of Climate Change must take a central role in our planning and policy making activities.

6.0 POTENTIAL REMEDIES AND CONCLUSIONS

In view of the undisputed nexus between water, energy and food, the solutions for the problems discussed above also lie in considering them in a holistic manner. Efficient and careful management of each of these three precious and scarce resource will result in the reduced demand for the other.

A diligent overview of the India's various economic sectors will clearly establish that these three sectors have not been optimally managed. The issues such as (i) unacceptable levels of air pollution (as per WHO 14 out of world's most polluted cities are in India); (ii) as per Central Pollution Control Board (CPCB) the number of polluted stretches of the rivers has increased to 351 from 302 two years ago, and the number of critically polluted stretches has gone up to 45 from 34; (iii) the draft national energy policy projects that by 2040 country's total energy demand may increase by 3 to 4 times with enormous increase in fossil fuel and nuclear power plants, which will in turn bring unbearable pressure on fresh water demand; (iv) country's population ma reach about 1.5 billion by 2050 putting enormous pressure on food, water and energy sectors etc. should clearly establish the magnitude of the challenge before our country during next 2 or 3 decades.

Vastly more responsible management of these sectors, which have relevance to every section of the society, is critical for a sustainable future for the country.

The ill-conceived and unsustainable practices such as the proposal to lift 60 TMC of water from Linganamakki reservoir in Western Ghats to meet the insatiable water demand of Bengaluru, setting up of more coal power plants in Karnataka (which has no coal reserve of its own and which is already the most water stressed state), setting up a pumped storage hydel power plant in Sharavathy river valley to meet the peak demand for electricity etc. are all completely unacceptable, and cannot be any part of our future developmental strategies.

The most suitable strategy for the future will be to minimise the total demand for water, energy and materials in all forms, and equitably distribute the food resources available to our society in the most optimal way. Such an approach will obviously necessitate the optimal harnessing of locally available resources and ensuring equitable welfare of all communities, without having to resort to large scale import/export between states and even between districts.

Effective steps in optimal rain water harvesting and ground water recharging, improving the irrigation methods by replacing flood irrigation by sprinkler and/or drip irrigation, recycling of water in industries, irrigated areas, and power generating units as well as from municipal waste water are critical imperatives to minimise the overall demand for water.

Rejuvenation and responsible management of every fresh water source by different communities will go a long way in efficient water and energy management at the country level.

Appropriate tariff for water supply and effective regulation of water usage are essential to optimise the demand for water.

Appropriate choices in the food sector, such as reducing the meat content in the diet and high efficiency in food agriculture and processing, will not only reduce the water and energy foot print, but also will greatly assist in health sector issues.

By minimising the number of hydro reservoirs, the evaporation of water can be minimised, which is a feasible option in view of the established & popular technologies of renewable energy sources. Floating kind of solar power panels are being increasingly deployed on the surface of the reservoirs to eliminate the need for land diversion and to reduce the water evaporation as well as to increase the overall efficiency of the panels.

Much higher efficiency in water pumping, transportation, and distribution, the usage of solar power pumps are the imperatives to reduce the water related energy demand.

Vastly reduced reliance on thermal and nuclear power plants in the short term and complete replacement by renewable energy sources, such as solar, wind and bio-mass energy units, while considerably reducing the demand for water in energy sector, will also go a long way in addressing the issue of Climate Change by minimising the GHG emissions.

Emphasis on public transport based on renewable energy sources and much higher efficiency will reduce the demand for fossil fuels, and hence for water.

Even in the case of renewable energy sources large size solar power parks can put unacceptable levels of pressure on local water supply due to the need for frequent cleaning of solar panels. Because of this reason and to minimise the land diversion, it is ideal to deploy distributed type of solar power systems, such as roof top solar power panels on top of roof tops of various kinds of buildings. Such a deployment is also associated with minimum energy losses and better voltage profiles.

The phenomenon of Global Warming can be basically associated with the vastly accelerated depletion/ degradation of various elements of the nature; which is also known as the transgression of Planetary Boundaries. So, in order to address this phenomenon, various activities of the humankind contributing to the accelerated depletion of the nature have to be thoroughly reviewed to ensure they become sustainable. Water and energy are the two essential ingredients of this consideration, and the kind of food habits and process of food production, obviously will have a major impact on these ingredients of the nature.