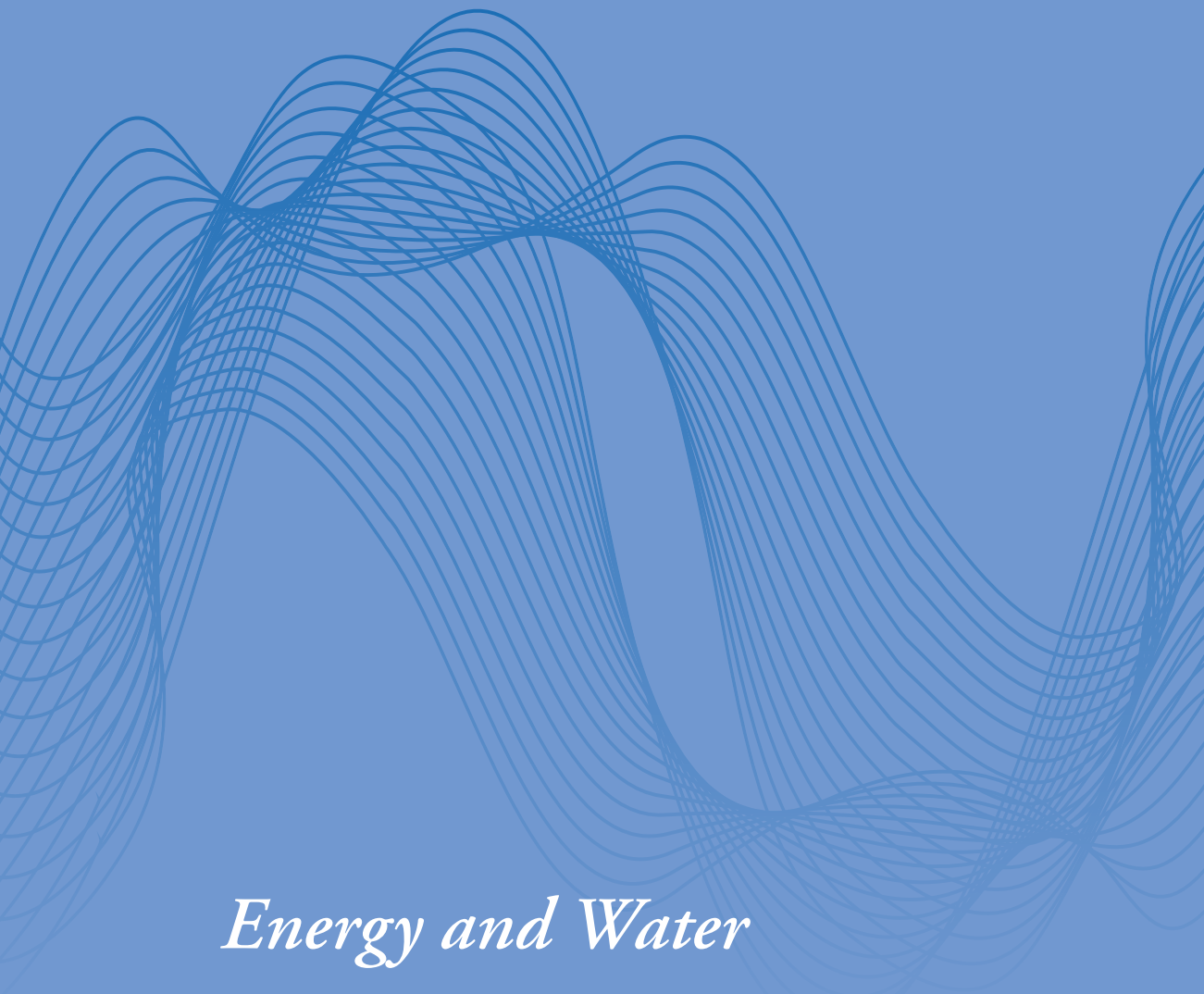
Abstract Volume

World Water Week in Stockholm
August 31-September 5, 2014



Energy and Water

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ABSTRACT VOLUME

World Water Week in Stockholm
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Energy and Water

Contents

Workshop: Entwined Predicaments: Limits Facing Water and Energy

Water in the Energy Industry: A Scientific Review on How and Where Water is Used in Energy Production

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Keywords: energy pathways, water, trusted data, sustainability

Introduction and objectives

The impact of increasing energy production on regional availability of freshwater resources has led the energy industry to alter its approach to water management. BP's collaborative research programme, the Energy Sustainability Challenge, has assessed the intensity of water used along the primary energy pathways: fossil fuels extraction and processing, electricity production (nuclear, fossil fuels) and biomass. The main objective was to research and present trusted data on how water is sourced, used, and treated in different processes of extraction, production, refining and conversion of energy. Through this research, methods of decoupling freshwater use for energy generation have been explored.

Methodology approach

This was independent research carried out by 14 leading Universities, funded by BP. The study focused on defining how the energy sector intersects with water while deriving water/freshwater intensities of different components of the energy pathways in the form of m^3 of water per Terra-Joule of energy. The research looks at historical trends as well as the current approach. The research conclusions and presented data are drawn from studies and published papers on water use in energy production from around the world, providing the wider policy, energy and water communities with trusted, scientific information.

Analysis, results, conclusions and recommendation

When choosing technologies or setting policy, it is vital to distinguish between withdrawal and consumption, and where freshwater is or can be reused or replaced with lower-quality water. The study shows a trend in better water management in the energy industry over the last 40-50 years primarily achieved through improvement son cooling and process efficiencies, through the reuse and recycling of water and through replacing freshwater with water from non-fresh sources.

A large body of water withdrawal, consumption and intensity data have been derived for each energy pathway and process. For example, in fossil fuel extraction, freshwater withdrawals and consumption has reduced as greater volumes of lower-quality water are adopted. For onshore, conventional oil production, the current freshwater consumption is around 0.75 barrels per barrel of oil, or 21 m^3/TJ. Natural gas is the most efficient fossil fuel, with freshwater consumption intensity less than 1m^3/TJ. Similar data are presented for unconventional oil and gas extraction, uranium extraction, biomass crops, oil and biomass refining and electricity power production.

Through the research, it is shown that the potential for managing the implications on water of the world's growing energy demands is significant. Existing technologies already vary by orders of magnitude in there freshwater withdrawal, consumption and intensity: matching the technology to meet the regional conditions will allow freshwater intensity to continue to lower. Effective local governance at national, regional and local levels is, however, a necessity if both energy and water sustainability requirement ere to be met.

The research has shown the importance of collecting and analysing good quality data and helps reveal the challenges that will be faced in achieving long term water and energy sustainability.

The Paradox of Assigning High Water Footprints to Reservoirs in Arid Areas

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Keywords: water footprint, multipurpose reservoirs, hydropower

Introduction and objectives

The IPCC-report on renewable energy (2012) benchmarked the renewable technologies with respect to 'the water needed to produce a certain volume of electricity'. The report revealed potentially very high water consumption rates from hydropower compared to the other renewables due to reservoirs. Later, the methodology has been criticised of being over-simplistic, not taking into account the need of reservoirs to secure the availability of water in dry periods. The objective of our study was to analyse if reservoirs located in arid areas with high water footprints should prevent them from being built, or rather opposite that reservoirs are a pre-requisite.

Methodology approach

In this study we have coupled a large dataset of water consumption estimates from hydropower plants with the calculated values for water-stress, the notable Falkenmark index, Water stress index (WSI), Aridity Index, Global monthly water scarcity (GMWS) and use of the relative evapotranspiration. From a map-based analysis we have identified hydropower plants with high water consumption rates located in areas of water stress. This sub-set of hydropower plants and reservoirs are further analysed with respect to how they affect the availability and use of the water resources in the river basin.

Analysis, results, conclusions and recommendation

Based on our study we find it pertinent to claim that high water consumption rates from reservoirs in water stressed regions should not disqualify reservoirs from being built, but rather the opposite – the fact that reservoirs store water from the wet to the dry seasons (increase the availability in dry seasons) make reservoirs needed, and the water losses is something we must accept in order to increase other and more important benefits of the reservoirs. If so, we would conclude that the water consumption values of reservoirs might be misleading unless the reservoirs' effect on the availability of local water resources is accounted for. Furthermore, from our study we propose recommendations for the design/location and the operation of reservoirs for the purpose of minimising the water consumption rates (losses of water) and maximise the water availability of water.

Water and Energy – A Competition for a Limited Resource

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Keywords: global warming, climate change, thermoelectric water use, scenario approach, water competition

Introduction and objectives

Water and energy are closely linked: cooling water is required for energy production and energy is used for pumping and water resource allocation. Water availability and water temperature play a crucial role in determining whether the cooling potential meets the requirements of the energy sector. Impacts of water scarcity on thermoelectricity production are expected to become more severe in the future as a result of socio-economic development, changing climate and energy demand. The objective of this study is to assess future freshwater needs and supply for thermoelectric plants under global warming and the competition for water as a limited resource.

Methodology approach

Current and future water availability and water uses are simulated with the global water model WaterGAP. Climate forcing data was derived from climate projections of five GCMs under different RCPs, which were prepared for the CMIP-5. In order to illustrate different pathways into the future, scenarios from the Water Futures and Solutions (WFaS) initiative are chosen, i.e. different socio-economic scenarios, including energy-related projections, are used to quantify future freshwater demands by the thermoelectric industry as well as other water-related sectors. Spatial patterns are identified where water availability is likely not to fulfil future requirements of the energy sector.

Analysis, results, conclusions and recommendation

Water availability is projected to increase at high northern latitudes, in eastern Africa and on the Indian peninsula, and to decrease in a number of regions including the Mediterranean and in large parts of North and South America. At 3 degrees of mean global warming, the pattern of change is similar to that at 2 degrees, though the changes are enhanced in many regions, and new robust trends emerge in some regions, most notably a strong negative trend in Mesoamerica. Especially in regions where freshwater resources become scarce and cooling water abstraction increase, the energy sector becomes vulnerable to climate change. Future water availability should be considered with planning new power plants to avoid cooling water shortcomings and economic losses. Rising water uses of other sectors results in an increasing competition for water, which may lead, in the worst case, to conflicts. Many power plants are expected to be located in water stressed regions. Technological improvements, the reduction of thermal energy generation and consumption combined with a shift to renewable electricity production will help to adapt to global warming and will also contribute to climate change mitigation. With these actions the vulnerability of the energy sector to changes in water availability is reduced which again has benefits for the environment, in particular aquatic ecosystems. Considering freshwater resources, trade-offs are to be made between environmental needs and objectives of the energy and other sectors, which can be achieved by cross-sectoral decision making processes.

The Energy Footprint of Water: Energy Requirements of Freshwater Supply and Disposal

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Keywords: national energy accounts, water supply systems, sectoral energy use, water footprint

Introduction and objectives

An effective crosscutting policy for a sustainable water and energy use requires a holistic approach accounting interdependencies and trade-offs. The existing accounts of energy for water supplies are fragmented. In the absence of a comprehensive picture of energy used for the existing water supplies, estimated using a consistent accounting system, it is difficult to make effective water and energy policy. This study draws a global overview of energy needed for water supplies for domestic, industrial and agricultural sectors, and wastewater treatment differentiating groundwater, surface, brackish and salt water sources for 32 countries. representing 2/3 of global water withdrawal during 1993-2002.

Methodology approach

Total energy requirement for water supply is a function of energy efficiency of various processes involved, e.g. desalination or groundwater pumping, and the volume of water supplied to domestic, industrial and agricultural sectors, the amounts of sewage generated and treated. The study makes an inventory of processes needed to supply as well as to dispose the wastewater. The energy needed per process is estimated per sector of water supply using best available energy consumption data from literature. The total energy used for water supplies per country is calculated using energy needed per process per sector of water supply per country

Analysis, results, conclusions and recommendation

This study finds that globally 50 per cent of the total energy requirement for water supply is related to domestic water supply, 25 per cent for agricultural water withdrawal, 10 per cent for sewage treatment followed by industrial water withdrawal (7 per cent), sewage transport (5 per cent) and desalination (1 per cent). There is a considerable variation in the share of different sectors to the total energy used for water supply by country. Desalination is the main contributor in Malta, Saudi Arabia and Cyprus. It is sewage water system in the US, Japan and Ukraine, whereas agricultural is the main contributor in agro-based economies such as India, Pakistan and Libya.

Globally, the energy used for water supply is 2 per cent of the global energy used in the period 1993-2002, though there is a large variation at national level. The comparison shows that in countries with relatively small total energy use, the energy requirements for water is relatively large, such as in Bangladesh (17 per cent), Pakistan (10 per cent), Morocco and India (5 per cent). Though the absolute energy required for water supplies is large in Germany, Russia, the US and the UK, it does not

contribute significantly to the total energy use in these countries. The energy requirements for water supply in the US is 5,300 MJ per capita, considerably higher than that in Bangladesh with 1,400 MJ per capita, the share of energy for water in the US is only 1.5 per cent of its total energy use. Hence, decisions made towards sustainability of water footprint need to be made more closely in the light of energy policy and vice versa.

The study provides a helpful insight to the inter-dependencies of water and energy for the 32 countries analysed. By presenting the energy requirement per water supply processes per sector of water use per country, it is a step forward in the global debate on the water-energy nexus.

Harnessing Water-Energy Nexus for Transboundary Basin Management Cooperation: A Case Study of Meghalaya (India)

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Keywords: nexus approach, trans-boundary cooperation, Meghalaya, South Asia, regional hub

Introduction and objectives

Water-energy nexus for sustainable development has assumed increasing importance since the 2011 Bonn Summit. After the 2012 Rio+20 conference, food has been added to this nexus and it is rechristened as water-energy-food nexus as inevitable for sustainable development. We argue that water-energy nexus approach is gradually finding acceptance in the trans-boundary basin management cooperation at regional level. However, implementation of this approach is facing hurdles like of lack of political will, absence of media and civil society role, lack of connectivity and networking etc. The objective is to enhance transboundary cooperation.

Methodology approach

The analysis is the outcome of three years of research. Our empirical work is based on documents, field research and about 100 interviews. We will first briefly discuss the salience of water-energy nexus over Integrated Water Resource Management (IWRM) for trans-boundary basin management in the Himalayan region of South Asia. Secondly, brief focus will be on the joint initiative undertaken after the 2011 Living Himalayan Summit and the potentials of Meghalaya Basin Development Authority (MBDA) in enhancing transboundary cooperation between India, Bhutan, Bangladesh and Nepal.

Analysis, results, conclusions and recommendation

Our findings demonstrate that institutional mechanism is essential for successful trans-boundary cooperation. We can show that water-energy nexus's overall effectiveness is robustly correlated with the degree of institutionalisation, political will, infrastructure and networking.

Our findings show that the trans-boundary river basin management in the Himalayan region of South Asia is faced with particular challenges pertaining to different national interests, power disparities between riparian states, differences in national institutional capacity, limited information exchange and lack of sufficient basin scale knowledge and institutional capacity to make decisions.

We analyse implementation of nexus approach by Meghalaya, located in the North-East region of India, as part of its Integrated Basin Development and Livelihoods Promotion Programme (IBDLP), which is being implemented in a mission mode through nine missions – Aquaculture Mission, Horticulture Mission, Livestock Mission, Sericulture Mission, Tourism Mission, Forestry and Plantation Crops Mission, Apiculture Mission, Energy Mission and Water Mission. Every mission is designed to leverage the comparative advantage that Meghalaya has in that sector and to generate livelihood opportunities for every household and to accelerate growth.

Trends emerging from different studies suggest that there are shared interests between different sets of stakeholders in the River Basin areas, and these alignments can be fostered and used to build grassroots coalitions around shared objectives. Therefore, we suggest for the establishment of a Regional Water Hub (RHB) in which all countries of South Asia should be represented. This Hub should have close synergy with water related national agencies of each member country of South Asia.

In Pursuit of Integrated Water and Energy Management in the Industrial Sector: The Importance of Coupling Human and Engineered Systems

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Keywords: industrial sector, mining, interdisciplinary, integrated approach, coupling

Introduction and objectives

Integrated and systemic approaches are promoted to improve water and energy management in the industrial sector; however implementation is challenging, requiring coordination between diverse actors with competing priorities. Within an industrial site, coordination is needed between engineers, managers and technicians from different organisational departments. External to site, coordination is needed with surrounding communities, governments and civil society. Inattention to these silos stagnates the implementation of system-wide efficiencies in water, energy and water-energy interactions. Through a practical case study, this presentation will demonstrate how understanding the dual complexities of human and engineered systems can overcome such implementation barriers.

Methodology approach

Insights are drawn from a recent PhD project that investigated how human and engineered systems should be coupled to improve water management in the mining industry. An in-depth case study was the primary means of data collection, and the methodology comprised of issue-driven interdisciplinarity whereby methods were integrated from across disciplines. Data sources included proprietary archival data, observation, an online survey, and interviews. Data analysis included materials balancing and systems modelling (to represent the engineered system), social network analysis (to represent the human system), and empirical tracking of responses to water related problems (to study interactions across systems).

Analysis, results, conclusions and recommendation

We define an integrated approach to water management as one wherein adequate attention is given to issues arising at different levels of complexity (e.g. water monitoring = simple; minimising impacts on groundwater = complex). It was hypothesised that simple problems should be managed using a tactical response, while complex issues should be managed using a strategic one. However, the analysis revealed a "Missing Middle" in connecting tactics and strategy. An understanding of how collaboration was taking place (via a social network analysis) and a systems representation of the water balance provided practical approaches to address this. The results raised important questions for the site to consider including:

1. What are the different types of water issues that are faced? (simple to complex);
2. How should water-related roles and accountabilities be delegated? (tactical to strategic); and
3. What kinds of collaborative mechanisms could assist in managing complex water issues?

Energy management faces analogous coordination challenges to those associated with water, and we therefore contend that the findings from this research may find broader applicability. The presentation reflects on such opportunities – within the mining sector, between mining and other industrial sectors, and with broader stakeholders including government and civil society. It is concluded that the adoption of novel interdisciplinary methods such as those described in this presentation may provide insights for overcoming common pitfalls cross-cutting the energy and water sectors and as explored during this workshop (The University of Queensland).

Trading Securities? A Comparative Study on Regulating Fracking in Europe (Spain) and USA (Texas)

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Keywords: water security, energy security, fracking, trade offs, regulation

Introduction and objectives

The paper will review and analyse the recent "quiet" revolution due to the growth of unconventional oil and gas reserves. The aim of the paper will be to compare the policy and regulatory framework for fracking to assess to what extent increased energy security has been at the expense of water security. Particular emphasis will be put therefore on the water/energy nexus choosing two arid areas in the world where "trading" water and energy securities could be particularly important.

Methodology approach

The paper analyses the regulatory framework in both Europe and the USA, to evaluate the robustness of regulatory frameworks at different levels (national, regional and local) to prevent a reduction on water security in the pursuit of energy security. The specific cases chosen refer to the USA and the European nion, to then zoom into Texas and Spain, two semi-arid regions. In the case of Texas, the pioneer of the industry, with a well-established industry, as compared to Spain, where the first timid steps are being taken in relation to fracking exploration, before the move on to the development stage.

Analysis, results, conclusions and recommendation

Shale oil and gas exploration and exploitation has been heralded as a game changer that has had repercussion across the world in terms of future energy scenarios (with water implications?). The paper outlines the growth of shale oil and gas, and how in the context of increased oil demand, increased oil prices, instability in key oil producing regions, and the move away from nuclear, unconventional oil and gas is seen as the transition fuel to a low carbon future. This "golden future" however has now come head to head with increasing concerns over water as the main limiting factor. The paper outlines how in the case of the USA, federal law has given way to regulation at state level. There is conflicting evidence however on the potential environmental impacts of shale gas, which in relation to water directly impact on water quality and quantity. Paucity of data is discussed and outlined, as well as some potential regulatory problems in relation to water security, like trade secrets over fracking fluids and implications for water quality. Meanwhile in the European Union, although there have been some discussions e.g. in the European Parliament, over specific regulatory instruments for shale oil and gas, it has been largely left to the member states to design their regulatory instruments, within the over-arching frame of EU law. Implications from the EIA Directive, Access to Environmental Information and the EU Water Framework Directive, (and groundwater directive) are outlined for the case fracking. In Spain, as a federal country however, the emerging picture is patchy, with very different paths taken at regional level, from complete forbiddance, like Navarre to the gradual move beyond the exploration to the exploitation phase in the case of the Basque country. Lessons are drawn on how to guarantee water security, while pursuing energy security.

Solar Energy Secures Safe Drinking Water for School in Uganda

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Keywords: solar energy, secures, safe, drinking water, schools

Introduction and objectives

Poor water conditions are one of the biggest challenges in Uganda, like any other developing country with nearby 2 million children dying from water related diseases every year. Kawuku Women's Development Association, a Community Based Organization promotes water harvesting and solar water purification to provide safe drinking water to schools in Uganda. The project has reduced on water related diseases mainly typhoid and diarrhea among the school children due to drinking dirty and contaminated water. If we are to work together to save millions of children from dying of water related illnesses, both water supply and energy must be regularly secured.

Methodology approach

The solar power serves as the water purification system for the project. Usually a regular water and power supply must be secured. In this case Kawuku Women's Group together with school promotes Water harvesting by collecting water from the school building roof to the storage tank and installing a solar panel, battery pack to the supply, and the pressure pump. This way the school is completely self supporting in creating its own safe drinking water supply for the school population and replication by the neighboring schools. The approach is a solution to limits facing water and energy by solar purification.

Analysis, results, conclusions and recommendation

The process is a plug and play installation that includes a storage tank, solar panels, battery packs, pressure pump, pre-filters and of course the water purification system. Water is pumped from the water harvesting storage tank to the water purifier through which it is purified by use of the solar power to the stainless tank and ready to drink by school children. The process is cost effective and efficient for safe drinking water because solar power is a free resource and harvested water is a free gift from God. Using solar power reduces the depletion of the water resources where hydro power is generated For example in Uganda, the once filled river Nile where hydro power is generated is reducing its water level which is due to the enormous climate change and using solar power is a climate change mitigation strategy.

- The project creates a sustainable link between water and energy because with water harvesting and solar water purification. No threat for continued climate change.
- There is increased access to safe drinking water in a total of 47 schools.
- There is reduction in illnesses related to water diseases due to presence of solar water purifiers in schools.
- Reduced costs on expensive firewood and electricity bills.

Given the many connections between energy and water, the choices we make in the near future about how we produce and use energy will determine not only the extent to which we mitigate the worst impacts of climate change, but also how resilient our energy system is to the variability of our water resources and the many competing demands for it. I call upon World Water Week participants to come up and support such an initiative to save the ever increasing death among the children in schools and the entire community.

Mexico's Energy Reform Challenges the Human Right to Water and Health Fulfillment

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Keywords: Mexico, fracking, water, human rights, health

Introduction and objectives

Since the ratification of United Nations acknowledgement to Human Right to Water and Sanitation (HRWS) in 2010, Mexico has acquired that obligation at the international level. Fostered by civil society, the Constitution was amended in February 2012. Thus Mexican government is officially responsible to guarantee water to the entire population in a sufficient, safe, accessible and affordable way. However, a recent Constitutional Reform encourages investments in the exploration of Shale Gas through hydraulic fracture technique (fracking). This paper will analyse risks and threats to draw recommendations towards a more sustainable way to manage Energy and Water without compromising human rights.

Methodology approach

This study is meant to highlight the potential side effects of the Energy Reform. Therefore, the hypothesis is that Gas Shale extraction in Mexico threats health and it challenges HRWS. Consequently, fracking also impacts on another issues related to development and migration. The research driver question is: What are those potential impacts and side effects to the quality of life for mexicans and to development of Mexico if the Energy Reform entitles private foreign corporations and public institutions in the Shale gas extraction? And how unsustainable energies are threatening Human rights in the sake of development.

Analysis, results, conclusions and recommendation

Since 1990s Mexico's economic performance has derived in one of the most severe pollution schemes. Due to the lack of law compliance, more than 70 per cent of its rivers have been polluted with industrial waste. That trend will increase and expand to groundwater with the Energy Reform that encourages foreign corporations to invest in fracking, claiming that Mexican Petroleum(PEMEX) lacks of investment resources. Fracking intensively uses millions of freshwater litters to drill shale gas wells (9-29 million ltrs/well). It is expected to drill 30,000 wells in Northern Mexico, where hydric stress is already declared. It's inevitable to foresee fracking will decrease water availability challenging the fulfillment of HRWS. Furthermore, while the Mexican Congress approved the Energy Reform (December 11, 2013) arguing that Mexico only had 3 fracking wells compared to the 9,100 wells in 2012 in the USA, the Dallas City Council passed one of the most restrictive gas drilling initiatives for the protection of their population. Moreover, the Pennsylvania Department of Environmental Protection (DEP) notes that while companies keep their fracking "formulas" secret, the individual ingredients are public. DEP discovered at least 54 chemicals in the fluid with impacts on health; since 34 of them are soluble, surface/underground water may be polluted. Some of the potential health risks are cardiovascular, respiratory, neurological, reproductive disruption, cancer, etc. By threatening water safeness, fracking harms HRWS too. These are some reasons why this technique is banned or declared "in moratorium" in at least 15 countries. The Energy Reform not just ignores international commitments to reduce GHG emissions but it's also missing any other transition strategy towards clean and sustainable energy resources in the future. Instead, Mexico should encourage sustainable energy alternatives. Ministries on Environment and Energy should work together to elaborate a real sustainable strategy with cleaner energies without challenging Human Rights fulfillment.

Renewable Energy for Rural Economic Development Project Breaks the Water Silos. A Successful Experience from Sri Lanka

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Keywords: coordination, partnership, energy prices, integrated, gravity irrigation

Introduction and objectives

Sri Lanka is aggressively developing its water and energy sectors to satisfy basic human needs, produce food and achieve economic growth avoiding mutual limitations they faced. Their security was a crucial target to develop public policies and technological innovations. About 92 per cent country population has access to safe drinking water and sanitation, 89 per cent households have provided electricity. Yet the system does not offer the resources needed to raise their livelihoods and emerge from poverty. The RERED project explained how coherence can be achieved in practice through cooperation and sharing mutually beneficial responses, because they are inherently inter-linked and inter-dependent processes.

Methodology approach

The methodology was the inter-sector collaboration at ministerial level working together with close cooperation, partnerships and good governance based on comprehensive policies, and gender balanced involvement of all stakeholders, to solve mutually interlinked problems to facilitate their sustainable management. It examines the basic concepts of RERED World Bank funded project, initiated by the Ministry of Finance and the University of Colombo and NDB, implemented in eight Districts and 32 local governance structure-Provincial Development Councils. It broadly address synergies across sectors, water, energy and food security, sustainable livelihoods and local resilience to climatic changes, adopting participatory development approach.

Analysis, results, conclusions and recommendation

The paper analysed the multi-leveled complexity and the growing challenge of water and energy demand. Training, information gathering and scheduling they prepared Water and Energy Master Plans for every Water and Energy Association. They initiated the New National Energy Policy 2010, identifying energy security as a strategic objective to accelerate the rural economic development and improve the quality of life by providing access to water and electricity. Provided financial support for mini hydro power and water supply projects with low cost funding, targeting of safe water and energy coverage of 100 per cent by year 2020. The increasing demand for water in the line ministries and facing negative impact of climate change, they activate uniquely in their own silos Project developed sound decisions, breaking the silos to reach out of the water community and involve with other sectors, through coordination and demand management system. Since 2010, UC and NDB have signed 137 MOUs at central level with WEA and Private Partnerships. They commissioned 119 mini hydro power, 4 Biomass, 6 solar, 3 wind power. 34 Drinking water and irrigation projects. Project provides incentives for growing crops for fuel rather than food, sugarcane, and cassava energy efficient crops introduced. Gravity irrigation promoted for paddy cultivation ensuring green economy instead of ground water, because energy production carries a heavy water bill. Higher energy prices increase the cost of agricultural inputs (water) consequently

customer had to pay higher prices for food. Project answered this kind of entwined predicaments through stakeholder participation and training. They diagnose conflicts between different water users, irrigation, food production-environmental, the project answers this through an integrated holistic approach with coordination and demand management system and proposes that close cooperation by breaking silos and working partnership are absolutely fundamental if we are to sustainably manage water and energy in the future.

Knowledge Sharing, the Basis of Reciprocal Dialogue and Coherent Practice: The Experience of CAFOD and Newcastle University with Farmers in Lake Paron

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Keywords: information, knowledge sharing, accountability, policy bridges

Introduction and objectives

Because communities affected by large scale water/energy projects lack information or cannot express themselves in a language that is internationally understood, their claims are often disregarded by companies and governments. Consequently, conflicts increase, communities wither, and the environment deteriorates. CAFOD and the University of Newcastle (UK) support small farmers near glacial Lake Paron (Huaraz National Park, Peru), to understand water pollution, flow and monitoring issues, so that they can represent their interests more effectively in a multi-stakeholder dialogue with Duke Energy (who owns the lake's flow gates), other water users and authorities. The project encourages participatory and responsible water management.

Methodology approach

The paper will discuss how CAFOD, its local partner CEAS and Newcastle University have worked with local stakeholders in the Peruvian Andes to identify information and training needs, and evaluate key documents necessary to support community claims and negotiations regarding contaminating activities. The paper will present how the collaboration between an academic institution and an INGO can propitiate knowledge sharing and appropriation, as well as foster accountability. The process heightened field visits to share expert technical opinion and regular communications with partners, as well as the presentation by Newcastle University of their impartial opinion to national/international stakeholders.

Analysis, results, conclusions and recommendation

Glacial Lake Paron provides drinking and irrigation water to approximately 5,000 small famers, 20,000 dwellers of Caraz city, and contributes to the generation of 263MW of electricity at the Huallanca power plant owned by Duke Energy. Until 2008, Duke Energy controlled the lake's gates in function of the flow needed for the optimal operation of the power plant, without regard for the small farmers who saw regular flooding of their land, cattle and crops, as well as severe irrigation water shortages at other times. In 2008, in a peaceful action, indigenous communities banned Duke Energy from the lake. Since then, the company has not been able to access the lake´s flow gates and the conflict has festered.

CAFOD, CEAS and Newcastle University are drawing on their experience in Andean Peru regarding water resource management in catchments with mining, to support local leaders in building their capacity to better participate in a multi-stakeholder group that involves national and local water authorities, Duke Energy and the municipal government. The group is responsible for the joint management of the gates at Lake Paron and for all decisions regarding the lake's water level.

Communities and municipal actors are gaining knowledge about the information they have the right to demand from Duke Energy and other companies operating in their territories, including the plans for a new gold-mine in the catchment; they are increasing their capacity to evaluate technical information and strengthening their understanding of the real issues at stake. Their capacity to negotiate and demand solutions to real problems is growing. The impartial technical opinion produced by the project ensures that companies take the demands from the communities more seriously. The project promotes dialogue, reciprocal encounters and shared learning. CAFOD and Newcastle University hope to replicate this model, linking scientific support with local community needs.

Water Consumption of China's Shale Gas Development

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Keywords: shale gas, fracking, water consumption, water pollution, China

Introduction and objectives

The success of US shale gas reduced the carbon emission and caused the energy independence. To imitate US success, China made an ambitious plan of shale gas extraction, 6.5 billion m^3 by 2015. The conversion from coal to gas will reduce China's carbon dioxide emission, atmospheric particular matter (PM2.5) pollution and respiratory illness. However, the shale gas extraction process using hydraulic fracturing (fracking) can bring risks to the water environment. This study analysed the potential water consumption and wastewater generation in China's shale gas development.

Methodology approach

Well reports was analysed for the direct water consumption at the gas well. Economic Input–Output Life Cycle Assessment method was used to estimate the water consumption for supply chain production at each life cycle stage of the well. Tool for the Reduction and Assessment of Chemical and other environmental Impacts was applied to assess the life cycle direct and indirect water pollution.

Analysis, results, conclusions and recommendation

10,000-24,000 m^3 water with additives, including heavy mental, acids and pesticides, is injected to each gas well to extract the shale gas. 10-90 per cent of the used water is returned to the surface, but the inadequate treatment of the flowback water brings toxic matter to the water and land ecosystem. Compared to coal, shale gas is a lower carbon energy. However, it is important to recognise the water consuming and environmental pollution during the gas exploitation. Strict monitoring and good coordination during the shale gas exploitation is urgently needed for the sustainable development of human society and natural ecosystem.

Workshop: Water, Energy, Food and Ecosystems Security

Water Allocation between Agriculture and Energy: Economic vs Social Values

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Keywords: water right, Irrigation, hydro-power, competing demand, socio-cultural

Introduction and objectives

Samanalwewa reservoir was constructed for hydro-power generation across the upper reach of the Walawe river, which has altered the river flow and water availability of downstream subsistence farmers in the traditional irrigation scheme (Kalthota Irrigation Scheme-KIS). The farmers enjoyed unrestricted access to water until the impoundment of the reservoir. However, farmers had the prior appropriation water right that has prevented full utilization of the installed hydro-power capacity, especially during the dry seasons.

The objective of this paper is to discuss the importance of balancing the economic and social consequences of water allocation among different water-use sectors and draw lessons for future policy formulation.

Methodology approach

Data was obtained through a questionnaire survey conducted in KIS. The data collection process followed three interrelated steps. First, available literature on the process and methodology adopted to establish current water allocation mechanisms was reviewed. Second, the key issues identified in the past experience of water allocation were listed and a checklist was prepared for focus group discussions and key informant interviews. In the third step, the information obtained from the first and the second steps was used to develop specific research questions with special focus on the consequences of current water allocation arrangements in the study location.

Analysis, results, conclusions and recommendation

The Samanalawewa dam never achieved the planned target in power generation due to competing water demand. The power authorities made various efforts to reduce the irrigation requirement through conducting awareness programmes and introducing various water management techniques, but without much success.

Based on the prices of 2007, the value of one cubic meter of water used for power generation was 2.77 times higher than the return earned for one cubic meter of water pumped to rice cultivation. Later the power authorities reached a consensus to introduce a compensation scheme for farmers' water right of dry seasons equal to the income earned from paddy cultivation as a win-win solution for the both water-use sectors. The power authority used the water meant to be released for agriculture, for much needed electricity generation in the dry season. However, the compensation scheme failed after a couple of seasons, as the farmers rejected the compensation for their water right. Therefore, the power authority had to be satisfied with the remaining water for electricity generation after the release of irrigation issues as usual.

Experience gained through compensation payment for the farmers in lieu of their irrigation rights in the KIS is a clear example to show the influence of social and cultural values in a peasant society which surpass the realised economic gains. Therefore, any economic model should incorporate the social cultural and environmental aspects in water resources planning in addition to the expected economic gains to obtain the sustainable outcome. The case study is a clear example to show the importance of basin level integrated water resource management planning considering all different users. Lack of integrated and multi-objective planning of available water resource seriously affects the fair and equitable access to water for different users and leads to conflicts and other side-effects in the allocation of water.

Remote Sensing and Watershed Modeling in Support of Transboundary Water Cooperation and Environmental Security in Central Asia: Lake Balkhash

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Keywords: Central Asia, ecosystem security, transboundary watersheds, remote sensing and modeling

Introduction and objectives

The second largest lake in Central Asia - Balkhash is unique endorheic lake with saline eastern and freshwater western part. Ili – Balkhash basin is situated in southeastern Kazakhstan and northwestern China and that fact raises transboundary water management issues in the region. The recent full-scale development of the Xinjiang-Uighur Autonomous Region and expansion of water use for energy and agriculture is hampering the flow of Ili River into Balkhash and heavily polluting it.The project based on water balance model of the lake that is developed and proposed as a visual tool for policy makers to achieve transnational cooperation.

Methodology approach

The project consists of collection, processing, and analysis of remotely sensed data and its usage for the lake water balance model development. Landsat imagery since 1984 is used for detection of land use patterns, pollution sources and assessing water quality. The results are used as input data for Ili-Balkhash basin modeling. The ArcGIS extension for The Soil and Water Assessment tool (SWAT) ArcSWAT is used to develop and run the model. Five scenarios of potential regional development have been formulated and analysed. Climate Change scenarios based on the IPCC report were encoupled by economical development plans of China and Kazakhstan.

Analysis, results, conclusions and recommendation

The ecosystem of Balkhash Lake deteriorates due to increase of water diversion from Ili River to agricultural fields and water pollution from developing industry in the Xinjiang-Uighur Autonomous Region. It was found that the water inflow into the reservoir can significantly decrease in the future threatening sustainable water supply and numerous water-dependent activities in the region.

The study suggests increasing transboundary cooperation on Water and Energy Nexus, reducing water uptake and restoring the inflow of water as a way to preserve the lake's ecosystem. Using remotely sensed data and watershed modeling can help in achieving agreements between Kazakhstan and China and maintaining regional environmental security. The model is developed and proposed as a decision-making visual tool for policy makers to support transnational cooperation based on mutual aim to achieve Millennium Development Goals by 2015.

The project on studying the Ili-Balkhash basin ecosystem and contributing to the regional environmental security has been launched at the Central European University in cooperation with Nazarbayev University Research and Innovation System. This initiative contributes to the ISEPEI Project carried by CEU under auspices of UNEP and Eye on Earth Summit.

Participation and Inclusion is Important for Achieving Environmental Flows in the Indus River

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Keywords: Indus River, environmental flows, participation, inclusion

Introduction and objectives

The Indus is one of the world's greatest, but most troubled, rivers. It drives Pakistan's economy, but there is increasing pressure on the river just to meet basic food needs, and to drive expansion of hydropower to overcome an unreliable power supply that relies heavily on imported fuel. A 1991 Accord apportioned water between the provinces, and recognised the need for environmental flow studies. These were done in 2005, but they were exclusive and non-participatory. Our objectives were to reduce uncertainty and resistance in the environmental flow implementation process by building upon existing research while engaging stakeholders.

Methodology approach

The main problem with environmental flows implementation in the Indus River is disagreement about the validity of the calculations and recommendations made by technical experts, and general mistrust among stakeholders due to ineffective engagement throughout the assessment process. We addressed technical issues through an independent scientific review. The problem of mistrust we tackled through a stakeholder engagement process, undertaken by an independent group. This involved a dedicated team undertaking face to face meetings with as many interested stakeholders as possible; this included representatives of the Ministry of Water and Power, Indus River System Authority, among others.

Analysis, results, conclusions and recommendation

We found that the existing environmental flow calculations and recommendations had some credibility issues, but the main problem with implementation was that many interested parties felt disengaged from the technical process. We found a high level of expertise among the technical specialists we met. Technical knowledge and ability does not appear to be a major limitation, but its communication and understanding among stakeholders could be improved. Our technical review found that the issues of sediment transport to the delta, saline intrusion in the estuary and the role and resilience of mangroves required more consideration. Significantly, our technical work was hampered by poor access to data, and inconsistent or low quality hydrological data.

There are many debatable scientific issues surrounding what are acceptable environmental flows for the Indus River. The objectives have yet to be universally recognised or prioritised. The main current flow recommendation is for a minimum flow downstream of Kotri Barrage that was driven by the objective of controlling the position of the salt wedge in the estuary. The attractiveness of this recommendation is its simplicity, but we found that most people accept that flow variability is a natural and desirable characteristic of rivers, and should be built into flow recommendations. We found that greater

understanding of the importance of environmental flows to the community was achievable through the use of conceptual models that linked ecological health with human benefits from use of the river.

Pakistan has a centralised and technocratic system of governance that does not naturally encourage participatory policy development. We cannot claim that our work solved the problem of environmental flows in the Indus River, but we did identify the main blockages to decision-making and we raised awareness among decision makers of the importance of environmental flows to achievement of social and economic development goals.

Water-, Carbon- and Land Use Footprint of Bioenergy Production in Mexico

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Keywords: water footprint, bioenergy, food security, rainfed agriculture

Introduction and objectives

Pressure on water and land resources in Mexico is increasing due to population growth and changing consumption patterns. This implies for bioenergy production that it needs to be designed in a way it does not compromise food security neither aggravate water scarcity. Water-, land- and carbon footprints are an instrument increasingly used by political decision makers and industry to guide decisions. This study aims to answer: How can bioenergy be produced to minimise pressure on water and land resources and reduce GHG emissions? And are proposed water footprint methodologies suitable to promote a change to a more sustainable water use?

Methodology approach

We used a life cycle assessment approach to analyze the impacts of six maize-bioethanol production systems in Mexico on water resources, land use and greenhouse gas emissions (water-, carbon- and land use footprint). We focused on the agricultural step since this is the most water- and land intensive part of the production. Three irrigated high-input maize systems and three rainfed low-yield systems were analysed and subsequently scenarios with improved agricultural managements were built (rainwater harvest, soil fertility measures). Inventory data was acquired by soil sampling and interviews with farmers. Field water balances were modeled using the FAO AquaCrop Model.

Analysis, results, conclusions and recommendation

In the status quo scenarios the trade-off between water use and land use is high: For the irrigated systems 0.3 ha are needed to produce one ton of ethanol but the blue water footprint in the heavily overused aquifer is large. In the rainfed systems the blue water footprint is zero but the land use is six times higher.

Results of the scenario simulations showed that by an upgrade of the rainfed systems through rainwater harvest and improved soil fertility management the land use footprint could be improved by a factor of 5 and the carbon footprint decreased from 85gCO_2/MJ to 55gCO_2/MJ. Rainwater productivity (=the amount of rain productively used by the plants) increased from 10 per cent to 28 per cent. This shift comes from non-productive soil evaporation to productive plant transpiration. This is especially interesting because no negative consequences arise on the water availability for downstream users.

Rainfed maize is cultivated in Mexico on 6.1 mio ha with an average yield of 1.9T/ha, 32 per cent of this area are managed without synthetic fertiliser input – comparable to the rainfed cases of this study. By an upgrade of this rainfed agriculture around 3 mio T of ethanol could be produced. This is around 9 per cent of the Mexican gasoline consumption. Interesting is that this could be produced without indirect effects on food security since the bioenergy would be produced from additional biomass.

We conclude that in the Mexican context improving rainwater productivity is a massive optimisation potential. However, rainwater productivity is currently a blind spot in water footprint methodologies. There is a need for further development of the water footprint methodologies to make them suitable to promote changes to a more sustainable water use that allows to meet the worlds future water demands.

Impacts of Large-Scale Investments in Agriculture to Water Resources, Ecosystems and Livelihoods, and Development of Policy Options

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Keywords: ecosystem, foreign direct investment, policy, land, water-grabbing

Introduction and objectives

As water availability is a strong driver for the acquisition of agricultural land, the implementation of foreign direct investments in land has also been described as "water grabbing" with severe impact to water and related ecosystems, creating water scarcity and impoverishing local population. The objective is to better understand the impacts of large-scale investments in agriculture to water resources, ecosystems and livelihoods, and to develop policy options for decision-makers for leasing agricultural land without compromising ecosystem services and ensuring equitable benefits including to the affected communities.

Methodology approach

As a significant share of a country's water resources may be used in these land deals, some policy options on land and water acquisition by large-scale investors would ensure that such investments promote food and water security without compromising local and downstream water availability and quality. Legal, political, socio-economic and environmental dimensions of large-scale land deals need to be further investigated to help decision-makers implement beneficial measures and formulate policies and programmes that ensure a wider distribution of such benefits.

Analysis, results, conclusions and recommendation

The presentation will showcase :

- the current extent and types of agricultural land leases (e.g. identification of the investors, the target countries, the surface area, the types of agricultural activities, etc.)
- the drivers of such foreign direct investment (FDI) schemes and the motives for the investment
- the pressures for and opportunities presented by implementing such FDI schemes
- a classification and qualitative assessment of the environmental and socio-economic impacts, with a focus on water, ecosystem services and livelihoods
- an analysis of the current policy and institutional frameworks to manage the FDI schemes and their impacts in 6 countries – (e.g. Ghana & Mali (West Africa); Ethiopia & Tanzania (East Africa); Mozambique & Zambia (Southern Africa) - (in terms of water allocation, protecting ecosystems, dealing with the local population, and monitoring of compliance with provision of agreements and the policy frameworks) and the identification of gaps.
- a simulation model of the environmental impacts on water resources and ecosystems services as well as the social effects on livelihoods on one specific River Basin (to be chosen), that could be used a decision-support tool.
- outcomes from the technical workshop and the policy dialogue to be held with the policy-makes in Africa in Spring 2014.

From Land Reform to Pump Energisation: A Shift in Agricultural Drivers in West Bengal

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Keywords: energy-irrigation nexus, groundwater, agricultural productivity, land-reform, West Bengal

Introduction and objectives

West Bengal is one of the few Indian states which implemented land reforms, called "Operation Barga" in 1978. The spectacular agricultural growth witnessed in the 1980's and early 1990's is attributed by many in the literature to Operation Barga. Nevertheless, it has not been the sole driver of this growth. Indeed in West Bengal, pump electrification rate for groundwater irrigation follows a very similar trajectory as the agricultural growth rate. Our purpose is to estimate the extent to which pump electrification has contributed towards West Bengal's agricultural growth, by providing farmers a cost effective way (compared to diesel) to access groundwater.

Methodology approach

Based on secondary data from government sources we built a 14 years panel database for 15 districts of West Bengal. Therefore, our approach uses inter-district and yearly variations in the pump electrification rate to measure its effect on agricultural productivity. Our main empirical results are based on regression analysis at the district level. The impact of pump electrification rate is estimated on rice (Aman and Boro) yields and areas, controlling for other timevarying variables including input use, rainfall, road-access, and land-reform. We also examine the trends in groundwater level to understand the sustainability of pump energisation and agricultural growth.

Analysis, results, conclusions and recommendation

The results indicate the positive and significant effect of pump electrification on agricultural output and areas over the period from 1994-2007. By this time, Operation Barga had reached a peak and the intensity of land reform in the State was stagnant. Indeed, pump energisation took over land reform as a driver of agricultural growth.

We note that the effect of pump energisation is more pronounced for boro cultivation which is a water intensive crop cultivated in the dry season and thus requiring intensive irrigation. This result argues that pump electrification (with an advantageous flat tariff rate before 2007) improved the physical and economical access to the water market, which in turn made boro cultivation viable for a lot of farmers. In a context where in West Bengal, most farmers are small and do subsistence farming, increased boro production goes a long way in ensuring food security for millions of poor farmers.

These results are of particular interest in view of the recent changes in West Bengal's policy of groundwater use. First in 2007, the tariff structure of agricultural electric connections has been changed from a flat to a metered tariff. Then starting in 2011, getting electric connection for irrigation purposes had been made easier through the removal of administrative permit requirement in areas with sustainable water tables and through a subsidy for the investment cost. These policies are in parallel accompanied by a new boost in the number of pumps electrified since 2007. Recognising the role of pump electrification in the agricultural growth history of West Bengal therefore helps us to understand the potential impact of these new policies.

Policies and Institutions for Achieving the Virtuous Nexus of Food Security, Energy and Water in Sub-Saharan Africa: The Case of Malawi and Mozambique

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Keywords: fuel efficient cookstoves, irrigation, subsidies local entrepreneurs

Introduction and objectives

Food security, energy and water policies and investments in sub-Saharan Africa (SSA) have been implemented separately. Even more seriously, SSA investment in irrigation and biomass energy used by the rural poor has remained limited. For example, only few countries – particularly Malawi – have invested in fuel efficient cookstoves (FECS), which cut woodfuel energy needs by up to 70 per cent and reduce significantly indoor air pollution. But production and marketing FECS have not yet attracted private investment. Our study explores how policies and strategies that stimulate virtuous nexus of food security, energy and irrigation can be achieved.

Methodology approach

We review literature on policies and strategies on food security, energy and irrigation water (FEW) that SSA countries have implemented. The review particularly investigates how the FEW policies are linked to exploit their synergies. We then use secondary data from Malawi and Mozambique to assess rural population uptake of main FEW practices promoted in the country policies. To determine the appropriate policies and strategies for achieving virtuous FEW nexus, we investigate the drivers of adoption of cooking energy sources, irrigation, fertiliser, and organic inputs using nonlinear bivariate models. We also use descriptive statistics to support the econometric results.

Analysis, results, conclusions and recommendation

Food security in Sub-Saharan Africa (SSA) remain the most pressing challenge despite significant government and donor support in the past 50 years. Food security has especially been severely affected by inter-annual and intra-annual precipitation variability since SSA agriculture is largely rainfed and investment in irrigation in the region is limited despite SSA's large hydrological endowment in many areas with high population density. Likewise, SSA investment in energy used by the rural poor has remained low. Approximately 3 billion people – more than a third of the world's population – cook their food and warm themselves on open fire cookstoves fueled by solid energy. The fuel-inefficient cookstoves result in indoor pollution, which is a cause of 1.6 billion deaths annually. SSA alone accounts 54 per cent of woodfuel consumption in the world and 90 per cent of wood harvested in SSA is used as woodfuel. Of the few SSA countries which have invested in development and dissemination of fuel efficient cookstoves, SSA government investments accounted for only 10 per cent of such investment and the remain share was contributed by NGOs and other foreign donors.

Using household level data from Malawi and Mozambique data, this study shows that access to market and household participation in the market greatly enhances adoption of irrigation, fertiliser and fuel efficient cookstoves (FECS). Additionally, access to extension services, education, access to credit, higher income enhance uptake of FECS and irrigation. The results suggest the need to increase and diversify government investment that will create synergies for uptake of FEW practices that will not only enhance food security but also health and other social welfare. For example, Malawi uses more than 60 per cent of its agricultural budget on fertiliser subsidy and this leaves limited amount of resources for investement in other rural services that enhance adoption of irrigation & FECS.

The Mekong Basin: Trade-Offs between Energy, Food and Water

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Keywords: hydropower, river, fish, protein, nexus

Introduction and objectives

Hydropower development in the Mekong River basin in SE Asia will reduce the wild catch of fish. Extending our research published in 2012, we model the food security options for replacing lost protein and lysine through imports or aquaculture, crop and livestock production in Cambodia, Laos, Thailand and Vietnam. Each of the alternative options has implications for land and water use, food security, and greenhouse gas emissions. Our objective is to provide data that enables the national governments and multi-lateral agencies to take more informed decisions that trade-off hydropower against other ecosystem services.

Methodology approach

We expand on our earlier research (Orr *et al.,* 2012. Dams on the Mekong River: Lost fish protein and the implications for land and water resources. Global Environmental Change, 22(4):932) by applying more accurate data and modelling four (rather than one) scenarios. Data from the Mekong Strategic Environmental Assessment, UN FAO and fish nutrition data from Vietnam is used to project the land and water use implications of suppling lost wild fish food through imports, aquaculture, crops and livestock. We focus on limited options for replacing proteins in general and lysine in particular, an amino acid essential for brain development.

Analysis, results, conclusions and recommendation

We find that it is physically possible to replace the lost wild fish food but each alternative (aquaculture, crops, imports, livestock) has high opportunity costs (or impacts) in land and water in the Mekong region or globally. Our earlier research underestimated the resources required to replace protein. Considering lysine, replacement foods have an even larger footprint again.

Thailand and Vietnam are already shown to be importing foods with a large global footprint. Cambodia and Laos are identified as the countries where there would be the greatest changes. Under some scenarios, rice exports (for example, to East Asia) from the Mekong region could decline.

The projections raise questions of equity, in terms of access to land and food. Even if alternative foods may be physically supplied it is questionable whether poor people can afford the alternative sources.

The research questions whether governments in the region have adequately integrated their energy, food land and water policies. Government in the region are making value judgements about the desirability of hydropower versus other essential ecosystem services. We challenge governments of the region to articulate credible food security, land and water management policies to match their hydropower development plans.

Size Isn't Everything, It's what You do with It That Counts: The Malawi Water Resources Investment Strategy

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Keywords: water resources, energy, water supply, irrigation, investment planning

Introduction and objectives

The Water Resources Investment Strategy aims to assist Malawi in delivering sustainable water resources management. In order to achieve both economic and social development targets and towards making investments that meet a range of water needs for productive purposes in agriculture, industrial/commercial, energy and water supply. The specific objectives are to:

- Analyse the country's economic development objectives and assessing how water resources affect the country's achievements in economic growth and poverty reduction
- Identify key water-related challenges for the country's economic
- Set-up priorities for water sector interventions in time and geographically
- Identify priority water resources sector investments

Methodology approach

Assessments were at water resource area (WRA) scale. The work considers the supply-demand balance for water and highlights the catchment constraints identified through water quality and catchment condition assessments.

National and regional, energy, irrigation and water supply sector policies and plans are mapped against water availability to highlight areas of conflict. An economic analysis of key water-reliant sectors was undertaken to understand the costs and benefits of different potential investments. A hydro-economic model of the Lake Malawi-Shire River system was developed to investigate the impact of up-stream water resource development on down-stream hydropower development and irrigation.

Analysis, results, conclusions and recommendation

The water resource assessments highlighted:

- Surface water makes up the large majority (98 per cent) of nationally available water resource. This availability is highly seasonal, and is projected to become even more seasonal in a changing climate.
- Water demand projections to 2035, at WRA and sectoral level, suggest that the use of water for irrigation dominates water demand.
- Most WRAs have sufficient water available in the average dry season to meet demand under 'low' demand scenarios. As demand increases, many WRAs show deficits in the dry season, suggesting that storage, lake water use and/or transfers may be required.
- Water quality and catchment condition assessments have stressed current and/or potential future issues with sediment ingress, invasive weeds and water quality.
- The water resource investment strategy made the following policy recommendations based on the following conclusions of hydro-economic assessments:
- Public water supply should take priority where water is scarce.

- Preference should be given to arrangements where irrigation abstraction takes place downstream of hydropower production. Hydropower should take priority where there is conflict between these uses, unless the irrigation is expected to produce high economic benefits.
- Construction of inter-seasonal storage should be considered for non-Shire hydropower schemes due to the highly seasonal flows and costs of alternative power supplies.
- Maintaining inflows to the Lake Malawi-Shire system should be a top priority. This will involve limiting consumptive water use upstream of Lake Malawi to essential, water efficient and high benefit uses. It will also require cooperation with Tanzania and Mozambique, both important sources of inflow to the system.
- Significant inter-seasonal storage, backed up by conjunctive use of groundwater where appropriate, is likely to be required to meet non-irrigation (principally public water supply) demand in many WRAs. The need for storage is likely to increase with climate change.

Corporate Water Stewardship: Achieving a Sustainable Balance

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Keywords: water, sustainability, neutrality, strategy, risk, stewardship, human right to water and sanitation, water stewardship certification

Introduction and objectives

Globally, corporations and industry are seeking to secure access to sufficient quantities of water to meet current/future needs in a socially, economically and environmentally responsible way in the midst of an unfolding global water crisis with risks that transcend communities, industry and the environment. Through a business case centered on sustainability performance, risk management and productivity and through implementation of a strategic framework based on a water mass balance at the enterprise level, industry can take actions that support restoration of a sustainable water balance at the community and watershed levels while also generating business value for that particular enterprise.

Methodology approach

The volume of consumptive water use is used to establish the target water volume that an enterprise would balance by implementing community water partnerships (CWP) that provide water access and sanitation, watershed restoration and protection, and water for productive use benefits. Quantification of CWP project benefits is achieved either through metering or standard methods known and accepted by the engineering, conservation, and social science professions. A 100 per cent sustainable balance is achieved when an enterprise implements a portfolio of locally relevant CWPs that produce an annual volumetric benefit equivalent to the annual volume of consumptive water use for that particular enterprise.

Analysis, results, conclusions and recommendation

This approach can also support efforts by industries that seek to operate in a manner consistent with the United Nations resolution regarding the human right to water and sanitation, as well as those that may seek certification under emerging global water stewardship standards.

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Potential for Off-Grid Community Micro-Hydro Schemes to Deliver for Energy, Water and Food Security: Lessons from 25 Years of Practical Experience

Author: Dr. Lucy Stevens, Practical Action, UK

Keywords: micro-hydro, systemic, energy, agriculture, resilience

Introduction and objectives

This paper explores the potential for community-level decentralised energy systems (micro-hydro) to improve energy, water and food security. Practical Action is extremely well placed to understand the practical realities of these systems. As an international development organisation focused on technology for poverty reduction, we have implemented decentralised energy systems in rural areas for over 25 years, and have led policy debates on energy access for the poor. We bring this together with expertise in resilient agriculture and market systems, to show how it is possible to maximise the benefits from micro-hydro schemes to increase incomes and improve resilience.

Methodology approach

In this paper, we draw on our long-standing and internationally-recognised field experience. We first present looking-back studies from Asia (Nepal) and Latin America (Peru) to highlight lessons for long-term sustainability. Secondly, we examine more recent case studies from Africa (Zimbabwe and Malawi) to consider water-energy-livelihood connections more closely. We apply systemic thinking from our Vulnerability to Resilience, and Total Energy Access frameworks. We compare the outcomes of micro-hydro schemes which have included an irrigation component with those which have not in terms of the impacts on livelihoods, environmental impacts and resilience.

Analysis, results, conclusions and recommendation

The looking-back studies in Peru and Nepal assessed the impact and sustainability of a number of micro-hydro schemes. Most were still operating 5-10 years after commissioning, but not always as efficiently as originally envisaged. Positive impacts included money-savings on energy, better community services (schools and clinics) and growing enterprises. However, the energy services were generally not well linked with the main agricultural livelihoods. The Nepal systems suffered from poorer management systems than those in Peru, which added to their failure to maximise their potential.

In our comparison of more recent scheme in Africa, we outline the reasons behind why they did or did not include an irrigation component. We consider the pros and cons of each model in terms of impacts on livelihoods, the environment and resilience (long-term water, food and energy security).

From a project design perspective, our recommendations recognise the growing drive for private sector engagement, and the search for 'viable' business models for decentralised energy. This often requires a base-load customer and closer links to agricultural livelihoods. Our experience suggests that adopting a participatory market systems development approach provides the greatest potential for ensuring benefits flow to small-holder farmers.

From a policy perspective, we are saddened by 'business as usual' approaches which fail to give adequate attention to decentralised energy options. This is despite the IEA's estimates that 55 per cent of new generation capacity needs to be in off-grid or mini-grid solutions. We continue to press for 'total energy access' defined as when households, enterprises and community services have sufficient access to the full range of energy supplies and services that are required to support human, social and economic development.

Application of Water Prism, a Decision Support System for Examining Strategies to Address Water, Energy, Food and Ecosystem Security Challenges

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Keywords: decision support, water prism, scenario analysis, conservation strategies

Introduction and objectives

Energy and food production, and ecosystem protection depend on freshwater supply. Under future scenarios of population growth and climate variability, many localities and regions throughout the world may find their economic growth and vitality constrained by available freshwater. The implementation of strategies to reduce freshwater use may help accommodate future energy and food demands and ensure ecological requirements are met. Under sponsorship from the Electric Power Research Institute (EPRI), a watershed-scale decision support system, Water Prism, was developed to support the evaluation and design of sustainable water use strategies in watersheds/catchments and basins.

Methodology approach

Water Prism is highly visual, yet computationally robust. The tool provides a watershed-scale assessment of water demands (withdrawals and consumption) from various water use sectors in the context of available supply, and includes an evaluation of both surface water and groundwater systems. Water Prism interfaces with an underlying hydrologic model to establish the available water reference conditions (natural streamflow without influence of withdrawals or discharges). Water availability and demands are projected for a 50 year planning horizon for all points within a watershed. Demands are characterised by individual sector (electric power, municipal, industrial, and agricultural).

Analysis, results, conclusions and recommendation

Water balance results are visualised as a 'prism' graphic with each sector's demand as a discrete color band within a spectrum as referenced against 'dry' and 'wet' available water conditions. After assessing the level of risk under "business as usual" (BAU) conditions, a suite of potential water management strategies can be constructed and evaluated within Water Prism. Scenarios can explore the benefits of water saving strategies such as nonpotable or in-plant reuse for industry, alternative cooling of power plants, low water crops and water efficient irrigation for agriculture, and reuse and improved water efficiency for municipal use. The tool also accounts for ecological demands and management objectives for reservoirs. Water Prism computes the aggregated benefits of community water sharing strategies as both reduced demand and net savings. Review of predicted outcomes of these strategies may bring to light surprising observations, confirm a relative range of expected benefits in terms of reduced water shortage risk, or simply provide an opportunity to educate watershed decision makers on the overall water balance of the system and demands from various water use sectors. The design of the tool promotes collaborative scenario development and evaluation of results. Water Prism has been successfully applied to several United States watersheds with differing water supply and demand characteristics: Muskingum River Basin (Ohio), Green River Basin (Kentucky), and Big Cypress/

Sulphur Basin (Texas). These Water Prism case studies provide an opportunity to examine regional similarities and differences in terms of water demands, features of the natural system, and options for improvement water management. The benefits of collaboration to achieve improved multi-sector water management are also highlighted through case study evaluation.

Workshop: Sustainable Hydropower – The Search for Common Ground

Applying A Sociotechnical System's Approach in Research on Small-Scale Hydropower: Understanding Why Projects Succeed or Fail

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Keywords: micro-hydropower, rural electrification, sociotechnical systems, electricity access, impact evaluation

Introduction and objectives

Earlier research shows that provision of reliable and affordable electricity services has the potential to fundamentally transform daily life and social relations in rural agrarian communities in sub-Saharan Africa. Chalmers University of Technology, as part of its interdisciplinary STEEP-RES initiative on renewable energy systems, has been conducting research on this topic in Tanzania's Southern highlands within a programme by the Italian NGO ACRA-CCS on micro-hydropower and integrated development in Mawengi. The research aims to identify and understand technical, ecological and societal prerequisites, drivers and barriers, and outcomes of renewable energy based rural electrification, and to develop interdisciplinary research approaches.

Methodology approach

The research applies a sociotechnical system approach, which is developed through case studies. In 2013, an in-depth 8-week qualitative case study was undertaken, as part of research collaboration between Chalmers and ACRA-CCS. Data collection included semi-structured interviews, group discussions, participatory observation, project documentation, informal interactions and participatory workshop to validate results. The study in Mawengi analyzed societal transformation following electrification. Specifically, it explored the linkages between drivers of change related to the technology itself, current use of natural resources, the ecological base of the economy, and the social transformation of daily life and human relations that come with electricity services.

Analysis, results, conclusions and recommendation

The case study in Mawengi highlights how to apply a sociotechnical system's approach to studies of small-scale hydropower systems that also includes a focus on ecological processes. The study illustrates how to theoretically and empirically bridge between disciplines. Through this case and earlier case studies, the STEEP-RES program has developed research theory and methods on: how to study and understand dynamic access to electricity for rural populations; how to make sense of differing perspective on functionality of renewable energy systems; how to understand dynamic and differing outcomes of electrification for groups and individuals, and; how to identify positive and negative system feedbacks in electrification processes that impacts on system sustainability.

The Mawengi case further illustrates how the materiality of the hydropower technology in itself and the specific needs imposed by technical characteristics of the system, together with the logic of development projects, drive a rapid transformation from an agrarian based seasonal economy towards a production and service based cash economy, where people are able to pay monthly bills and plan for regular expenses. As current practices of using land, forest and water resources in the area threaten the long-term viability of the hydropower system conflicts over resource governance emerge and must be dealt with. Further, the presence of electricity carries important symbolic meanings and brings rural poverty into sharper contrast. The Mawengi case illustrates the usefulness of the sociotechnical system's approach for generating insights regarding dynamics and outcomes of electrification processes in sub-Saharan Africa, for small-scale hydropower in particular and renewable energy systems in general.

Driving the Sustainability Agenda in Hydropower Development via Strategic Partnership

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Keywords: sustainability, hydropower, stakeholder, partnership, guidance

Introduction and objectives

Hydropower Sustainability Assessment Protocol is a set of tools which assess the sustainability of an individual hydropower project taking into consideration all aspects of the project at various stages of its development. Sarawak Energy's decision to become partner to IHA, was driven by its strong commitment to the sustainable development of hydropower projects. IHA Protocol is one of the main pillars of sustainability in Sarawak Energy. The Protocol helps Sarawak Energy in identify gaps and weaknesses in their project planning, management and implementation via detailed assessments that rely on objective evidence to justify the scoring in each topic which is factual,objective and verifiable.

Methodology approach

The adoption of the protocol was purely on a voluntary basis and goes beyond the legislative requirements. As a sustainability partner to IHA, Sarawak Energy is committed to implement and develop its projects in accordance to the guidelines set out by the protocol to ensure that the projects development taking into consideration all sustainability aspects.

As a sustainability partner, SEB has received training on the Protocol and assessment of one of our hydroelectric power project. This process allowed Sarawak Energy to fully understand the Protocol and provide valuable insight on how to move forward.

Analysis, results, conclusions and recommendation

The Protocol provides a comprehensive and valuable reference for Sarawak Energy in managing sustainability issus. To ensure that SEB is developing these projects in a sustainable way, the company has made commitments to embed relevant international standards into the way it develops these projects.

As a sustainability partner to IHA, SEB has been drawing significant benefits that can be summarised as follows: reaping

1. The training and assessment of one of our project provides

- Synthesis of information across comprehensive range of sustainability topics, and a concise summary of performance on the sustainability profile
- Targeting of weaker areas through the scoring system and identification of significant gaps
- Objective third-party expert judgement on complex issues
- Opportunity to engage stakeholders
- Enhanced management of project-level information

2. Support from IHA in addressing sustainability and greenhouse gas issues at international level
3. Cost-effective method to accelerate our competency development in-line with best international practices in HEP project development
4. Reflects our commitment toward sustainability
5. Future undertakings for continues improvement.
6. Provide significant level of credentials to the way we develop our hydro projects.

As a result of this partnership, SEB has embedded the Protocol into its Project Development Model (SPM) to ensure that the sustainable development agenda is captured in the way SEB doing business as well as enhance our credibility as a responsible developer and operator. On the other hand, it also benefit the company in terms of identifying risks and impacts of its projects and provide guidance mitigation measures to avoid sustainability risks and impacts.

While SEB wants to internalise and systematise the Protocol as part of project development, SEB also recognise that there is still a long way to go. In doing so, SEB believes that the partnership with IHA will provide a platform for continues improvement in the way we develop our hydroelectric power projects.

Implementation of the Hydropower Sustainability Assessment Protocol in France: The Sustainability Profile of the Romanche-Gavet Project under Construction

Author: Mr. Emmanuel Branche, EDF, France

Keywords: sustainability, hydropower, stakeholder engagement, partnership, Romanche-Gavet, EDF, France

Introduction and objectives

The Hydropower Sustainability Assessment Protocol is a framework to assess the performance of hydropower projects according to a defined set of sustainability topics, encompassing environmental, social, technical, and financial issues. Developed by the International Hydropower Association in partnership with a range of government, civil society and private sector stakeholders, this Protocol is a product of intensive and transparent dialogue concerning the selection of sustainability topics and the definition of good and best practice in each of those topics. Important reference documents that informed its development include the World Bank safeguards policies, the Performance Standards of the International Finance Corporation, and the report of the World Commission on Dams.

Methodology approach

EDF has partnered with IHA to receive training in the Protocol and to perform one protocol assessment of a hydropower project. As part of the partnership EDF has performed an official assessment of Romanche-Gavet project, currently the biggest project under construction in France. This process linked with EU Life+ approach has allowed EDF to engage with a wide range of external stakeholders, and the strength of the protocol as dialog tool and as a common basis for discussions on sustainability issues has been proved.

Analysis, results, conclusions and recommendation

The Romanche-Gavet project is a 94 MW project in the implementation stage, located on the right bank of the middle section of the Romanche river in the Isère department in south-eastern France. The project will replace six facilities on the Romanche River which were built in the early 20th century and have a total capacity of 82 MW, thereby increasing average annual generation by over 30 per cent. The main objective of this official assessment is to obtain impartial and verifiable findings on the performance of the Romanche-Gavet project in relation to the sustainability issues set out in the implementation tool. This assessment by external accredited assessors was carried out over the period May to July 2013. In addition to this main goal for the assessment of this project, EDF expects: (i) to identify how appropriate the Protocol is for EDF and France in general; (ii) to benchmark EDF to international companies and best practices; (iii) to evaluate the sustainability of this project (the biggest project in development in France); (iv) to identify risks and thus to find opportunities in the project both during construction phase and decommissioning of the six existing HPPs; and (v) to ensure transparency of the project and engagement of stakeholders. Based on the training and the experience EDF has got during the process, EDF clearly sees the value of the protocol. It gives EDF a common platform for dialog on sustainability issues related to hydropower. The method is robust, assessment criteria are clearly defined, the assessment is evidence-based and reporting format is standardised. The findings of this assessment reflect very high performance against the Protocol topics and criteria. EDF and its partners meet this high level of performance through a combination of EDF's corporate management systems, and an open working relationship with all stakeholders.

Considering Ecosystem Services Loss into the Price of Hydropower in China

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Keywords: hydropower, ecosystem services, China

Introduction and objectives

The development of hydropower is controversial because of its negative impacts on watershed ecosystem. Many studies have revealed the ecological damage and environmental degradation caused by dams especially small scale ones around the world. However, these scientific results has not well informed the policy, one of the reasons is the discussion on the approaches to internalise the ecological losses is still lacking. In this paper, we proposed a new way to introduce the ecosystem services loss into the price of hydropower in China by reviewing the studies on the price components and other scientific studies.

Methodology approach

In this study, China's process of hydropower pricing will be firstly critically reviewed, including the procedure and its components. The recent evolvement of the pricing policy in China will also be discussed. Secondly, a review of the loss of ecological damage and environmental degradation due to hydropower development will conducted, particularly from the perspective of ecosystem services valuation. To include the most of the relevant studies, those of payment of ecosystem services or ecological compensation for hydropower development will also be inclusive. Finally, the above results will be summarised and a recommendation to improve current pricing mechanism will be proposed.

Analysis, results, conclusions and recommendation

Currently, the price of hydropower in China is composed of construction cost without consideration of its loss of ecosystem services. Without considering this environmental costs of hydropower development, the negative impacts of hydropower development on watershed ecosystem could not be compensated, and it is finally burdened by those vulnerables. Therefore, it's important to introduce the negative impacts of hydropower development for a sustainable watershed. Three dams were selected in a preliminary study in Jiulong River Watershed, various ecosystem services affected by the dam construction were identified, models were employed to compute the loss in the monetary term based on the collected data, the results show that the rates of the negative impacts over positive ones are 64.1 per cent, 66.0 per cent and 91.2 per cent. Meaning the negative impacts should not be ignored in the pricing process. More supporting studies will be reviewed in this relevant field. Conclusions will be summarised based on the above results, including, China should revise the hydropower development policy by improving the pricing mechanism, especially to internalise the environmental costs to the whole costs; a more open pricing process for hydropower development is called for in China to ensure the participation from all stakeholders.

Blue Gold for Whom? Multi-Level Games and Divergent Positions in the Development of Himalayan Hydropower

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Keywords: hydropower, hydropolitics, India, Nepal, Bhutan

Introduction and objectives

The development of transboundary hydropower projects with positive-sum outcomes is contingent on more than just an alignment of interests in direct negotiations. Factors exogenous to the negotiation process influence the positions each actor develops, and the priority it places on these positions vis-a-vis other national interests. States play multi-level games and are thus subject to the influence of domestic concerns, non-water-related interests, global trends, pressures from non-state actors, and dynamics of transnational networks. The hydropolitics between India-Nepal and India-Bhutan illustrate how multi-level games affect non-zero-sum negotiations over transboundary hydropower projects and may undermine the equitable distribution of 'blue gold'.

Methodology approach

How dynamics on multiple chessboards promote or hinder the development of transboundary hydropower projects is the subject of this paper. It elucidates the complexity of the issues through a multiple chessboards prism and begins by establishing the concepts relevant to interest-based negotiations and multi-level games. It then goes on to apply these concepts to the transboundary water interactions between India, Nepal and Bhutan. The paper discusses how India's position on importing electricity from these two countries creates an opportunity for non-zero-sum thinking in the pursuit of their national interests and why, despite this opportunity, multi-level games undermine positive-sum outcomes.

Analysis, results, conclusions and recommendation

The way in which multi-level games and non-water related interests affect the development of mutually beneficial transboundary hydropower projects is exemplified by the hydropolitics between India and Nepal, and India and Bhutan. India has pursued its own interests in Himalayan hydropower for many decades now, and those interests align – on one level, at least – with the interests of Nepal and Bhutan. Where the non-zero-sum thinking falls apart, however, is in the quality of water interactions Nepal and Bhutan have with India.

Both Nepal and Bhutan see the sale of their 'blue gold' to energy-hungry India as the key to socio-economic prosperity. Yet the alignment of interests between these three players has not created an even spread of mutual benefits. Bhutan has strong domestic support for hydropower development, a unified government and clearly defined environmental objectives. Bhutan has therefore succeeded in establishing a pattern of non-zero-sum thinking with India. In contrast, Nepal's water interactions with the hydro-hegemon remain mired by long-term instability, environmental concerns, and political misgivings. This divergence of hydropolitical outcomes illustrates that the development of mutually beneficial transboundary hydropower projects requires an understanding of dynamics and interests in multi-level games.

The process of developing hydropower projects on transboundary rivers is complex. Direct negotiations over such projects are enmeshed in intricate water interactions that are themselves set within the construct of a multi-faceted and shifting political environment. Competing interests at local, national and international levels influence these water interactions and create dynamics that may undermine – or, indeed, precipitate – the progress of such projects, irrespective of the official positions taken in the negotiation process. Understanding the effects of these dynamics on multiple chessboards is important for measuring the progress of transboundary hydropower projects and assessing which interests have been addressed.

Auditing Concessions for Hydroelectric Plants: An Example of Water Management for Sustainable Hydropower

Author: Ms. Rosa Huertas, Duero Basin Authority, Spain

Keywords: water management, inspection and monitoring, ecological flows, fish passages, hydropower concessions

Introduction and objectives

Since 2009, the River Duero Basin Authority has been conducting an intensive inspection plan of existing hydropower plants in the Duero basin (Spain), with the following objectives:

1. To understand the real extent of the impact of hydropower in the basin, in order to improve information for planning and water management.
2. To make a diagnosis of environmental problems and impacts that this use has on riverine ecosystems in the basin to take the necessary measures to ensure the least environmental impact.

Methodology approach

All the 168 hydroelectric plants in Duero Basin were analyzed. The process involved: first, deskwork to collect all the information; second, field work to obtain information, to check gaps between the existing water concessions and reality, as well as other incidents. The focus was to assess the fulfillment of specific environmental conditions (fish passages, ecological flows, etc). Third stage included the consideration of alternative actions and also the requirements made to concessions holders to take the measures needed. Finally, the last stage concentrated on ensuring the effectiveness of the measures taken regarding implementation and proper working.

Analysis, results, conclusions and recommendation

Valuable information for management and planning was obtained (update of the Water Register, updated fees and rates, relevance to the national electricity system of hydropower from the Duero basin, comparison of results from the impacts of large and small hydropower,...). This also facilitates access to environmental information that is required by citizens. From an environmental point of view, there are important results. For example installing a set of devices has allowed on-site and remote control of ecological and turbine flows. As a result of this valuable monitoring information, numerous solutions have been adopted to ensure ecological flows and restore river connectivity that before had been interrupted by dams and weirs, thus improving water quality and overcoming habitat fragmentation. This has in turn incentivised a collaborative model, where the water authority is now studying solutions with both universities and companies, promoting new opportunities for monitoring and research. Some highly innovative solutions have emerged as a result, adopting new methods and techniques like a swim assessment channel, better biological assessments, all arising from the establishment of new partnerships between government, scientists and companies. All these measures and new initiatives have been paid by the water right holder (the hydropower company) under the principle "polluter/user pays", at a crucial time when the administration is in the midst of an important economic crisis and lack of resources could have been an issue. A number of useful lessons have been learnt: the receptive attitude of the hydropower sector and how control is perceived as an equity tool and a security guarantee to their water rights; rigorous surveillance and control management, and new partnerships involving shared learning between water managers, energy companies and researches can be more efficient for environmental protection than expensive works programs.

System-Scale Approaches to Hydropower Planning, Development, and Management

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Keywords: sustainable hydropower, hydropower planning, freshwater conservation

Introduction and objectives

There is a growing consensus that sustainable hydropower can be achieved most effectively through system-scale approaches to planning and development. In this talk we will:
1. Review the case for system-scale solutions
2. Summarise results from the modeling of hydropower development alternatives within river basins, illustrating more optimal outcomes through system-scale approaches; and
3. Review promising policy approaches that can incorporate system-scale approaches into planning, licensing, and development.

Methodology approach

For the three objectives, we:
1. Reviewed current recommendations for sustainable hydropower from industry, funders, and NGOs and the literature on system-scale approaches;
2. Developed a platform that integrates spatial data on hydropower, environmental and social resources and then modeled a range of hydropower development alternatives in two river basins, with each scenario representing a different spatial arrangement of dams. We then compared outcomes across hydropower, environmental, and social resources;
3. Reviewed emerging policy methods for integrating system-scale approaches into hydropower planning and development, such as through environmental review and licensing.

Analysis, results, conclusions and recommendation

Several recent recommendations for improving the sustainability of hydropower have emphasised that system-scale planning can foster more sustainable and balanced development outcomes. However, the necessary components to achieve these recommendations are relatively poorly developed, including quantification of the benefits of system-scale approaches for diverse stakeholders, analytical methods to integrate planning across resources, and policy mechanisms to incorporate system-scale analyses into decision-making.

Our results indicate that, for a given level of cost and capacity in a river basin, hydropower development alternatives can vary widely in their social and environmental impacts. Similarly, for a given objective for maintaining social or environmental resources, the amount of energy that could be developed in a basin varied widely. For example, in one basin, three alternative dam scenarios satisfied the objective of maintaining 80 per cent of indigenous reserves without infringement by hydropower dams or reservoirs. The amount of potential hydropower capacity that could be developed within these scenarios

varied from 15 per cent to nearly 60 per cent. This illustrates that system-scale approaches have the potential to identify more sustainable scenarios that can maintain a greater balance across multiple values from river systems.

Translating the results of these types of analysis into decision making remains a significant challenge. We conclude by describing some recent policy mechanisms that can integrate system-scale approaches into hydropower planning and site selection.

Run-Of-River Hydropower as a Strategy for Sustainable Development: The Colombian Experience

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Keywords: run-of-river, hydropower, renewable energy, CDM

Introduction and objectives

Located in the northernmost part of the Andes, and with high precipitation, Colombia has an electric system dominated by hydropower. The system is very sensitive to the ENSO conditions and severe droughts caused nationwide blackouts in the past. To avoid this, there are market incentives for sources that can provide reliable energy, i.e. large hydro and thermal power plants.

Under the current market conditions, it is very difficult for sustainable energy to compete. But in the past 10 years, run-of-river hydro has become a successful alternative to generate power, which reduces emissions and triggers local sustainable development.

Methodology approach

Run-of-river hydro consists of a hydropower plant that doesn't have a reservoir. This means that it cannot store water for extended periods of time, it is incapable of regulation and so it must generate with the available flow.

The Colombian experience is studied in terms of its social and environmental impacts of run-of-river projects, taking into account the market conditions and the existing legislation that allows this projects to be feasible and to be the sustainable fraction of the power system.

Analysis, results, conclusions and recommendation

The lack of a reservoir avoids the flooding large extensions of territory, significantly reduces the environmental impacts of run-of-river projects, and prevents population displacement. Under operation conditions, a fraction of the river flow is used to generate power while a remaining flow must be guaranteed to maintain the integrity of the river ecosystem downstream. Several methodologies have been developed to properly assess these "ecological flows".

The Clean Development Mechanisms is a key component of the feasibility of run-of-river hydro. As these plants are dispatched first, they displace power from thermal power plants, resulting in emission reductions. Under carbon markets, this becomes an additional income on for the projects. Moreover, the Colombian legislation includes value added tax exemptions in the imports of machinery for emission-reduction projects. Electromechanical equipment (turbines, generators) are not produced in Colombia and represent some of the most expensive components of this kind of projects.

The largest run-of-river project in Colombia is the Amoyá River Hydropower plant, with an installed capacity of 78 MW. However, it is more usual to have projects under 20 MW because projects this size are considered marginal, and are not required to compete with large hydro and thermal power plants to enter to expand the system. This has resulted in small grid-connected plants that improve the local power services, and create wealth for small municipalities around the country, with little disturbance of their geographical conditions.

With the societal concerns of the development and the significant environmental impacts of large hydro, run-of-river generation becomes an alternative to generate power from an available resource using a proven technology with minimum environmental impacts. Lessons from the Colombian scheme can be applied to promote this technologies in other countries around the world.

Value Creation at Hydropower Projects: Developing Methods to Identify, Evaluate and Increase the Positive Externalities

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Keywords: sustainability, hydropower shared benefits, methodology, positive externalities

Introduction and objectives

Existing and planned hydropower projects present multiple opportunities to create environmental and macro-economic value for their host communities, region and environment. They are not only a major source of renewable electricity generation but also significant managers of water resources (75 per cent of all surface water in France) and prime economic actors in local economic development. In this context, sustainable hydropower management today implies taking into account non-power considerations around drinking water supply, environmental services, irrigation, tourism, navigation, and flood protection. A methodology to identify, then evaluate created benefits and to show optimization pathways for operation and planning is therefore needed.

Methodology approach

This project aims to develop a methodology for the evaluation of all forms of value created around hydropower projects. These included values linked to the uses of the water resource (drinking water, agriculture …) as well as non-water values created around hydropower (tourism, development of local transports networks or economy …). The developed methodology will list current uses, show created shared values (in monetary terms where possible) and thus propose options to increase created values for the communities and environment and positive project externalities.

Analysis, results, conclusions and recommendation

Creating a methodology to evaluate shared benefits around hydropower projects and to express them, where possible, in monetary terms, allows the consideration in future operation and project planning of value creation approaches for the communities and environment. This project considers all forms of value created, i.e. water uses and non aquatic project benefits, considering both the social and environmental aspects. Currently no such methodology exists and therefore evaluation of created values according to a proven method has not been possible The methodology is being developed by EDF with a network of scientific and/or economic experts. In a first batch, the new methodology will be tested in 2014 on up to 5 case studies in France on topics varying from tourism, snow culture, irrigation and navigation. Once the methodology has been refined and stabilised through these case studies, it will be applied on its first two full-scale cases, namely the Durance River (France) and the Nam Theun 2 project (Lao PDR) Since a widely applied methodology of this kind does not yet exist, the result of this work will also feed into efforts around multi-use reservoirs of the EIA, collaborations with the World Water Council and 7th World Water Forum and other international initiatives. A successful methodology will allow for future assessment of values created around hydropower projects and incorporation of opportunities into future sustainable hydropower planning.

Global Application of Environmental and Social Safeguards to Hydropower Dams – Who Applies what, and How Effective are They?

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Keywords: tools, social, environmental, policy, safeguards

Introduction and objectives

Large hydropower dams are constructed according to complex sets of national, regional and/or donor imposed regulations or compliance requirements. In addition there are increasingly sets of voluntary guidelines to promote good practice and help avoid the often significant impacts of these large infrastructure projects.

Objectives:
1) review the coherence of the key good practice guidance starting with those proposed by the World Commission on Dams and
2) assess their application and ability to measure and guide the sustainable implementation of large hydropower projects.

Methodology approach

The study reviewed the decision-making processes and conditionalities applied to different kinds of project in different parts of the world, analysing the coherence and intention of different safeguard regimes.

Analysis, results, conclusions and recommendation

The report lays out the spectrum of applicable standards and recommends that parties adopt and promote the Hydropower Sustainability Assessment Protocol as the most practical dam sustainability evaluation tool; harmonise applicable standards at basin or regional level; and review the effectiveness of the process for measuring respect for World Commission on Dams recommendations under the EU linking Directive (carbon credits).

Water and Energy in Africa: Conflict or Cooperation

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Keywords: hydropower, allocation, transboundary, competition, common interest

Introduction and objectives

The demand for energy to power national economies rivals that of water as the source of food and environmental security. In Africa, rivalry between countries over use of shared waters for irrigation has been intensified by the drive for hydropower, at times threatening to engulf contending riparians in war.

Oddly, the river basins where the stakes are highest are now experiencing unprecedented cooperation between the neighbouring countries. But also between competing users at local level.

Methodology approach

Case studies from Eastern and Southern Africa will provide real examples for analysis and deepening understanding of how to manage competition between states and among water users to secure public goods for social and economic development, while reducing impacts of adverse climate.

Often facilitated by the Regional Economic Commissions, but always with negotiations concluded between the competing countries, hydropower schemes across borders has become a recent and accelerating phenomenon.

Despite acrimony in the Nile countries have without fanfare invested in each other's hydropower schemes, with Egypt, Ethiopia and Sudan in the most outstanding example of cooperation trumping ongoing dispute allocation

Analysis, results, conclusions and recommendation

Why waste a crisis? asks Rahm Emmanuel. Years of competition and conflict between water users are giving way to creation of multiple use infrastructure to meet the interests of all groups. In Kenya, sisal estates that used to take up all the water leading to Lake Jipe have reduced their dry season uptake.

Lake Naivasha, the epitome of value added water efficient agriculture, has seen flower farmers, fisherman and nomads create and mutually enforce regulation that secures each sides access and safeguard of water they need. In Tanzania's Pangani Basin and South Africa's collaboration with Mozambique at the hiether of apartherid, and with Lesoto for the White Higlands project, present two exaples of how urgent economic needs can overcome political obstacles to cooperation.

Similarly, Burundi, Rwanda and Democratica Republic of the Congo have been running a joint hydropower scheme soon to be expanded at Ruzizi. In Southern Africa, though the Zambezi agreement failed to be signed despite 30 years of negotiation, Zambia, South Africa and …. Are partaking of each others hydropower.

Unexpected benefits are spilling over as well. Mozambique, Zimbabwe and Zambia are sharing information and organising to synchronise the opening of dams that affect each neighbor state.

Distributing Costs and Benefits through Operations of the Grand Ethiopian Renaissance Dam

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Keywords: Nile, hydropower, modeling, reservoir, development

Introduction and objectives

The construction of the Grand Ethiopian Renaissance Dam opens a new chapter in the management of the Nile and presents opportunities and challenges to the sustainability of the river. The new dam and resulting flow modifications will result in both benefits and costs to riparian countries in the form of power generation, flood protection, drought protection, changes to agricultural production and environmental flows. The distribution of these effects will be determined by the operation of the dam itself. This paper presents the spatial and temporal trade-offs between potential operations and provides an analytic framework to support the ongoing inter-governmental dialogue.

Methodology approach

This research utilises the RiverWare hydro-policy modeling framework to develop a planning model of the Eastern Nile region. Current operational practices of existing reservoirs were identified and a prioritised set of management 'rules' was constructed to simulate these practices. The Renaissance Dam was then incorporated and four potential operation scenarios were tested that simulate:
1) releases to provide constant hydropower,
2) constant outflow,
3) run-of-river operations, and
4) releases to meet downstream demands. Each alternative was evaluated against common criteria to demonstrate the effects on power generation, flood control protection, agricultural water supply and environmental flows.

Analysis, results, conclusions and recommendation

The model was executed under various hydrologic conditions to provide a risk-based understanding of the sustainability of the benefits. The results of all scenarios demonstrate the significant increase in Ethiopian hydropower generation (16,000 to 19,000 GWH per year) and the hydropower "uplift" effect for the Sudanese dams as a result of the Renaissance Dam operations (1,400 to 2,300 GWH per year). Results also show the reduction of hydropower generation from the High Aswan Dam (150 to 1,200 GWH per year) as a result of the presence of the Renaissance Dam. The improved reliability of flows for both irrigated Sudanese agriculture and Egyptian supplies are apparent when the dam is specifically operated to meet these downstream demands. While the benefit of flood control is apparent under all management scenarios except the run-of-river operations, the significant reduction in water available for flood recession agriculture and environmental flows are also apparent. Overall, the results demonstrate the advantages of coordinating reservoir operations between the countries to maximise the sustainable use of the river.

The purpose and product of this study was not the development of a comprehensive list of potential management alternatives, but the primary goal was to develop a tool to support the negotiation process which could be further developed and applied by the stakeholders within the basin. As various solutions are proposed within the technical and political arenas, the model is flexible enough to reflect the potential complexity of the proposals yet transparent enough to be trusted by the affected parties.

Optimal Operation of Multi-Rservoir Hydropower Systems under Climate Change Scenarios

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Keywords: climate change, multi-reservoir systems, reservoir management, hydropower, Karkheh River basin

Introduction and objectives

Climate change can significantly change the hydrological properties of water resources systems. From an operational point of view, it is important to investigate how climate change affects the operation of water resources systems. Karkheh River, is the third largest river in Iran. Five large hydropower reservoirs have been planned to be built on this river, two of which have already been constructed. The importance of hydropower to the national electric system alongside with the large impacts of climate change on the inflows in the basin, makes it necessary to study the adaptive operation of the system under climate change scenarios.

Methodology approach

A stochastic optimization model using SDDP (Stochastic Dual Dynamic Programming) technique was developed for the optimal operation of the multi-Reservoir system in the Karkheh River basin. Several potential inflow time series were generated based on statistical downscaling of the predictions of climate change scenarios using HadCM3 AOGCM model. These series were then used in the optimisation model, in order to analyse the impacts of different climate scenarios on the operation of the system.

Analysis, results, conclusions and recommendation

Karkheh River basin has experienced significant decline in the amount of the inflow in the past 10-15 years and part of this decline is identified as a consequence of climate change. The results of this study have shown that surface runoffs of different sub-basins in the study area have been decreased to less than half of the long-term averages during the period of 1998-2009. Predictions under SRES B2 and A2 scenarios have shown various behaviors of increase or decline of surface runoffs till the year 2100 in different sub-basins. The SDDP model results have shown that the future hydro-climate variations can be effectively considered in modifying the reservoir operation policies and the negative impacts can be avoided by proper adaptation policies especially in multi-reservoir systems.

Workshop: Water, Energy and Urban Development: The Potential for Integrated Approaches

A Transactions Approach to Estimate Regional Dependencies between Urban Areas and Water Resources in Colombia

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Keywords: regional water and urban systems interaction, hydropower development, changes in water balance components, Magdalena-Cauca Basin

Introduction and objectives

The assessment of pressure levels of urban systems over freshwater resources is currently done using several analysis frameworks, such as metabolism analyses, water resources pressure indexes, and water footprint assessments. While these frameworks quantify the interdependence of urban areas and water resources, the increasing regional, and indirect, ramifications of cities into water systems remain unquantified and necessitate additional elements to comprehensively assess the problem.

Here we present a water transactions framework that integrates elements found individually in the water footprint, the water pressure indexes and the urban metabolism framework.

Methodology approach

In this study, we developed a water transactions (input-output) model, that allows the integration of regional direct and indirect interactions between urban and water systems. The framework proposes four main categories: mass diversion, energy diversion, changes in water balance components and changes in the spatial structure of stream networks. For each category were implemented different metrics to determine the degree of change,including flow regime alteration, streams connectivity, evapotranspiration volumes, among others.

Analysis, results, conclusions and recommendation

An example of the proposed framework was implemented to evaluate the regional dependencies of large scale hydropower development in the Magdalena-Cauca river system, which hosts a population of 30 million, and provides 70 per cent of the country's hydropower.

The regional effects were estimated by generating projections of spatio-temporal patterns of water balance components at different points of the basin to observe cumulative effects of 23 hydroelectric projects. The analysis was developed using the water evaluation and planning system – WEAP21. Transaction pairs between regional resources and population areas were measured in terms of energy fluxes (electricity) to each city.

The results illustrate the level of regional dependencies of urban areas, in terms of the variations of the water balance components at different points in the watershed (associated to water or energy storage and exports) and the relative contribution of each city in the basin to overall alteration patterns. The main changes identified include those associated with the hydrological regime attributes, such as the magnitude, timing, frequency and duration of short-term events.

In comparison with existing approaches, the transactions approach allows estimating the concurrent effects of groups of cities into water systems, as well as population agglomeration effects, specially those associated to effects of collective consumption.

Results show evidence of cumulative changes in the water availability patterns, that suggest the need of a further evaluation of how the per-capita regional effects varies across settlements of different sizes along the basin, or hydropower development strategies.

Used Water Driven Biorefineries, the Foundation for Urban Sustainability

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Keywords: used water, wastewater, biorefineries, resource recovery, urban sustainability

Introduction and objectives

According to some estimates, by 2050, approximately 80 per cent of the global population will reside in cities, leading to an enormous increase in resource utilisation and resulting in a severe strain in the urban infrastructure. The resources and infra-structure elements that will be most in demand and least in supply will likely relate to food, water and energy. Clearly, the current "once used and discarded" model for these resources followed presently cannot be sustained.

In order to be viable, urban centers of the future must focus on resource recovery and decentralised generation and provision of food, water and energy.

Methodology approach

The opportunities that this new model based on resource recovery from used water or wastewater provides are substantial. Food waste, human waste and animal waste are rich in nutrients, energy precursors and water, of course. Therefore, by focusing on resource recovery than on waste removal, underdeveloped and developing communities no longer have to invest substantial capital to provide basic food, sanitation and water to their most at need and in many cases, the most vulnerable populations. Urban cities are the ideal setting for large-scale implementation of resource recovery owing to the high population density that they foster.

Analysis, results, conclusions and recommendation

To cite a few examples, we are working in Accra (a Millennium City) to convert fecal sludge into biofuels, which when coupled with a social enterprise business model can empower local populations and develop local engineering knowhow. The nutrients and biofuels that are generated can promote decentralised urban agriculture and electric power and further offset to a large degree the costs for providing sanitation. This work is being supported by the Bill & Melinda Gates foundation. Additionally, source-separation latrines are being built in the Engineering School at Columbia and are being implemented in the US and in Ghana for recovering fertiliser and provide sanitation and water.

Two challenges for implementation of this model include the social perception that resources recovered from waste could be unclean and the need for local capacity building (in both developing and developed settings) for embracing the technologies developed. However, the significant benefits that could be realised provide sufficient incentive to develop further and adopt this new model for urban sustainability in the cities of the future.

Finally, resource recovery is not a panacea. Rather, a structured approach is needed to tailor the inputs and outputs from resource recovery based biorefineries. For instance, given the dire need for food and water security in underdeveloped cities, it is imperative to recover nutrients (N&P) rather than energy from biorefineries therein. On the other end of the spectrum, in advanced (developed) cities, it is more important to recovery energy than nutrients. In developing cities (BRICS), we could recover both energy and nutrients.

Integrated Sewage Heat Recovery

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Keywords: heating, energy saving, heat exchanger, sewer, innovation

Introduction and objectives

VIVAQUA has installed, as a first test, a real scale heat exchanger at the bottom of a sewer. The temperature of the sewage being between 10 and 15 °C the heat exchanger/pump are able to recover sewage energy to warm up the water circulating in the heating system. The heat exchanger is fabricated as an element that increases the stability and the endurance of the sewer.

The objective is to use the sewage heat as a source of energy, which can be supplied to the houses situated nearby, without extra costs compared to a classic consolidation of the sewer bottom.

Methodology approach

The study consists in quantifying the net energetic effect of heat recovery by measuring the coefficient of performance (COP) of the installed heat pump and observing the operational problems caused by the degree of pollution.

The measured parameters are defined to acquire all data characterising the functioning of the pump and the influence on the sewer content.

Tackling the operational problems related to the sewage should result in guidelines for installing heat exchange and pumping systems in sewers.

Analysis, results, conclusions and recommendation

The COP of the heat pump has exceeded every expectation. At the bottom of the sewer the heat exchanger operates as a water/water exchanger; above the sewage level the upper tubes of the exchanger function as an air/water exchanger, increasing the system's performance.

The philosophy of the project is to install heat exchangers without generating additional costs. Every rehabilitation project for sewers results in a local energy stock. New housing projects should already contain adapted heating installations in order to gain the energy from the sewers.

Nowadays local authorities are constantly looking to save energy and they will certainly continue doing so in the future. One of the outcomes will be that the population is urged to use all kinds of heat capture systems as an energy saving and environmentally friendly heating solution. VIVAQUA, which executes the Brussels sewer renovation scheme, has 300 km of sewers that can be exploited as a potential energy source, which could generate up to 100 GWh.

The development of this sustainable urban system is an example of an integrated approach, combining public hygiene with heat recovery, and an innovative way of improving the energy balance of the urban water cycle.

On-The-Spot Pattern, Sustainable Community Management of Water and Energy Infrastructures: A Case in Beijing

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Keywords: on-the-spot, pattern, reclaimed water, community, distributed framework

Introduction and objectives

Beijing now uses 3.6 billion tons of water every year. All sewage plants in Beijing are located in outer suburbs, and there are no pipes to convey the reclaimed water back into urban area. Lots of civil uses of reclaimed water cannot get supply. Hence a great deal of pure water is wasted.

China now has the largest photovoltaic equipments output every year in the world. But the domestic demand of photovoltaic equipments is comparatively very low.

How to make the link between water and energy has become the most important task for China to construct ecological city.

Methodology approach

Chinese metropolis have been using pattern of single-nuclei development for decades.

Infrastructures are centralised together. The circulations of material and energy in metropolis are in "big loop". But accompanied by the rapid expansion of metropolis, the transportation of material and energy in it has been paying more and more economic cost, and triggering lots of environmental problems.

On-The-Spot Pattern has community as its object of study. It suggests to use "distributed framework" in town planning, to divide centralised infrastructures into small one, to create On-The-Spot circulations of material and energy. So it may effectively solve the "transportation problem".

Analysis, results, conclusions and recommendation

Recently China has been using administrative method and legal method to encourage energy-saving and emission-reduction. Those can be seen as "top-level design" of the blueprints of Chinese sustainable urban system.

By creating On-The-Spot circulation of material and energy in community, On-The-Spot Pattern will shape the "bottom-level design" of the blueprints. We can actualise it in four ways.

- First, model demonstration. In 2003, we built an eco demonstration park in the downtown area of Beijing. There was a sewage plant underground the park. Domestic sewage from neighboring community was collected to produce reclaimed water. This sewage plant can produce over 100,000 tonnes of reclaimed water every year, and all the reclaimed water was used On-The-Spot. The sewage plant has been working for over ten years! It can be seen as the embryonic form of On-The-Spot Pattern.

- Second, technology application. We have been constantly adding new technology into the eco demonstration park, and we have paid close attention to make the link between water and energy. For example, we used photovoltaic technology to produce energy for the sewage plant. We also used water source heat pump technology to collect energy from reclaimed water, and the energy was used to heating-cooling for local building;

- Third, internet thinking. We should use "internet thinking" to create On-The-Spot Pattern. "Sharing- Cooperation- Innovation" should be the consensus of us when we begin to work.

- Last, idea spreading. The core of On-The-Spot Pattern is "people". People must learn to cherish our living environment, and do something to protect it. Only if the people in the community accept the idea and carry it out conscientiously, On-The-Spot Pattern can bear fruit. We have organised over 100 popularizing activities in the last 3 years, and hundreds of thousands of Beijing citizens were influenced.

Enhancing Sustainability of the Urban Area Jenfelder Au by Implementing the Integrated Wastewater and Energy Generation Concept Hamburg Water Cycle®

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Keywords: source separation, blackwater digestion, energy generation

Introduction and objectives

The settlement "Jenfelder Au" currently is one of the largest housing construction projects of Hamburg. In addition to urban targets the Hamburg Water Cycle® (HWC) will be implemented as an integrated concept for wastewater treatment and energy generation. It is based on different separation and on-site treatment of household wastewater- blackwater, greywater and rainwater. Because of this separated treatment, energy can be saved as well as produced during the treatment process by using biogas production through blackwater fermentation. Furthermore the local water cycle can be restored. These processes including legal framework setting and stakeholder communication increase the settlements sustainability.

Methodology approach

Before HWC could be implemented different challenges had to be managed. First of all there had to be found a network system which collects mostly undiluted blackwater and enables a reliable operation of the sewers. After the vacuum technology have been chosen the technical planning started. At the same time the legal framework had to be amended by adding the vacuum sewer system to the wastewater law of Hamburg. In a final step it was of great importance to involve all relevant stakeholders to the project "Jenfelder Au". Therefore considerably client oriented communication tools have been evolved.

Analysis, results, conclusions and recommendation

The implementation of the HWC in the settlement "Jenfelder Au" is the greatest realization of an integrated sanitation system in Europe based on source separation of household wastewater. It started its sewer construction work in October 2013 and upon completion it will collect concentrated blackwater (toilet wastewater) of about 2,000 inhabitants by vacuum networks. Together with additional substrates the collected blackwater will be used for biogas generation in an anaerobic fermenter directly on-site. The produced biogas will be utilised through a combined heat and power generation and supplies local residents with carbon dioxide neutral heat and electricity. In addition drinking water will be saved as a result of the low flush water demand from vacuum sanitation. The digestates from the fermenting process can be used for soil improvement and agricultural fertilisation by recovering the contained nutrients. The collected greywater will be treated separately and then restored to the local water cycle together with rainwater.

To get this sustainable concept implemented to the "Jenfelder Au" there had to be set legal framework for the vacuum system first. Thatswhy the legal department of Hamburg Wasser added this system to the wastewater law of Hamburg in 2010 and is still working on it. To give the HWC legality even if the amendment process is still ongoing the HWC became part of the purchase agreement between municipality and investors.

In addition to the HWC the district authority established a sustainable social construction plan to increase the image of the residential area. To improve the acceptance of the new social district and the innovative HWC concept the different involved stakeholders as well as their attitudes had to be detected. To guarantee the success of the project all stakeholders have to be informed and integrated. Because of that a considerably stakeholder oriented communication plan was realised.

Water Recycling and Reuse in the Urban Environment in Sydney, Australia: Energy Consumption and Environmental Impact, Where do We Draw the Line?

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Keywords: stormwater harvesting, wastewater reuse, electricity consumption

Introduction and objectives

Water recycling and reuse is becoming increasingly common and in Sydney, Australia, there are a large number of stormwater reuse systems and wastewater reuse plants in operation.

The objective of this study was to asses a number of water recycling and reuse systems for their ongoing electricity consumption and how this compared to water from the mains supply. The study also looks at the guidelines for water recycling and reuse and how this impacts on the systems adopted. Further, the study looks at development policies and how these have encouraged or discouraged water reuse.

Methodology approach

Five treatment systems were included in the study, three stormwater harvesting systems and two local wastewater reuse systems. Data on electricity consumption were collected and compared to electricity consumption if the same volume of water had been supplied from the mains water supply. Only electricity consumption from the ongoing operation were considered.

The arguments for proposing the reuse or recycle systems were assessed, and the guidelines underpinning the design and management of the systems.

Electricity consumption was translated into carbon emissions and any offset scheme used taken into consideration when discussing the environmental merits of the individual systems.

Analysis, results, conclusions and recommendation

While the energy consumption for individual systems could not always be isolated from other electricity usage at the sites, the analysis shows that water reuse can provide water at the same or less energy consumption and carbon emissions compared to water supplied through the mains network. In terms of carbon emissions this is particularly true where offset schemes are used. While environmental benefits are not always the main objectives of a water recycling scheme, these findings are encouraging.

However, where systems have been designed to achieve a very high standard of water, the energy consumption and cost can be many times higher per volume of water compared to mains water, and the financial and environmental benefits of these systems can be questioned. This is particularly true where the water recycling ethos of "fit for purpose" has not been considered, and highly polluted water is treated to a high standard to suit the end use, even where such water is available from the mains supply.

There are incentive schemes in place that may have overlooked other potential impacts of a water reuse or recycling scheme and thus rewards systems that it would be difficult to argue provides significant environmental benefit and where there are few if any direct financial incentives for implementing the scheme.

This study highlights the need for regulatory bodies to consider a wider range of impacts when preparing developing guidelines and incentive schemes for water reuse. This is particularly important for organisations that are not traditionally involved in water supply, such as local government organisations in the Sydney area or private developers, where the reason for getting involved is often environmental. When the focus is too narrow, in the case of this study a focus on reducing mains water usage, there is a risk that unintentional negative impacts such as increased carbon emissions is the outcome.

Use of Gravity Pipe Line of Water Supply System for Generating Micro Electricity

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Keywords: micro hydro power, water supply, cost reduction, energy management

Introduction and objectives

Uva province in Sri Lanka is located in hill country where most of water supply schemes are operated as gravity water supply schemes. The gravity water supply schemes were designed with break pressure tanks for control high pressures applying pipes and avoid possible pipe bursting. Wellawaya urban water supply was constructed with gravity supply pipe system which has a head of 200m from intake to plant and total demand of system is 8,000 cubic meters per day and introduced micro hydro-power system in place of break pressure tanks.

Methodology approach

Break pressure tanks are being design and constructed to release energy in the pipe system in order to control the pipe pressure. Wellawaya urban water supply was constructed with gravity supply pipe system which has a head of 200m from intake to plant and total available water in gravity system is 8,000 cubic meters per day. Pilot project was implemented in Wellawaya urban water supply scheme in order to use the available energy as micro electricity generation for cover the important electricity demand of treatment plant of Wellawaya Water Supply Scheme. Calculating the energy available in the system

Analysis, results, conclusions and recommendation

Small micro generator was installed in pipe line with control system close to treatment plant. The total average electricity production is about 55 KW and is sufficient to cover most of needs of plant including lighting of area and quarters. The investment cost of the micro hydro power project can be recovered within 6 years by reducing electricity bills which are supplying from main grid. The main challenge of micro hydropower system introduced is proper maintenance non availability of skill workers in water Board. The pilot project experience can be used to develop micro hydropower system in other gravity water supply schemes which have high potential of power production that power can cover at least day to day demands of plants and houses in plants. In future, Production of small generators can be used to drop pressure in gravity pipe system while generating micro power without break pressure tanks and control valves are being introduced by manufactures.

Hydro Electricity Options and Sustainable Water Supply in Nigeria. A Case Study of Arakanga, Abeokuta and Hill Top, Abakaliki WTP on Ogun an

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Keywords: energy supply shortage, WTP underperforming, all season river yield, hydro power potentials, abandoned hydro power generating facilities

Introduction and objectives

Water treatment plants WTPs in Nigeria operates under capacity due to energy shortage despite perennial river sources. The Arankanga WTPs Old and New with combined capacity of 90.6MLD supplies water to Abeokuta, with population of over 1,000,000. Hill Top WTP of 15MLD capacity supplies water to a section of Abakaliki with population of 500,000. Both plants are served by Ogun and Ebonyi rivers respectively with dams and elevated weirs and other appurtenances for hydro power generation. The study seek to establish that hydro power options will solve problem of energy supply to Urban Water Utilities in Nigeria through integrated approaches.

Methodology approach

Hydrology analysis of the Ogun River and Ebonyi River and the potential power generation capacity. Desk Study on the Status of 12 MW Oyan Dam project along the Ogun River.

Visits and investigation of already constructed inlet chambers to support underground turbine at the Ebonyi River abstraction point. Feasibility study to determine hydro generation capacity and sufficiency to meet demands of both WTP

Sensitivity analysis to determine the impact of cost of energy on the total recurrent expenditure and the long term cost reduction effect of hydropower options for the power plants.

Analysis, results, conclusions and recommendation

The Arakanga Water treatment pays an average of Naira 16 million per month with the Utility's revenue covering only 44 per cent of the cost. In what has become a vicious circle, most treatment plants fail to meet water demand for connected customers principally due to epileptic electricity supply, which also results to low revenue generation and ultimately failure to meet recurrent needs. The Hill Top station operates at 5 per cent capacity due partly to irregular power supply. Yet, the Utility pays an average of 1.5M Naira per month for power supply with average monthly revenue of 800,000. With the privatisation of the power companies, WTPs higher cost of energy is envisaged.

Coping with Power Disruptions in Sub-Saharan Africa's Cities: The Challenges of Utility-Community Water Service Delivery Systems in Kenya

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Keywords: partnerships, urban poverty, delegated management models, urbanization, water accessibility, urban informal settlements, urban energy disruptions, Kenya, slum water service

Introduction and objectives

The fast pace of urbanisation in Sub-Saharan Africa challenges the capacity of water utilities to safely increase water-service coverage. Partnerships in which utilities delegate management of water infrastructure and service delivery to slum dwellers are being promoted to accelerate the provision of safe water-service coverage. The objective of this study was to examine how small-scale providers who have partnered with Kisumu city's water utility to provide safe water in the informal urban settlements cope with power disruptions that affect the utility's water supply. The study was conducted in Nyalenda, Kisumu's largest informal settlement. The utility with support from donor agencies has partnered with small-scale service providers to increase service coverage through a delegated management model (DMM).

Methodology approach

On May and June 2013, seventy water kiosk service providers from Nyalenda were interviewed. Data was collected included, the functioning of the partnership arrangement, causes of system disruption and frequency, and methods of coping with service disruption, especially power outages in the city and their disruption of the utility system.

Analysis, results, conclusions and recommendation

Survey data was summarised using descriptive and inferential statistics to understand causes and frequency of service disruption, methods of coping, and socio-demographics of water kiosk suppliers vulnerable to service disruption. Results showed that water-kiosk operators had adopted strategies to augment water supply by having access to alternative sources, mainly protected wells, and some planned to invest in tanks to store water to continue serving customers after power disruptions occurred. While the idea of partnerships is appealing, donor and government agencies need to recognise that service-delivery performance, outcomes, and sustainability can be affected by the urban energy supply. Failure to recognise this connection and prepare for disruptions to energy supply can adversely affect the performance of water-service partnerships, particularly during critical periods (e.g. extended droughts).

Morgenstadt: A Multi-Disciplinary Approach to Urban Systems Research

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Keywords: sustainable urban development, resource management, multi-disciplinary strategy approach

Introduction and objectives

To overcome challenges of nowadays cities (demographic- and climate-change, aging infrastructure, increased awareness of inhabitants etc.) as well as to stimulate innovations and to coordinate urban developments in different sectors, a systemic understanding as well as inter- and trans-disciplinary cooperation processes are essential.

The Fraunhofer Innovation-Network "Morgenstadt:City-Insights" (m:ci) has developed a pioneering approach to urban systems research to evaluate impact factors, drivers and key application fields in different sectors of urban development to enable the cities to sharpen their strategy-processes towards increased sustainable development and to support their decision processes, allowing to combine interlinked sectors such as energy and water.

Methodology approach

With an interdisciplinary team of researchers, inspiring practice examples were analyzed during two weeks on-site each in six selected cities.

Amongst others, the two sectors "water" and "energy" have been focused on in the cities Singapore, New York City and Copenhagen. Main objective of the research was to identify the impact factors that are required for transformation processes towards sustainability and to compare these factors between the different sectors and the selected cities. On this basis, a model-approach for the sustainable development of cities was created, which can now be applied to analyze other cities regarding their strengths and deficits.

Analysis, results, conclusions and recommendation

The topics of the investigated practice examples were similar in all three cities. However, individual solutions and approaches did vary due to local conditions: In all three cities measures were implemented that secure the future supply of potable water, e.g. by reducing the water consumption (in Copenhagen: from 170 l/p/d in the 1980's to 104 l/p/d in 2013). All three cities improved their stormwater management concept to reduce flooding events, and at the same time to increase the city's attractiveness e.g. by increasing the area of green-spaces and protecting open water bodies from combined sewer overflows. In all three cities energy efficiency is becoming a more important topic. Last but no least, in all three cities very innovative technological approaches were implemented to support the aims above, such as the treatment of road-runoff in Copenhagen, the wastewater recycling systems in Battery Park City in New York City, and the concept of NEWater Singapore.

In the investigated cities, external factors, such as limited water resources or more frequent flooding events, triggered the development towards more sustainability. The combination of a highly engaged administration and a government with the will to improve conditions, as well as the long term thinking of the responsible decision makers led to a holistic strategy process towards a more sustainable development in all investigated cities. While the individual aspects vary due to framework conditions, specific technological and organisational aspects can be transferred to any city worldwide.

The interlinkage of aims of different sectors (e.g. water and energy) can lead to multiple benefits, allowing the implementation of most innovative approaches, even if they seem costly when considering only the fulfillment of the aims of one single sector. Especially here, there is still potential for future development in most cities worldwide, even in the inspiring cities investigated within m:ci.

Urbanisation with New Infrastructures among Water, Energy and Land in Qiuqua Region at Arid West China

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Keywords: groundwater, wind energy, eco-system, urbanization, infrastructures

Introduction and objectives

Severe water and energy shortage is a critical barrier to basic living and economic development in Qiuqua (Jiuquan) region locating at the oasis of arid West China. The local people have struggled to produce a subsistence level of food, drinking water and energy for living survival. The limited availability of periodical surface flow and deeply storied groundwater restrained economic growth. Without hydropower or coal mine, the fuel for households only relied on vegetations, which caused eco-system deterioration. To improve the economic infrastructure, the strategies dealing with water and energy management, land reuse, urbanization and eco-environment reclamation must successfully be optimised.

Methodology approach

New urbanization policy lets Jiuquan become the main wind power base due to the abundant wind energy resources. Electricity grids cover urban area and main communities when low-temperature biogas generation ponds are widely introduced to the remote communities. Many households are trained to work in wind energy or tertiary industries. Farmers are encouraged to turn agricultural lands into prairies and forests for reducing groundwater demand and recovering the damaged eco-environment. Irrigation water must be paid instead of free use as usual when water-saving technologies are emphasised with the financial supports. With growth of potential job opportunities, urbanisation becomes accessible.

Analysis, results, conclusions and recommendation

According to the economic develop project designed by Chinese Government, urban population of China's would increase from 52 per cent in 2012 to 70 per cent in 2030. However, shortage of water and energy resources is the big challenge for this goal, particularly for remote and arid West China. Located at oasis in West China, Jiuquan region only has the annual precipitation of 80 mm and tremendous evaporation 3000mm. Unconfined aquifer is the unique water resource recharged far away. Without hydropower, farmers used diesel engines to over-pump groundwater for irrigation. Thus groundwater levels decreased by 70m to 90m, consequently 60 per cent of vegetations vanished in last 3 decades. There people lived in pervert and were worried about water, energy and land. With the urbanization project, a large wind power base has gradually been established in Jiuquan region due to the abundant wind energy capacity of 40 million KW. Since 2008, US$2 billions have been invested into the wind power base construction. The generators of 20 million 5.16 million KW were installed in 2010, and will reach KW in 2015. With the expansion of power grids, electricity is widely used for groundwater pumping, agricultural productions and living condition improvement. At the remote areas, the low-temperature biogas ponds are introduced to households for fuel production using agricultural wastes as the rare materials. For the purpose of saving water resource and land, the new policy called farmers to turn agricultural lands into prairies and forests meanwhile the relevant economic losses are officially compensated. This measure also significantly enhances eco-system

reclamation with annual increase of vegetation areas 4.6 per cent. With the swift expansion of tertiary industries, lots of laborers are possibly released from agriculture and turn to work in industries after the special education. The integrated management of water, energy, land and labor has successfully promoted urbanisation in Jiuquan region.

Workshop: Mitigation and Adaptation Measures for Climate Change: How to Converge over Energy and Water

Impacts of Climate Change on the Blue Nile Basin Reservoirs for Hydropower Production

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Keywords: climate change, reservoirs, hydropower, blue Nile basin, WEAP

Introduction and objectives

Few analysis of different alternatives from regional perspective that include integrated water resources management in the Blue Nile basin has been found. Planning for adaptation should include water resources planning (taking into account climate change). Adaptation to climate change tools, scenarios and approach is very crucial to be addressed and disseminated. The impacts of climate change and other stresses on water resources and changes to flooding risks in the future will require adaptation on the part of governments, water resource management institutions, water users and a host of other stakeholders in the Blue Nile Basins.

Methodology approach

For better understanding the research used the following steps to evaluate the effects of climate change on the Blue Nile Basin reservoirs (including the suggested Grand Ethiopian Renaissance Dam (GERD)) which is very essential in developing any alternate scenarios. The analysis consisted of:

- Assessment of the water resources hydrology in Blue Nile Basin;
- Analysis of climate change and variability impacts in Blue Nile Basin by using WEAP model;

Evaluation of sustainability by considering:

- Reliability
- Resilience
- Vulnerability

The research will benefits from the on-going project under Nile Basin Capacity Building Network.

Analysis, results, conclusions and recommendation

The research aim to evaluate the expected influence of the climate change on the runoff, and its seasonal and spatial variation. The expected climate change in Blue Nile river basin for the scenario can be characterised by an increase of mean annual temperature and precipitation.

The research used a two-way ensemble prediction approach for the evaluation of the future river runoff from the territory of Nile:

1. An ensemble of regional climate models (RCMs),
2. The ensemble of hydrological models (WEAP) will be used to calculate the climatic time series of runoff.

Finally the results of the research are:

- Optimal water allocation and hydropower development strategy under climate change scenarios,
- Solutions for water balance related constraints by considering different water supply and demand with climate changes.

The utilization of Hydropower could be combined with the demand to further store Nile floods and to control siltation processes. An interesting question will be how the vast hydropower and irrigation potential will be used to their optimum within the next decades.

The Blue Nile Basin region is characterised by highly variable river flows and a significant proportion of the annual runoff volume of the Eastern Nile, contributing over 85 per cent of the total River Nile flows, namely on three months, July to September. During high rainfall periods, major rivers in the region often give rise to large scale river flooding, particularly in the floodplains of the Sudan and Ethiopia, with devastating effects on lives, livelihoods, and properties.

For the reservoirs, the performance of specified operating policies using associated operating rule curves was simulated by the WEAP model. Rule curves define the desired storage volumes, water levels, and releases at any time as a function of existing water level, the time of the year, demand for water and possibly expected inflows.

Carbon-Credits: A potential Source of Energy and Operational Cost in Wastewater Treatment plants (Egypt)

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Keywords: carbon-credits, cost recovery, wastewater, biogas

Introduction and objectives

The wastewater treatment sector can support CDM projects. AlGabal El Asfar wastewater-related CDM projects developed in Egypt. This facility serves 10-million Egyptian. Currently, average influent COD is 484 mg/L, and 44 mg/L for the outflow,and removal efficiency of 91 per cent. The BOD and TSS removal efficiency is reported to be 94 per cent.The main elements of the plant are: 20 primary anaerobic digesters(11,000 m^3 each),10 secondary anaerobic digesters (9,000 m^3 each), 2 biogas holding tanks(11,000 m^3 each),10 internal combustion engines (2.3 MW each). The objectives were to study a wastewater management case to not only mitigate and adapt measures for climate case but also for operation cast recovery.

Methodology approach

Carbon Credit Calculations-The greenhouse gas generated by the anaerobic sludge digesters is methane (CH4), and the average daily generation of CH4 is about 60,300 m^3. At standard temperature and pressure ("STP"), this volume of methane has a mass of 43,235 kg. Since methane is a more potent greenhouse gas than carbon dioxide, its mass is multiplied by 25 (IPCC AR4, 2007) to calculate the equivalent mass of carbon dioxide ("CO_2e"). This mass is approximately 395,000 tonnes of CO_2e per year. This represents the total amount of greenhouse gas emission which is avoided at the treatment facility.

Analysis, results, conclusions and recommendation

The sludge management component generates 90,000 m^3/day of biogas. Of this, approximately 60,300 m^3/day is methane (67 per cent); 28,800 m^3/day is carbon dioxide (32 per cent); and 9,000 m^3/day is hydrogen sulphide (1 per cent). The biogas flows from the anaerobic digesters under pressure to the 2 holding tanks, then passing through a gravel filter and gas booster to the internal combustion engines. The fuel blend used by these engines to generate electricity is about 90 per cent biogas and 10 per cent diesel. The on-site system generates about 70 per cent of the total facility energy demand which is reported as being 24 MW. Each verified tonne of avoided GHG emissions is equivalent to one CER, and since CDM projects are generally registered to generate credits for a 10-year term, this means that if this sludge management system had been registered as a CDM Project at the outset, it would have generated approximately 3,950,000 CERs over a 10-year life. In addition to avoiding methane release, the captured methane is used to generate electricity. The onsite electricity generation from the methane is approximately 17 MW. Generation of electricity for use in Egypt's national grid results in approximately 0.531 tonnes of CO_2e per MWh (DOE 2007), and therefore the amount of electricity generated by the captured methane displaces approximately 149,000 MWh and 60,000 CERs per year. Thus the total potential CER generation over a 10-year term would be approximately 4.55 million CERs.

The CDM potential at other large-scale wastewater treatment facilities should be investigated as a source of revenue to offset capital and operational costs. When assessing potential upgrades to the sludge management components of facility systems, emission reduction (including methane capture and combustion) techniques should be considered as well.

Electricity Generation, Cooling Water Use and Pathways to 2050: Results and Methodological Insights from a UK Study

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Keywords: pathways, cooling water, electricity generation

Introduction and objectives

Numerous national and international studies investigate low-carbon energy pathways, yet few consider the water intensity of electricity generation. Our work (Byers *et al.* ,2014), builds on Schoonbaert (2012), and assesses water use by the UK electricity sector from 2010 to 2050 using six decarbonisation pathways from the UK Government's Carbon Plan (2011). We present the first validated and peer-reviewed work of this type for the UK. The pathways and results are consistently low-carbon, yet with dramatically contrasted water futures. We discuss policy conflicts identified from the work as well as methodological challenges in replicating similar studies for other countries.

Methodology approach

We developed a widely deployable framework and methodology, using the UK as case study. We used the pathways from the Carbon Plan available in the DECC 2050s Pathways calculator, calculating water abstraction and consumption with water-use factors from Macknick et al (2012). All pathways decarbonise in line with the UK Climate Change Act 2008, and contain various mixes of nuclear, renewables and carbon capture and storage (CCS).

A detailed survey of the UK electricity asset-base was performed to determine both current and future scenarios of cooling technologies and potential water sources, with a sensitivity analysis exploring various policy tradeoffs.

Analysis, results, conclusions and recommendation

For the UK, the closure of current coal capacity due to the EU Large Combustion Plant Directive, will reduce water use considerably by 2020. The capacity developed post 2020s will largely determine water use to 2050. Pathways with high CCS lead to freshwater consumption 37-107 per cent higher in 2050 than 2010. Risks to the environment and freshwater resources will be elevated if CCS facilities are clustered, as planned by the UK Government's CCS Roadmap. Pathways with higher renewables have lower freshwater use, as does the high nuclear pathway. With high nuclear capacity, increases in tidal and sea water far exceeds current levels (by 148-399 per cent), with potentially damaging impacts for marine environments.

Our sensitivity analysis considered: limiting abstractions from freshwater sources, the levels of closed loop and hybrid cooling, the balance between freshwater and tidal abstractions, and the balance of coal and (more efficient) gas capacity on freshwater.

We show that: increasing hybrid cooling is a very effective policy, given that cooling is provided efficiently when water is plentiful, and reliably when it is not, whilst reducing consumption considerably. However

it is more costly and less efficient, meaning penetration will remain low unless regulated. Reducing coal capacity on freshwater by 50 per cent would deliver the greatest reductions (35-40 per cent).

Although focussed on the UK, our results have relevance for all countries undergoing energy transitions. Pathways with high levels of nuclear and CCS are likely to respectively increase abstraction and consumption. Significant increases in intensity of freshwater consumption can be expected in futures with carbon capture and storage, particularly for coal capacity. Pathways with less nuclear and CCS, and often more renewables, minimise the risks to aquatic environments.

Byers, E.A., Hall, J.W., Amezaga, J.A., Electricity generation and cooling water use: UK pathways to 2050. Global Environmental Change. 2014. Accepted. Byers, E. A.; Hall, J. W.; Amezaga, J. M. Electricity generation and cooling water use: UK pathways to 2050. Global Environmental Change 2014, 25, 16–30.

Life Cycle Approach for Determining the Water-Energy Nexus for Drip Irrigated and Micro Propagated Banana Cultivation

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Keywords: life cycle assessment, water-energy-food nexus, drip irrigation, micro propagation, water and carbon footprint

Introduction and objectives

Use of modern technology in agriculture is key in water-energy nexus. Due to traditional method of banana cultivation , the ultimate pressure is on natural resources viz: land, water and energy. And due to growing population, changing food habits and increasing consumption patterns it needs a lot of attention. The integrated model successfully implemented by Jain Irrigation is an excellent example for mitigating and adapting to the climate change. This model needed a proper understanding, thus Life Cycle approach was adopted. Monitoring of energy and water consumption in producing banana from micro propagation and then on the farm was monitored to understand the water-energy nexus.

Methodology approach

The study is divided into two parts: LCA of micro-propagated banana plantlet and LCA of comparison of banana production in the field with drip and conventional method of irrigation. The micro propagation (Tissue Culture) facility of Jain Irrigation for banana plantlet is biggest in the world with 100 million plantlet capacity per annum. Here the facility is using insitu harvested rain water and recycling all the water into storage pond. Solar PV panel are installed power for it 75 acre facility in Jalgaon. These plantlets are distributed thorough out India and abroad as per the demand.

Analysis, results, conclusions and recommendation

In first stage of LCA, the field study at the farmers plot and at research plot the comparison was made between the drip irrigated banana and conventional banana. It was found that the water savings for cropping cycle is in the tune of 6,000 cubic meter per ha and energy savings is in the tune of 2.08 MWh per ha. Considering this impact, if 5,000 ha area if brought under drip irrigated and micro propagated banana sapling. This will ensure that savings can be in the tune of 30 million cubic meters and more area can be brought under irrigation, and energy savings in the tune of 10, 800 MWh in one single year are and hence the carbon dioxide that can be reduced will be in the tune of 8,383 tCO_2e. Based on this aspects CDM project was also registered with UNFCCC for Tapi river basin region of Maharashtra region (UNFCCC CDM project no 7186 on 05 Sep 12).

Second part of the LCA study, micro propagation (Tissue Culture) of Banana plantlet the water and carbon footprint was calculated. Other than Carbon Dioxide (energy) rest of the GHG were insignificant. Carbon sequestered by the trees planted in the premises of Tissue Culture Park was also significant in reducing the carbon footprint. The water recycled also improved the efficiency and hence over all water footprint was minimised. It was found that water used by banana saplings is 1.99 litre in it life cycle up to despatch of the plantlet to farmers field while in traditional method of planting water consumed per sapling is 122 litres. And energy consumed in laboratory and green house and poly house for preparation for micro propagation is nullified by the using solar PV energy and plantation of more native trees which sequester carbon dioxide from the atmosphere.

Strategies Adapted for Reduction of Energy Consumption in Drinking Water Supply and Mitigation of Climate Change

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Keywords: climatic, drinking, energy, mitigation, sustainability

Introduction and objectives

The National Water Supply and Drainage Board (NWSDB), Sri Lanka, is the principal national agency responsible for the supply of potable drinking water to the nation. The present pipe borne water coverage is over 42 per cent and the safe water coverage has increased progressively over the years, aiming the MDG targets set out for water supply sector. At present the primary energy requirement of the country is supplied by fossil fuels (74 per cent) and the hydro power (25 per cent) remains as the secondary energy source. As the energy demands grow, the electricity supply depends more and more on fossil fuels.

Methodology approach

Energy cost represents 22 per cent of the water supply production and distribution cost. The per capita consumption of water has increased rapidly over the last few decades due to the change of life style resulting in an increase of energy consumption for water extraction, pumping, treatment and distribution. This increasing energy consumption has to cope up with fossil fuels which produced environmentally harmful greenhouse gases. The extensive usage of energy to meet the water demand is sensitive to the climatic changes and critically affects the sustainability of water resources

Analysis, results, conclusions and recommendation

In order to address this issue, NWSDB has taken measures to implement an energy auditing program and set guidelines and policies within the organization to reduce wastage. After introducing this programme it is expected to reduce 20 per cent of energy consumption at water systems of NWSDB. Annual potential of energy conservation is 44.8 million Kwh. Annual Carbon Emission Reduction (CER) potential is 32,700 tonnes of CO_2. This reduction will contribute to mitigate the climate change.

Two thirds of the area of the country falls under the dry zone. This area gets exposed to direct sunlight more than 6 hours a day. Sri Lanka Sustainable Energy Authority with the support of other agencies has now taken steps, to implement provision of solar energy for rural villages. Steps have been taken to utilise this solar energy for water supply and household electrification. This programme has also supported to reduce the production of energy using fossil fuels.

The Jaffna Peninsula in the Northern part of Sri Lanka people depend on shallow Ground Water for domestic usage. In the past, water over extraction from wells has drawn down the fresh water stored in the aquifer resulting in sea water percolating into the wells. Since ground water is not feasible in this area, the only feasible water source to supply drinking water was the "Iranamadu" irrigation tank which is 80km away from Jaffna. The energy required pumping water from this source could have been avoided if the water resources in that area had been properly managed without over extraction. Considering this type of experiences, water management systems have been strengthened by establishing policies to overcome such situations. To address climatic changes and its impact, Sri Lanka has taken above measures to optimise the energy consumption for the provision of drinking water to community.

How Much Water and Energy Do We Need for Irrigation under Climate Change in the Mediterranean?

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Keywords: mediterranean, agroecosystem, irrigation water requirements, climate change, photovoltaics

Introduction and objectives

Anthropogenic climate change will very likely alter the hydrological system of already water-limited agricultural landscapes around the Mediterranean. This includes the need for, as well as the availability of irrigation water. On top of that Mediterranean agroecosystems are very likely to be under strong pressure in the near future through changes in consumer demands and diets, increasing urbanisation, demographic change, and new markets for agricultural exportation.

Methodology approach

As a first step to assess the water demand of the agricultural sector, we use an ecohydrological model (the Lund-Potsdam-Jena managed land model, LPJmL) to estimate current and future irrigation water requirements of this region, considering various climate and socio-economic scenarios. LPJmL is a process-based, agricultural and water balance model, where plant growth is ecophysiologically coupled with hydrological variables. For these simulations, the model was adapted to the Mediterranean region in terms of agrosystems as well as crop parameters, and a sensitivity analysis for the irrigation system efficiency was performed.

Analysis, results, conclusions and recommendation

Patterns of current irrigation water requirements differ strongly spatially within the Mediterranean region depending mainly on potential evapotranspiration, the combination of crops cultivated and the extension of irrigated areas. The simulations for the future indicate that the Mediterranean may need considerable additional amounts of irrigation water. However, the regional patterns differ strongly depending on changes in length of growing periods, changes in transpirational rate (temperature and precipitation change, CO_2-fertilisation), and the consideration of potential improvements in irrigation system efficiency.

Bearing in mind that the water demand of other sectors is also likely to increase, the implementation of precision irrigation systems may be not only a useful option to save water but a necessary measure to compensate the increases in irrigation water requirements. However, these systems may also need more energy. Therefore, a first estimation on the potentials of driving irrigation in the Mediterranean with solar energy was performed. The possibilities of using photovoltaics for driving irrigation pumps depend not only on the insolation rate, but also on the inclination used, the desired timing of irrigation and the technical properties of the panels and the pumps (different energy requirements depending on the water flow rate needed). This study shows that solar panels can drive irrigation pumps under certain conditions, showing that this coupling has the potential of being a realistic adaptation option and also a contribution to climate change mitigation.

Energy Efficiency in Water Pumping in Jordan

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Keywords: climate change mitigation, energy efficiency in the water sector of Jordan, energy performance based contracting, water-energy nexus, eco efficiency of water pumping

Introduction and objectives

The German Federal Ministry for Environment, Nature Conservation and Nuclear Safety (BMU) started in 2008 the International Climate Initiative (ICI) to support reducing greenhouse gas emissions. "Improvement of Energy Efficiency (IEE)" of Water Authority of Jordan (WAJ) is a first project under the ICI; it is implemented by the Deutsche Gesellschaft fuer Internationale Zusammenarbeit (GIZ) with WAJ and the Performance Monitoring Unit.

Sustainable energy supply is a challenge in Jordan. Water pumping consumes 15 per cent of electricity supply. High pumping inefficiency results in high costs and increased CO_2 emissions. Therefore, an eco-efficient and sustainable model for water pumping is crucial.

Methodology approach

Energy saving potential in water pumping was assessed in various stations. Pump performance and electro-mechanical aspects were investigated. Water flow, pressure and electricity consumption were measured. Eco-efficiency benefits were estimated assuming the use of improved technology and enhanced operation and maintenance. Technical measures were developed as well as institutional concepts and respective contracts to support implementing the measures in a sustainable manner; such as via energy service performance contracting models with the private sector investing in and operating the pumps, and sharing benefits. Then pilot projects were implemented; most recently the project in Wala/Lib station in Madaba has started.

Analysis, results, conclusions and recommendation

The assessment revealed that the annual energy saving potential from all of the pumping facilities (well fields and pumping stations) would reach to 42'100 MWh (33.5 per cent reduction), equivalent to 3.3 million Euro (based on 2013 electricity tariff). The saved power will result in reducing CO_2 emissions by 30,637 t/y. Around 1/3 of the savings can be obtained from 10 well-field pumping stations, while 2/3 of savings from other 15 network pumping stations.

The Wala/Lib pumping station project involves water supply by WAJ/Miyahuna (water company), while an Energy Service Company (ESCo), comprising an engineering company and pumps producer company, takes the responsibility of pumping the water to the network. The investment in the pilot project is 726'426 EUR (GIZ contribution: 24 per cent) including 8 new high quality pumps to improve the specific energy consumption from 1.02 to 0.90 (kWh/m^3) in Wala and from 1.1 to 0.82 (kWh/m^3) in Lib. At an average of 9 mm^3/y of pumped water and electricity tariff (0.078 EUR/kWh, in 2013), the shared annual savings would reach to (280,800) EUR/y, thus the project simple payback period is 2.6 years. The expected reduction in CO_2 emissions is 1,886 t CO_2 /y.

The outcomes demonstrate a triple win case. The savings from improved energy efficiency are shared; WAJ via the water company can obtain new infrastructure for water pumping together with optimised operation for a long term (due to reductions in operational costs and down time); and reduced carbon footprint of the water supply sector can be ensured.

The sustainability of energy efficiency projects in the water sector can be assured by having high quality equipment and adequate operation and maintenance. Private sector participation via performance based contracts is crucial. This approach is worth considering in other water/energy intensive sectors.

Balancing the Water Requirements of People, Power and Agriculture in Coastal Perú in a Changing Climate

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Keywords: Perú, water, climate change, hydropower, irrigation

Introduction and objectives

The tropical nations of the Andes are beginning to experience the consequences of global climate change. Perú, which has the greatest concentration of glaciers in all of the tropics, is dependent on runoff from its cordilleras for water for hydroelectric generation, irrigation and drinking water supply. Rapid recession of the mountain glaciers will lead to reduced meltwater contribution to stream flow, and diminished water availability in the near future. The concentration of Perú's population, industry and commercial agriculture along the narrow Pacific coastal plain poses sustainability issues for a future which promises warmer temperatures and limited glacial storage of water.

Methodology approach

Analyses of glaciers throughout the central Andes show rapid mass loss as the average annual environment warms. Presently the contribution of melt waters in selected basins has been determined to be as much as 40 per cent of the annual discharge. Melting will increase discharge of the rivers in the near term, however long term prospects are for decreased flow. Reservoir capacity is being increased in the headwater regions of Lima's supply. For drinking water supply this water should only be utilised at critical times, however for hydropower generation within this same hydrologic basin, a steadier year round discharge is desired.

Analysis, results, conclusions and recommendation

Much of the agricultural production of Perú is in the dry coastal regions where year-round climate is consistent, and water is supplied by massive irrigation works. Electric generating capacity in the country (6.2 GW) is about 50 per cent from hydropower (3.24 GW), mostly from small generators of less than 100 MW. Due to the higher cost of thermal generation, about 70 per cent of the energy produced annually is from hydro generation. Even without a changing climate and disappearing glaciers, Perú will face a monumental challenge to meet the water and energy needs of the country's rapidly growing population.

The concentration of Perú's population, industry and commercial agriculture along the narrow Pacific coastal plain poses sustainability issues for a future which promises warmer temperatures and limited glacial storage of water. Less meltwater contributions to the rivers will result in lower flow to the coast, and ultimately will impact irrigation, power generation and most importantly, drinking water supplies. SEDAPAL, Lima's public water utility, is in a race to increase supply from the mountains, to try to catch up to the cities rapid population growth. These costly projects are designed for the needs of today, but may not be adequate for the demands of tomorrow.

Energising the Drops: Towards a Holistic Approach to Carbon and Water Footprints

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Keywords: water footprint assessment, carbon footprint, water footprint, corporate sustainability, water-energy nexus

Introduction and objectives

Assessment methods for energy and water such as carbon footprint and water footprint were developed independently and are often used in isolation. Identifying and prioritizing strategic actions from a single issue perspective can be difficult, especially where impacts from energy and water use are geographically distributed. As challenges around using energy and water sustainably continue to mount and linkages between water and energy resources rise, it is imperative that investments into response strategies are considered within a holistic framework which highlights benefits, synergies and trade-offs. The study presents a holistic framework prioritising response measures for water and energy.

Methodology approach

Best practices adopted by leading private sector organisations in assessing water and energy in their sustainability strategy are collected and analysed through a face-to-face workshop and follow-up consultations. The questions addressed are: what are the real challenges organizations are facing in dealing with carbon and water sustainability? What emerging good practices have been applied to that challenge? How can the science of carbon and water footprint provide direction on steps to be taken toward integration of these two resource use issues? Combining practical experience with scientific underpinning, a synthesis approach to identifying and prioritising mitigation and adaptation measures is developed.

Analysis, results, conclusions and recommendation

Five steps were identified to guide organizations in integrating water and energy holistically in their sustainability strategy. Case studies demonstrated the challenges of addressing the sustainable use of single resources and the leading edge solutions adopted. The scientifically-based methodologies of carbon and water footprint were used to develop a framework which can be applied by any size organization at any point along their sustainability journey. To begin, the carbon and water footprint methodologies are used independently to prioritise were to work and:

1. Formulate response strategies
2. Trade-offs and synergies between carbon and water footprint mitigation and adaptation are assessed and
3. An integrated sustainability strategy is developed
4. Finally, strategic actions, e.g., mitigation and adaptation measures, are implemented
5. To go beyond managing water and carbon as environmental issues, companies need to look at water and energy from a variety of perspectives to address the strategic, operational and supply chain implications. In the trade-off analysis, linkages between water and energy need to be examined for the se-

lected set of response strategies. Differences between the carbon and water footprint must be considered, e.g., the temporally and spatially explicit nature of the water footprint may require special attention to ensure that response strategies that address the single issue of water are not lost; a portfolio assessment is preferred when trade-offs are assessed. Response strategies could include, but are not limited to: new investment in technology and improved practices, resource use reduction, strategy & due diligence, stakeholder engagement, knowledge sharing, and innovation. Not all benefits can be monetised: strategic considerations such as long-term business viability, interruption of supply, reputational damage and impact on share price need credible evaluation. This study provides a comprehensive but feasible approach that both encourages and supports more organisations to integrate water and carbon footprint strategies.

Long Term Water Requirements for Energy Generation: An Analysis of the Shared Socioeconomic Pathways

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Keywords: mitigation, biomass, electricity, shared socioeconomic pathways, integrated assessment modelling

Introduction and objectives

A growing world population and rising consumption increase the pressure on energy and water resources. At the same time, water is a key input of all energy production and conversion processes and, as a consequence, the evolution of energy systems has significant repercussions for future water demand. These need to be taken into account in order to plan coherently future climate, energy, and water strategies. This presentation aims to analyse the implications of future baseline and mitigation pathways on global water and energy use, with a focus on electricity generation and biomass production.

Methodology approach

The analysis is based on results of the REMIND-MAgPIE modelling framework, which incorporates an integrated assessment model of the economy, the climate system and the energy sector (REMIND) and a land use model representing costs of agricultural production, food and energy demand, and land and water constraints (MAgPIE). The investigated scenarios combine assumptions on future narratives of demographic, economic, and natural resource developments, known as Shared Socio-economic Pathways (SSPs), with baseline (no climate policy) and ambitious climate policy (2-degree target) conditions. The three analysed SSPs include the 'Sustainability' (SSP1), 'Middle of the Road' (SSP2), and 'Conventional Development' (SSP5) scenarios.

Analysis, results, conclusions and recommendation

The results provide important insights on the effects of future socio-economic developments and ambitious climate stabilization targets on demand for energy and water. Bioenergy is an important component of the future energy mix, in particular under climate change mitigation and in a world of high energy demand. Irrigated bioenergy production results in substantial water withdrawals and increased water scarcity, but is accompanied by lower land requirements and prices for bioenergy. Negative effects on water resources are aggravated in scenarios with higher bioenergy demand. Electricity demand expands significantly over the course of the century in both baseline and climate policy scenarios, but this expansion varies considerably across SSP scenarios. Associated water demand increases more conservatively, due to structural changes in the electricity mix resulting in lower water intensities per unit of electricity across time. Cumulated water consumption over the century rises for hydropower but decreases for all other electricity generation purposes in climate change mitigation scenarios. Total cumulated water withdrawal also decreases with climate policy due to the phase out of fossil fuel-based power generation. Variation across SSP scenarios is considerable, with the 'Sustainability' scenario having the lowest water demand,

while the 'Conventional Development' scenario, characterised by high demand and abundant fossil fuel availability, being associated to the highest. These results enhance our understanding of the interactions between energy and water and the associated uncertainty across a number of future socio-economic narratives. They also provide an indication on the synergies and trade-offs of ambitious climate mitigation policy for water resources, highlighting the need for integrated energy and water planning in the process of combating climate change.

Micro Irrigation for Enhancing Energy and Water Use Efficiency: Analysis of Climate Change Mitigation and Adaptations Impacts in India

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Keywords: agriculture, irrigation, groundwater, performance, sustainability, climate change adaptation

Introduction and objectives

The water and energy policies pursued over last five decades have put India in a bind-political compulsion to supply highly subsidised energy to mine the groundwater for irrigation with adverse environmental impacts. Micro-irrigation, which has spread over 4 million hectares, as a result of new programmes like accelerated irrigation benefit programme in agriculture (AIBA) and national horticulture mission (NHM), could be a mechanism to establish synergy between energy and water use in agriculture to reduce its carbon footprints. A quantitative analysis of the impact of micro-irrigation on adaptation and mitigation of climate change impacts in India is presented

Methodology approach

The impact evaluation is based on country level estimates from area under micro irrigation in respect of increased crop production,irrigation efficiency and the energy saving on account of reduction in groundwater pumping. The impact indicators were, change in greenhouse gas emission (mitigation), increase in per ca-pita food availability (adaptation) and water withdrawal to renewable water ratio (sustainability) between 1990 and 2010. The impacts were adjudged as poor, fair, good and excellent depending upon the percent positive changes in the performance indicator values. The emission reduction due to avoidance of forests conversion to agriculture was treated as adaptation led mitigation.

Analysis, results, conclusions and recommendation

Most of the micro irrigation in India is ground water based. Since it saves water, it reduces the pumping requirement and thereby saves energy even after taking into consideration the energy used in pressurising micro irrigation. Above all, there are reports which show increase in crop productivity 20-40 per cent, and higher irrigation efficiency by 20-60 per cent. We evaluated the impact of micro irrigation at three discrete levels of efficiencies: 20, 30 and 40 per cent. Water savings from the currently micro irrigated area of 4 million hectare (Mha) at 30 per cent efficiency increase was of the order of 0.73 billion cubic meters (BCM) with the possibility to reach 10 BCM, if the entire area of 42 Mha, adjudged suitable, is covered. The current incremental food production was 3.5 million ton (Mt) with potential to reach 37 Mt raising the per capita food availability by 3.13 and 33.86 kg/cap/yr, respectively. The current and potential reductions in GHGs were of the order of 2.152 and 22.24 Mt CO_2e. It also improved the sustainability rating by keeping water abstraction ratio below 0.85 (Fair). The current contribution of micro irrigation towards climate change mitigation, adaptation and sustainability was rated fair (20 per cent change in desired performance parameter value) in irrigation sector.

Workshop: Valuation, Economics and Finance

Embedding Good Water Stewardship Practices in the Supply Chain – A Discussion of Why and How

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Keywords: supply chain, risk management, water, stakeholder engagement

Introduction and objectives

The real value of water to business is increasingly recognised. This is coupled with growth in the number of companies seeking to understand material risk and seek mitigation strategies that increase business resilience, secure licenses to operate and protect brands.

An increasing proportion of respondents to CDP's water program report exposure to water risk across their supply chains. In 2013, 39 per cent of Global 500 respondents reported this – a 44 per cent increase since 2011. A number of leading companies are beginning to take action.

This presentation provides an overview of experiences from four companies, who engage their supply chain on water.

Methodology approach

In 2014, 14 CDP Supply Chain member companies identified 1,362 suppliers to engage on water issues, the results of which will be available in October. Last year, 229 suppliers disclosed water information through CDP:

- 33 per cent report operations located in water-stressed regions
- 36 per cent report exposure to substantive water risks
- 20 per cent report their own supply chains are exposed to water risk, but few are ready to engage on this issue.

Analysis of responses will be presented alongside a review of purchaser vs investor power. Insights of how companies are using reported data to inform their purchasing decisions and improve business operations will also be presented.

Analysis, results, conclusions and recommendation

In this workshop, we will aim to:

- Shine a light on water risk exposure across the supply chain
- Explore purchasing power vs investor power when driving greater water stewardship
- Highlight the benefits to companies of working with their supply chains on water
- Provide practical insight into how the power of supply chain transparency can increase water stewardship and deliver greater business resilience

"We encourage our suppliers to measure, reduce and report their climate change and water-related impacts and strategies through CDP. A factor of our success in driving supplier performance and ambition in these areas is that it is no longer solely our environmental experts who discuss these issues and areas for improvement with suppliers; purchasers trained in this area have now also become ambassadors."

– Miguel Castellanos, Director of Global Safety, Health & Environment, L'Oréal

While there is increasing acknowledgement of the importance of engaging suppliers on water, the disparate and complex nature of supply chains can make engagement difficult. This presentation will showcase how a selection of large multi-national companies, L'Oreal, Unilever, Dell and Pfizer, are using the power of transparency and corporate governance to engage with their suppliers and promote good water stewardship resulting in reduced risk exposure and improved business resilience.

Assessing Hydropower in Ecosystem Services Conservation Scenarios – A Case Study in the Alpine Region

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Keywords: hydropower, ecosystem services, optimal locations, cost minimisation

Introduction and objectives

The Alpine Region is a major source of renewable energy: 15 per cent of the total power production of the Alpine Countries is generated from hydro-power plants based in the Alps. It is expected that the capacity will increase due to the goal sets by the European Union by the year 2020 as well as the withdrawal from the nuclear power production from Germany, Switzerland and partially Italy. Its expansion is rather limited; all sites economically interesting and less constrained are well equipped since a long time, but some places still remain for the expansion of both small and large hydro-power plants.

Methodology approach

Based on the locations of the existing hydro-power plants, a detailed slope map, precipitation map, information on the most interesting water flows for hydro-power plants set-up, and distance to power grid connection, the optimal locations of potential hydro-power plants will be determined on a minimization cost approach. On top of the location of the hydro-power plants, an analyses and a ranking of the different types of ecosystem services in the Alpine Space Region will provide detailed information on where and with which ecosystem services the hydro-power plants come into conflict.

Analysis, results, conclusions and recommendation

Starting from a "no restriction" scenario down to a "very constrained" scenario on different ecosystem services that will be selected and ranked, the results will provide information of a set of spatially explicit locations of hydro-power plants that are optimally located for increasing the power production. And a cost of power production at each specific site will be derived depending on the priority set on the ecosystem services.

The preliminary results show that the expansion of hydro-power can be consequent if no restriction on the ecosystem is set, but a highly constrained scenario limits the production of larger scale hydro-power plants or even marginal production.

This information will be highly valuable for policy makers, when a compromise has to be overcome between setting up a hydro-power plant (definition of the location and the capacity) and limiting the threat on the ecosystem services.

Water-Related Business Risk Assessment in the Oil and Gas Industry

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Keywords: oil, gas, water, risk, adaptation

Introduction and objectives

A generic approach to water-related, scenario-based business risk assessment from the Oil and Gas industry's perspective is proposed and demonstrated for Shale Gas and one or a few other cases.

It is argued that the "abatement cost curve" which is widely used in CO_2 policy-making does not work for water risk mitigation. When it comes to reducing water stress and vulnerabilities to climate change with extreme events, the "cost of adaptation" is suggested to be the key performance indicator.

Methodology approach

Principally speaking, water constraints can be met technologically, whether physical (hydrological), regulatory or reputational by nature. However, what matters from a business risk perspective is the cost of adaptation to water constraints by means of smart water management solutions, and the impact of these adaptation costs on operational cash flows.

Generic approaches to operational water accounting and to calculating costs of water management solutions have been developed. These enable the comparison of water-related business risk on a like-for-like basis for different energy businesses, and for different potential water management solutions. Also, quantitative long-term scenario-based risk assessment is made possible.

Analysis, results, conclusions and recommendation

The present paper proposes a generic approach to water-related business risk assessment from the Oil and Gas industry's perspective.

Quite some water scarcity, water stress, water security and water footprint tools exist already and are further developed by several institutes. However, none of these tools enable the assessment of business risks that result from operational exposures to reported water risks, and none is solution-focussed.

To fill the gap, generic approaches to operational water accounting and to calculating costs of water management solutions have been developed. These enable the comparison of water-related business risk on a like-for-like basis for different energy businesses, and for different potential water management solutions. Also, quantitative long-term scenario-based risk assessment is made possible.

The approaches and methodologies will be demonstrated for Shale Gas and Light Tight Oil production and one or a few other cases.

Businesses know their current and future needs for water intake from sources and disposal into sinks. On the other hand, academic, governmental and non-governmental institutions investigate physical, regulatory and reputational availabilities of both water sources and water sinks, both today and into the future.

Evidently, mitigation of water risks necessitates good interfacing between water availability assessment tools and water-related business risk assessment tools. This notion prompts a firm call for collaboration between all stakeholders involved.

Finally some fundamental differences between carbon-related and water-related business risk assessment are discussed. It is argued that the "abatement cost curve" which is widely used in CO_2 policy-making does not work for water risk mitigation. When it comes to reducing water stress and vulnerabilities to climate change with extreme events, the "cost of adaptation" is suggested to be the key performance indicator.

Business Value at Risk as a Strategy to Address/Mitigate Water Risk in the Energy Sector

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Keywords: water – energy nexus, water risk, business value at risk, stranded assets, collective action

Introduction and objectives

Evaluation of the business impacts of water related risks to O&G/Power has moved beyond water scarcity and water quality mapping. Businesses have reported that their operations/supply chains are exposed to water risk and have been impacted. Investment in mitigation is hampered by the price of water and not the business value at risk. Determining quantifiable business value can catalyse water stewardship strategies and capital investments to address water related risks. A case is made for moving beyond evaluating risk to business value at risk with case studies.

Methodology approach

A detailed roadmap will outline how physical, regulatory and reputational risk can be quantified and the steps to develop a water stewardship strategy and stakeholder engagement action plan to mitigate business value at risk in the energy sector. Steps to evaluate the impact to the top and bottom-line along with estimating the potential value lost and helping to attain a business case for action in terms that business can finally estimate the materiality of risk will be presented.

Analysis, results, conclusions and recommendation

The presentation will consist of the following elements:

- An overview of water risk – physical, regulatory and reputational
- Examples of business disruption and potentially stranded assets in the energy sector
- A detailed framework for quantifying business value at risk
- A roadmap for moving beyond water risk evaluation to water stewardship strategy and collective action to mitigate business value at risk
- Discuss the growing maturity of business forays into water and where they are beginning to touch closer to public water management challenges

The value of the presentation is that it will:

- Support the business case for collective action between the private and public sectors;
- Move closer to quantifying the business value of water (business continuity, social license to operate and brand value); and
- Create a roadmap linking water risk to business value at risk to strategy development and implementation.
- Move the corporate debate along the continuum of water footprint to impact to risk to materiality
- Provide more depth and understanding to corporate forays into water issues and challenges that are more aligned to wider water issues
- Bring corporate actions and interest in water closer to the point of advocating and supporting the management of water in the public interest – as determined by societal and business value

Payments for Ecosystem Services to Alleviate Poverty – A Case Study of Mangrove Wetlands in Vietnam

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Keywords: payment for ecosystem services, wetlands, Vietnam, poverty reduction, mangrove

Introduction and objectives

The coastal wetlands and mangrove ecosystems in Vietnam suffer from two interconnected challenges that need to be addressed - poverty and degradation of ecosystem services (ES), which include climate regulation, protection of fresh water supplies from saltwater intrusion and food provision. This project examines how alternative Payment for Ecosystem Services (PES) schemes may improve income possibilities for local landusers, while also improving the supply of ES.

Methodology approach

This project is a practical application of economic theory and best international practices, complemented by field research and a livelihood pilot study in Mui Ca Mau National Park (MCMNP), to propose and evaluate alternative PES schemes in the coastal wetlands and mangrove ecosystems in Vietnam.

Analysis, results, conclusions and recommendation

Ecosystem services in the coastal wetlands in Vietnam are under pressure by population growth, economic development and climate change. Further, high levels of poverty and the lack of adequate economic incentives for households makes the preservation of mangroves a low priority for those living in the area. Creating markets and putting a price on ecosystem services can be a cost-efficient approach to address these environmental problems while possibly also improving the livelihood of low-income households.

The report identifies five alternative PES schemes: 1) Agriculture, 2) Eco tourism, 3) State buyers, 4) Carbon markets, and 5) Eco-labeling. These alternative PES schemes illustrate the opportunities for diverse PES approaches, which cover several ES with beneficiaries on different geographical level (local, national and global) and provide alternative funding opportunities. The report also considers how to combine and layer these PES schemes to maximise environmental benefits and household incomes. The benefits and challenges of these PES schemes are evaluated in terms of their economic, social and environmental merits. The report also identifies unavoidable value judgments and discusses the resulting trade-offs facing policymakers, for example regarding relative value of conflicting ecosystem service, income distribution effects or other goal conflicts.

The authors recommend that further research analyse the opportunities for (1) developing a carbon sequestration program that can be integrated into international carbon markets and (2) an eco-labeling program for aquaculture production. The analysis concludes that these two schemes have the greater potential for improving the flow of ES – in particular climate regulation, food provisioning and water purification – relative to the current baseline management scenario. Moreover, these two schemes provide funding from the global community and do not depend on Vietnamese tax-revenues or international donors.

Workshop: Integrated Water and Energy Policy and Governance

Water and Energy as a Catalyst for Middle East Peace

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Keywords: water, energy, middle east, peace process, peacedividend, Israel, Palestine, Jordan

Introduction and objectives

Agreements reached in Europe over steel and coal were the backbone to the creation of the European Union. Water and energy issues could be the backbone to a more peaceful and sustainable Levant.

Methodology approach

While the Memorandum of Understanding signed in December 2013, between Jordanian, Palestinian and Israeli Water Ministers, witnessed a new era for potential water exchange, the inclusion of energy into the mix makes for a far more sustainable interdependence of geopolitical interests in the Levant based on the water and renewable energy nexus.

Analysis, results, conclusions and recommendation

In the water sector, new technologies related to water supply, both in treating waste water for reuse in agriculture and in the desalination of marine water for domestic purposes have already revolutionised the water sector in Israel. From a water economy just a decade ago of 2 billion cubic meters, the development and adoption of these technologies have increased Israel's water economy to over 3 billion cubic meters per annum today. Of critical importance to the Middle East peace process, the additional water available should make it more politically feasible to reach a water sharing agreement over shared natural waters between Israelis and Palestinians.

Likewise the discovery of natural gas in the Eastern Mediterranean has the potential to be another game changer, not only from the use of the gas itself, but no less importantly from the government royalties to be gained. The premise here is that the investment of wealth funds be directed to advance long term sustainable renewable energy production for the region that would power more sustainably the high energy use of new water supply technologies.

Jordan well understands its potential to be a solar energy power house, blessed with an average of 320 sunny days a year. Unlike Israel, Palestine or Lebanon however and perhaps most critically, Jordan holds the extensive desert land reserves needed to house the extensive solar farms that would need to be built.

The long term relationship to be created is one of interdependence with Israeli, Palestinian and potentially Lebanese Mediterranean shores providing the much needed additional water to the Levant as a whole, in the short term fuelled by natural gas reserves, but in the longer term to be fueled by extensive investment in solar energy production in Jordan.

Energy Pricing and Water Services

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Keywords: hydrology, generation-mix, tariff regulation, energy efficiency, operational efficiency

Introduction and objectives

During 2007, 2009, 2010 and 2011, Tanzania experienced low precipitation resulting in low volumes of water stored in the major reservoirs for hydropower generation. Tanzania by then relied highly on hydro-power generation by up to 60 per cent. The drought situation led to a change in the generation mix between hydro and thermal sources, increasing operational costs and necessitating an increase in tariff by the National Power Utility. This paper analyses empirical evidence in a case study of the Tanzania National Electricity Company tariff regulation and the consequential impact on operational costs for Dodoma Water Utility, which predominantly depends on water pumping.

Methodology approach

The impact of low water levels at the hydropower reservoirs caused by drought and dependency of hydropower generation particularly at Mtera dam, which is a determinant in the national grid system stability, is analysed. Further, the study highlights the effect of a revised electricity tariff on Dodoma Water Supply and Sanitation Authority (DUWASA), which is predominantly relying on a water pumping system and, therefore, facing high costs. Finally, recommendations for energy efficiency installations for water pumping systems for DUWASA are outlined.

Analysis, results, conclusions and recommendation

The paper highlights the importance of hydropower for controlling grid system reliability in Tanzania and the multiplying effect of tariff regulation in the energy sector. To this end, the impacts of the decreasing dam water levels at Mtera Hydroelectric Plant are analyzed. Power generation from the plant is essential in controlling the grid system reliability. Corresponding changes in tariffs are showcased. The regulatory authority approved an emergency tariff increase of 40.29 per cent in January, 2012 and a multi-year tariff increase of 39.19 per cent in December, 2013. These tariff increases subsequently affect operational costs of water utilities, especially where utilities have to rely on pumping systems for water production. The case of Dodoma Water Utility (DUWASA) which has 100 per cent water pumping system is analysed focusing on the existing pumping system installations. The analysis includes a look at the impact rising operational costs have on the water tariffs and, therewith, on the access to safe water services by the customers. The case study is used to establish and recommend proper energy efficiency installations that will reduce water pumping costs and allow affordable water tariffs. Additionally, the paper assesses regulatory instruments able to improve the interrelationship between and the planning for both, the energy and water sector.

Overall the paper gives recommendations on 1. Improved energy efficiency in utility pumping systems and potential for using renewable energy sources; 2. The interdependency of multi-sector tariff regulation; 3. The development of regulatory instruments to guarantee affordable energy and water for all.

Context Vulnerability of Isolated Water and Energy Governance in Nigeria: A Critical Review of Sector Reforms

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Keywords: water, electricity, energy, Nigeria and utilities

Introduction and objectives

Urban Nigeria suffers from absence of functional amenities, infrastructural decay and environmental degradation etc. There can hardly be socio-economic development and sustainability in any situation where a majority of the urban population lives in poverty and lack basic services. Current sector reforms in water and electricity services are aimed at improving utilities' performance as the provision of basic services, water and energy; remain the yardstick of urban environmental action. The hazard of energy costs on Nigeria's economy is not unconnected to realities in water utility operations.

Methodology approach

A case study of four water utilities in Imo, Cross River, Rivers and Bayelsa states of Nigeria assessed the water utilities' vulnerability to high operation and maintenance costs especially energy costs and its implications to achieving operational resilience. The study used a combination of the Delphi technique and the survey questionnaire to obtain primary information in addition to a review of literature. The survey covered 8 respondents per utility (or 32 persons from the 4 utilities) and lasted for a period/duration of 4 – 12 weeks.

Analysis, results, conclusions and recommendation

It is estimated that a financial need of US$2.5billion is needed to finance water and sanitation in Nigeria through 2015. However, the energy cost of this proposal was omitted. This is against the background that intermitted energy services causes persistent electricity outages that results in intermittent water services and damage to electromechanical equipment of water utilities. The poor availability of electricity from the grid and the reliance on diesel generators has enormous impact on water utility operating and maintenance costs. Nigerian economy expends an average 2.6 million liters of diesel per week or an average US$22.2 M yearly using high GHG-emitting off-grid diesel generator at a high cost of about US$0.22 a kWh as compared to the current grid based tariff of US$0.081 per kWh to generate their own electricity. In monetary terms it indicates that water utilities in each of the 36 states and the Federal Capital Territory (FCT) Abuja, spends a conservative estimate of about US$25,000 on diesels in a month to supply water intermittently. This high cost forces water utilities to scale down hence shrinking opportunities for enhanced public health and economic prosperity for the urban residents. The result is that many utilities remain uncompetitive as a result of the low base tariff that hardly covers the water production cost. The study underscores that reliable electricity supply is essential to value-addition in water services. And that water utilities can achieve energy supply security by utilizing the nation's renewable energy resources (including wind, solar, hydro and biomass) to diversify and optimise the energy mix, while ensuring sustainable and environmentally friendly energy practices. Outstanding here is the nexus of sustainable energy generation and water services which needs to be integrated to underpin water sector governance in an uncertain world.

Desalination Units Using Renewable Energy Sources on the Arid Islands of Greece

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Keywords: desalination, wind, solar, Greece, island

Introduction and objectives

This study examines the cover of water needs on the arid islands of southern Aegean Sea using desalination plants which will produce potable water. Part of the desalination energy requirements will be covered by energy produced from Renewable Energy Sources (RES). This study is based on the new RES/2010 legislation framework. The purpose is to detox the islands of the quantities of water being transported with ships from mainland Greece. Furthermore, this project strives to investigate and promote the exploitation of the rich wind and solar resources of Greek islands.

Methodology approach

There is a methodology set in order to dimension desalination plants on the islands, the selection and the dimensioning of RET plants that will supply part of the energy requirements of desalination, for calculating energy balances of the operation of the connected to the grid desalination system using RES and, finally, calculate the cost of the desalinated water and the selling price of that so as the investment to be viable and profitable for the investor. This methodology is applied on 3 characteristic islands (large, medium, small). Several scenarios based on law interpretation and RES penetration are then carried out.

Analysis, results, conclusions and recommendation

Input and default data are the following ones: water demand of each island, water tank capacity, variation of the annual electricity demand, tourism and demographic figures to project the water demand in 20 years perspective, wind speed and solar irradiation time series, desalination's energy requirements, feed-in tariffs, fuel prices, wind power curves, solar photovoltaic efficiencies, investment, operating and maintenance (O&M) costs of the technologies, water tank cost, tax and subsidies figures.

Optimised wind turbines and solar photovoltaic capacities are proposed for each island. The optimised solution for larger islands is the installation of wind turbines while additionally solar photovoltaic panels can be installed.

In smaller islands the RET unit selection is not as clear, since the installation cost per KW of smaller wind turbines is significantly higher in comparison with the larger ones. In that case the solar PVs are competitive and screening criteria play important role in the RET selection. The water selling price is expressively lower than the transported water cost in all cases and the implementation of such a project would be beneficial for all the involved actors; the Hellenic State, investors, and of course islanders and tourists who will be able to drink potable water without being obliged to spend a significant amount of money on bottled water.

The methodology and the tool developed for this project contribute to the dimensioning of desalination units and RET units which can be integrated in such a system in order to diminish water and energy costs and environmental impact. The tool developed constitutes a planning and design aid for the Hellenic Ministry of Environment, Energy and Climate Change as well as the Hellenic Ministry of Shipping. It is also an assessment tool for related investment plants.

Changing Water Consumption Patterns Alter the Course of Governance in the Zambezi River Basin, Southern Africa

Author: Ms. Belynda Petrie, OneWorld Sustainable Investments, South Africa

Keywords: policy reform, economic growth, consumptive behavior, transboundary systems, climate change

Introduction and objectives

Water is increasingly critical to development. Increased agricultural yield from irrigation improves food security and hydropower is essential to development and trade in growing economies in the Zambezi. Additionally, drought induces water stress and demand is growing. Until recently, the Zambezi experienced low consumption. This meant that explicit trade-offs posed less of a challenge for the basin overall. This is likely to change requiring explicit agreements. Energy is a recognised water benefit but the region is unused to manage for benefit sharing and the impacts of future climate necessitate explicit overall system planning. Alternative institutional arrangements are suggested.

Methodology approach

Analysing development and climate change drivers follows a political economy of water approach looking at benefit sharing given rapid economic growth. Climate and development considerations demonstrate how basin investments are affected. Two hydropower investments in countries making other development decisions highlight returns on investment. This raises questions for governance and policy development, facilitating a consideration of institutional arrangements that keep abreast of the pace of change in the Zambezi, as representative.

Institutional analysis linked to the requirements of cross-sectoral planning is assessed across major development sectors. The authors with governments and RBOs conduct this analysis using international benchmarks where appropriate.

Analysis, results, conclusions and recommendation

Economic development is a driver of change in consumptive patterns in the Basin. Climate change is a stress multiplier, with changes potentially happening in parallel with rapid economic growth in many of the basin's economies. The Basin has already experienced examples of the negative economic impacts of inadequate rainfall and some hydropower investments are not realizing expected returns on investments as a result of climate as well as policy-based development decisions. Sector based policy continues to prevail with relatively little incentive for mobilizing cross sectoral investment planning, an issue that is exacerbated by vested national and sector based interests. Civil society activism and compliance mechanisms are an inadequate solution particularly as consumption patterns show rapid change.

The water energy nexus in rapidly growing economies and increasingly stressed river basins creates a further impetus for change but cross sectoral as well as transboundary accountability and robust, relevant institutional arrangements are critical success factors. This is what should underpin alternate institutional arrangements in embryonic regulatory environments in Africa's shared river basins and growth-based economies, such as the Zambezi.

Energy and Water Strategic Plan. Department Montevideo – Uruguay

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Keywords: strategic plan, alternative energy, efficiency, water, citizen participation

Introduction and objectives

Strategic Plan lines are defined to contribute to:
1. The development of alternative energy.
2. Energy efficiency.
3. Raise awareness about the value of energy and water.
4. The link between water and energy.

Objectives
1. To develop energy efficiency and water management plans.
2. To improve energy efficiency in Montevideo, adjusting departmental regulations and infrastructure of public space.
3. To promote the use of renewable energy sources and know their potential in Montevideo.
4. To generate projects.
5. To create areas of citizen participation, train staff and spread the Energy and Water Plan.

Methodology approach

Departmental policy guidelines integrate the goals, targets and programs in the framework of an Energy and Water Strategic Plan.

Some questions arise.
1. What is the state of the subject?
2. Which are the operational paths for their development?
3. Which management and formal approval are necessary?

A committee for the development Strategic Plan for Montevideo, for design, development, implementation and monitoring of the Plan, was formed.

Secondary information was reviewed, meetings with political actors and citizen participation workshops were made. In addition, the members of the Commission were trained on issues such as renewable energy, energy efficiency, water efficiency, sanitation, etc.

Analysis, results, conclusions and recommendation

- Energy efficiency plans were developed. Energy and water balances were made based on historical information of consumption of electricity, gas and water, inventory of equipment which consume energy (pumps, air conditioners, computers, lighting, etc.).

- A total of 40,000 efficient public lights were placed in Montevideo. It meant an average savings of 16 GWh/year.
- Bikeways were performed in the context of the Mobility Plan of Montevideo and it is diversifying the transport matrix to promote sustainable transport, reducing their impacts on energy and the environment.
- It has been worked on the Thermal Insulation for Buildings, incorporating the efficiency of energy and water from design and construction.
- A multisectoral place to promote Solar Thermal Energy in Uruguay was generated.
- Solar thermal collectors were installed in the locker rooms of the Technical Unit for Public Lighting, to heat the water. Currently this experience is being replicated in different sectors that use water in the Government of Montevideo.
- The possibility of using municipal solid waste for energy purposes in Montevideo was analysed. The sanitary landfill has methane capture devices, and the possibility of using the gas for electricity generation is being evaluated.
- The viability of installing large-sized wind turbines in Montevideo was studied and, as a result, the Wind Map of Montevideo Department was performed.
- The Energy and Water workshops are part of Montevideo Environmental Agenda. The citizen participation is very important.
- Technicians and professionals were trained. Courses were focused on: Energy Efficiency, Energy Audits, Street lights Efficient, Cleaner Production, etc.
- Finally, the Energy and Water Strategic Plan of the Government of Montevideo was drawn. It contains the main actions to be framed in the energy and environmental policy issues, conclusions and recommendations.

Broadening the Lens – A Regional Perspective on Water and Energy Integration in SADC

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Keywords: regional integration, institutional economics, transboundary, policy, governance

Introduction and objectives

This paper examines what a regional strategic perspective on water-energy-food linkages might look like in the Southern African Development Community (SADC). While transboundary water and energy projects have developed for several decades in SADC, the question arises as to whether this is the optimal mode for the future.

One can identify four modalities of transboundary infrastructure projects for water and energy: national projects with transboundary impacts; joint projects between states; infrastructure developed in one or more countries for regional benefit; or regional benefits arising from a regional decision-making process. It is this latter approach that is examined in this paper.

Methodology approach

The methodology used was based on an institutional economics approach, linked to an assessment of the physical endowments in relation to water, energy and agriculture of the various countries in SADC and the region itself, as well as possible climate change impacts in the region. The analysis was conducted through an economic, institutional and political to examine what a regional view of optimal energy, water and food development might look like.

The institutional requirements to achieve a regional WEF development vision were examined, in relation to policy, legislation and governance requirements, within the SADC context.

Analysis, results, conclusions and recommendation

The paper analysed the potential opportunities arising from a regional perspective on the provision of water, energy and food, as opposed to a national or basin level view, taking an integrated view on water, energy and food.

As it stands, within the region, there is a regional power producing pool, with a regional view on energy generation, and there are a number of transboundary water projects. There is also a process underway to move towards enhanced regional integration. The research examined what opportunities for regional water, energy and food production might be offered by the regional integration drive, by the specific natural endowments of the various countries and the region, and the level of development in the various countries, and what the picture generated by using this lens might look like.

The paper concludes that the regional opportunities in relation to food, energy and water are rooted in the current endowments of the various countries and the region, their level of development, and the institutional and political framework in the region. The paper highlights the opportunities and challenges that arise from taking a regional perspective on water, energy and food. The paper offers a new perspective on addressing the challenges faced in the SADC region in relation to the provision of water, energy and food, particularly in the face of climate change.

Integrated Approach towards Water Security in Central Asia

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Keywords: integrated approach, water security, water efficiency, water governance, driving forces

Introduction and objectives

The practical success of wide IWRM implementation in Central Asia could be achieved due to existing objective factors such as water scarcity and understanding among water professionals of the need to improve water use and management efficiency. Certain political support already gained from the government officials who become aware of visible benefits from IWRM concept in on-going reforms in water and related sectors, including energy. For farther expansion of IWRM principles, it is essential to generate driving forces as the major underlying causes that trigger change and help to promote further development and progress in the water and energy sector.

Methodology approach

The challenge is to form a critical mass of driving forces for further IWRM implementation at different levels of water resources management hierarchy. This critical mass of driving forces that involves incentives, motivations and stimulus will ensure that IWRM is self-sustained. Motives could be divided into natural (demographic and geographic) and social factors. Social factors are divided into material-economic, socio-political and ethical, objective and subjective. Due to the fact that driving forces are more material and moral incentives are only developing towards more efficient water management, the role of stakeholders at all levels is crucial

Analysis, results, conclusions and recommendation

Acceleration of the IWRM implementation and more complete realization of its principles can be achieved through the increase of IWRM adopters. Achieving critical mass that is about 25-30 per cent of total stakeholders will allow IWRM to become self-sustaining and create further growth. Currently, IWRM implemented only on about 5 per cent of total irrigated area in Central Asia. It means that we need to engage another 20-25 per cent of IWRM adopters to reach the stage when process will continue without strong external support and promotion.

The IWRM related project interventions helped to create driving forces that are able to assist the countries in formulating their national water development strategies on the basis of IWRM with a view of reaching water security. The following outcomes are expected in the coming years (up to 2017):
1. IWRM consistency should be fully understandable and acceptable by almost the all Governments (National Water Authorities) and the key stakeholders.
2. IWRM procedures should be fully documented and presented in the form of know-how packages, applicable by different stakeholders at all hierarchy levels of water management.
3. There should be created IWRM Knowledge chain in the form of capacity development system.

More extended driving forces will help to raise capacity and ability of the Central Asian countries to use the power of IWRM for sustainable development and increase water security, which should ensure the following dimensions:

- Provision of every household with public utilities related to water supply and sanitation;
- Achievement of economic productivity in all sectors of economy (including irrigation and energy sectors);
- Sustainable development of the urban zones and cities (which still is not properly maintained in the region);
- Maintaining healthy river and aquatic ecosystem environment;
- Adaptation of society to various changes (climate, risk management, preparedness for manmade and natural disasters, etc.).

Workshop: Access, Poverty and the Post-2015 Development Agenda

Innovative Drip Irrigation as a Tool for Alleviating Poverty, the Case of Jharkhand, India

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Keywords: drip, smallholders, poverty, food, water

Introduction and objectives

Approximately 500 million smallholder farms provide over 80 per cent of the food consumed in the developing world. Operated by full or part-time growers, these farms support an estimated 2.5 billion people. Some 55 per cent of that, about 1.4 billion, lives on less than $1.25 a day, with the majority residing in Southern Asia and sub-Saharan Africa. Offering smallholders innovative and affordable drip Irrigation, together with knowledge transfer and capacity building, can save water, increase food production, reduce or eliminate energy usage, and help close gender gap. Ultimately, these efforts can move smallholders from below the poverty line to above the poverty line.

Methodology approach

Analyzing a recent project in the Indian state of Jharkhand, we will show how drip irrigation improves smallholders' lives, transforming them from subsistence to commercial farmers.

The project involved the introduction of a gravity-based drip irrigation solution requiring little-to-no energy for operation.

The many parameters we will evaluate include the ROI for different crops, growers' earnings, and water savings. We will describe the importance of partnering with other stakeholders and the subsidy and loan mechanism used to finance the project. Finally, we will discuss potential energy concerns and the impact of drip technology on the lives of local women farmers

Analysis, results, conclusions and recommendation

Jharkhand is one of India's poorest states; 45 per cent of the population lives below the poverty line, and that figure rises to 75 per cent when taking into consideration non-income factors. Nearly 80 per cent of the state's residents are farmers. Most of the farms are rain-fed, only 10 per cent are poorly irrigated, and over half of the farming area is degraded due to soil erosion. Overall, the local agricultural sector suffers from low investment, low productivity and low income.

We analysed various stages of the project and identified myriad challenges: learning how to work with smallholders, as well as addressing the lack of water infrastructure, insufficient availability of credit, inadequate or non-existent electricity, poor soil, and challenging topography.

At the outset of the project, which started as a pilot with 30 farms and has already scaled up to 20,000, we identified potential participants through local agencies and banks, and then selected a minimum number from several villages to create a sufficiently large pool for carrying out training and logistics efficiently. Training and agronomic knowledge transfer were essential components to ensuring capacity building and project success. Some of the topics covered included the operation and management of an irrigation system, soil preparation and crop planning, fertigation & irrigation scheduling, plant protection, project monitoring, and post-harvest management.

Financing to cover the cost of the drip irrigation systems and related agricultural inputs was divided between local government subsidies and loans.

Participating farmers grew vegetables during three seasons each year, leading to a steady cash flow that enabled them to repay their loans after one-to-two seasons.

Innovative technology, particularly simple, practical and widely applicable drip irrigation, can lead to real change among rural poor by creating a more knowledgeable agricultural community.To make this a reality, however, partnerships with governments, NGOs, banks and the private sector are required.

Power and Water Security in Zimbabwe: Assessment and Recommendations on Reducing the Impact of Power Outages on Water Services

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Keywords: electricity, outages, water services, Zimbabwe

Introduction and objectives

Water and energy are inexorably linked. A critical but neglected dimension to this relationship, with a direct impact on the lives of the urban poor in developing countries is the impact of power outages on water and sewerage services. Since a major cholera outbreak in 2008/9, poor performance of Zimbabwe's water and sewerage services are a source of national concern. This paper reviews evidence from an assessment of impact of power outages to these services in urban, town and growth centres and considers policy options to limit this impact.

Methodology approach

To assess the status and impact of power outages, an assessment was made (through site visits and telephone interviews with municipal engineers) of 10 cities and towns and 10 smaller towns and growth centres in Zimbabwe. On the basis of the assessment 4 in-depth case studies were undertaken.

Analysis, results, conclusions and recommendation

The comparative results of the assessment shows that intermittent power supply is found to be a major preventable cause of erratic water services, worsened water quality and cost escalation. Case studies show different management responses to power outages. Inexpensive modifications to existing power supply networks and amended policies by ZESA would significantly improve services, reduce the future risk of cholera, increase the financial viability of service providers and improve service provision to all water users. Recommendations are made to policy makers to elevate the status of water services to be "unsheddable" in terms of their power supply; to donors and development banks to prioritise support to the energy component of water services; and to water operators to identify pragmatic solutions to power shortages and prioritise these in service improvement projects.

Solar Irrigation Pumps: Farmers' Experience and the State Policy in Rajasthan, India

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Keywords: solar pumps, rajasthan, energy-water nexus, Rajasthan

Introduction and objectives

Encouraged by the plummeting cost of solar systems and its environmental benefits, the Government of Rajasthan launched a Rs. 5.15 billion scheme in 2011 to provide subsidised solar irrigation systems to 10,000 farmers in the state over three years. 1675 farmers in 16 districts of the state got solar pumps at a subsidy of 86 per cent in 2011.

This paper tries to estimate the impact of solar pumps on agricultural production and farmers' income. We also assess the effectiveness of state's subsidy policy to promote the new technology and suggest ways to make the policy more effective and pro-poor.

Methodology approach

This paper is based on an extensive fieldwork and a survey of a random sample of 107 solar pump owners spread across 105 villages in Bikaner, Jaipur, and Shri Ganganagar districts in Rajasthan. We focus on farmers' experience with solar pumps, challenges they faced in using them, main benefits and limitations of solar powered irrigation, and the ways in which solar pumps could be made more useful to farmers. We also analyze state subsidy policy and suggest ways to make it more effective in light of findings of our survey.

Analysis, results, conclusions and recommendation

Our interaction with the first adopters of solar pumps in Rajasthan during the fieldwork and the primary survey shows that this technology works. Solar pumps are convenient to use, require minimal attendance and have few maintenance problems. Each 3000 wp systems saves its owner Rs. 45-65,000 of diesel besides increasing land and water productivity and crop quality. It also saves him labor and exposure to noise and air pollution. All owners, we talked to, were very happy with their PV pumps. They hoped to recover their share of the system's cost in less than two years. Each one of them thought other farmers should get solar pumps. It also saves him labor and exposure to noise and air pollution. All owners, we talked to, were very happy with their PV pumps. They hoped to recover their share of the system's cost in less than two years. Each one of them thought other farmers should get solar pumps.

However, the subsidy (86 per cent) is too high. Solar pumps should be promoted with attractive financing rather than high subsidies because it pays for itself. The subsidy system also needs to change from the current pro-rata subsidy to a lump sum subsidy to foster competition and customer orientation. Small and marginal farmers have got almost no direct or indirect benefits from subsidy on solar pumps in Rajasthan. There is a need to target the subsidy to smallholders. Use of solar pumps for groundwater irrigation could lead to wasteful use of water because its negligible variable costs of use creates incentives to use it as much as possible. Linking solar pumps to grid and offering buy-back of power at attractive rates can create incentives for farmers to use groundwater efficiently.

Adapted Technologies for the Integrated Management of Water, Energy, and Food in Asian Cities

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Keywords: water-energy-food nexus, water reuse, biogas, semi decentralised, urban sewerage

Introduction and objectives

The urban population in Asia is growing by 44 million people per year. This rapid urbanisation brings about major challenges for urban supply and municipal utilities in the fields of water supply and sanitation systems, energy supply and energy efficiency, land use and food security. Instead of copying technologies from western countries, Fraunhofer, German institute for applied research, and the GIZ (Deutsche Gesellschaft fuer Internationale Zusammenarbeit) Project "Integrated Resource Management in Asian cities: the urban Nexus" give technical advice to different stakeholders in the cities on how to integrate adapted technological solutions into the existing state of development.

Methodology approach

Demonstration projects can serve as catalysts in the development and spreading of new technologies and concepts. The "Urban Nexus project", funded by the German Federal Ministry for Economic Cooperation and Development, started in April 2013. Ten cities in six Asian countries have been chosen to benefit from technical advice on how to use their resources more efficiently. In the first phase, the state of development regarding the management of water, energy, and food in these cities is being assessed and main fields of action are defined in accordance with local stakeholders.

Analysis, results, conclusions and recommendation

By adding the practical "sur place" experience of GIZ to the innovative approaches from applied research, a new method for the adaptation and development of technologies and concepts for the growing cities in developing countries is being generated. In the majority of the selected cities, water management is yet on a relatively low standard. Only part of the population is connected to the public water network, the water quality of the supplied water is often not potable, and existing water resources are being depleted, leading to declining groundwater levels. The situation regarding wastewater treatment is even worse. In many cases, wastewater is collected in front of the houses in septic tanks, from which water is overflowing into a drainage system, and with no further treatment discharged into water bodies. Many septic tanks are not sealed, so sewage is seeping into the ground, polluting the groundwater, which often is the source for drinking water. Flooding is also a frequent challenge in tropical regions, and during floods the wastewater is floating on roads and into houses, causing diseases and deaths.

Solutions which have been identified as feasible so far are:

- Semi-decentralised reuse of treated wastewater for irrigation, flushing toilets, cleaning, and laundry to replace scarce water resources.

- Modular installation of sewer systems using a mix of gravity driven and vacuum sewer systems (tight systems, wastewater cannot seep out), especially in areas that are frequently flooded.
- Generation of biogas from a mixture of wastewater, sewage sludge, bio-waste, pig manure, and organic leftovers from local agriculture and utilization of the biogas either for generation of electricity, or as fuel for cars, or for cooking and heating water.

Micro-Hydro and Water Supply Hybrids in Developing Countries: Infrastructure Design and Potential Assessment in a Data-Scarce Environment

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Keywords: micro hydropower, remote sensing, Nepal, potential assessment, infrastructure design

Introduction and objectives

Water and energy are essential to well-being and economic development, yet inaccessible to millions. Unfortunately, financial barriers often impede the development of rural water supply schemes. However, micro-run-of-river hydropower (MHP) is a cost effective and environmentally friendly power supply technology. Combining these two infrastructures in multi-use systems (MUS) saves costs and allows water supply to be subsidised through MHP revenue. While many successful MUS cases exist in Switzerland, data are missing to evaluate its potential in developing countries.
We develop and validate methods using satellite data and probabilistic analytical techniques to evaluate the feasibility of MHP and MUS remotely.

Methodology approach

We derive analytical expressions relating the optimal capacity (design flow Qd) and profitability (net-present-value NPV) of MHP to remotely-sensed site characteristics. This allows MHP potential to be mapped for optimal infrastructure siting.

We use a validated analytical model of streamflow variability to derive annual power generation. Accounting for construction costs and local electricity market characteristics, we derive the NPV. We finally use linear programming techniques to derive the Qd that maximises the NPV.

Cases of metered and unmetered household connections, the integration of water supply in a MUS and the financial impact of climate variability are incorporated as design constraints

Analysis, results, conclusions and recommendation

We validate our approach using a case study in Nepal, a mountainous developing country with low electricity access and promising MHP conditions. We first test the model's ability to reproduce optimal design flow in detailed case studies of six existing MHP schemes with unmetered household connections and spanning the range of accessibility, topography and flow conditions in Nepal. We then test the model's ability to accurately map MHP potential by comparing the location of 200 Nepalese MHP to the spatial distribution of the NPV generated by our model using satellite data.

In a second phase, we use the validated approach to make design recommendations on three specific topics: First, we are interested in treating and distributing MHP outflow to households in a MUS. This decreases the financial burden of water supply but adds constraints to the volume of turbined water. Second, recent technical innovations have decreased the costs of installing meters on household connections, affecting household consumption incentives. Third, streamflow variability affects annual electricity production and increases the likelihood that the infrastructure owner – typically a resource-constrained community – defaults on the financing loan. These issues are of particular relevance in developing countries, and we integrate them as constraints in the proposed design procedure. Through stochastic numerical simulations we investigate the effect of these constraints on the optimal design capacity and profitability of infrastructure.

We find that the proposed approach successfully reproduces both the design flow and the spatial distribution of existing MHP plants in Nepal, which supports its use as a design and potential evaluation tool. We also find that adding the three proposed design constraints increases the profitability of the infrastructure modeled in the numerical simulations, which supports their inclusion in currently implemented design procedures.

A Technical and Economic Review of an Affordable Renewable Energy Powered Pumping for Smallholder Farmers in Developing Countries

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Keywords: solar, irrigation, pumping, smallholder farmer, renewable energy

Introduction and objectives

Of the 1.1 billion people in the world living on less than $1 per day, 800 million are subsistence farmers, many of whom lift and haul over four tons of water daily to irrigate their crops. The inability to increase their farm productivity, and consequently their income, locks these families into a cycle of subsistence poverty. With increasing international focus on the nexus of food production, water, and energy, iDE, an international non-profit, and its partners developed an affordable renewable energy pumping system to relieve hours of daily, enabling farmers to efficiently expand their irrigable area and increase crop yields.

Methodology approach

Building on 30 years' experience providing smallholder farmers with simple irrigation solutions through the private sector, iDE has researched farmers' needs, aspirations, and preferences and evaluated the economic viability and market potential for a renewable energy powered pump. With affordability as a key design principle, iDE and the PRACTICA Foundation designed a renewable pump that is the only of its kind on the market. The pump offers a game-changing option for smallholder farmers due to its optimal balance of appropriate size, pumping ability, and price. iDE has partnered with Futurepump (a UK-based company) for manufacturing and distribution of the pump.

Analysis, results, conclusions and recommendation

Traditionally, renewable energy powered pumps have been too expensive for smallholder farmers to afford and oversized for farmers' fields, resulting in higher fuel consumption and wasted water. Considering the shortfalls of current pumping options, iDE ensures this product is capable of high efficiency pumping from depths out of suction-pumping range; can pump from several sources – surface water, open wells, and small-diameter tube wells; can irrigate up to 1,500 square meters; and simple to install. iDE's product, called the Clean Irrigation Solution (CIS), centers around a uniquely designed piston pump. The piston pump can utilise energy from multiple energy sources – solar steam, PV, manual and AC grid, and maintains a slow, steady water discharge rate during daylight hours.

In order for the product to be commercially viable, the CIS needs to be cost competitive with alternative pumping options. Currently, the most affordable and available motorised pumping option for smallholder farmers is a 4-7 horsepower fossil fuel engine pump. Although these pumps are currently more affordable than renewable-powered pumps, the recurring fuel costs make fossil-fuel powered pumps a more expensive option in the long-run. Without recurring operating costs, the CIS pump becomes cheaper per unit of water pumped within the first two years of use.

Use of the CIS saves smallholder farmers time, leads to a more efficient use of water, and increases the quantity and quality of crop yields. This allows rural families to increase their income, send their children to school, access better healthcare, build better housing, and reinvest in their farming business for continued growth – permanently escaping the cycle of poverty.

Through its iterative product design process and economic analysis, iDE and its partners can fundamentally shift the market for renewable energy irrigation solutions for smallholder farmers and serve as a scalable and sustainable industry standard.

Beyond the Buzzwords: "Innovation" and the Closing of Equity Gaps

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Keywords: water, energy, innovation, socio-technical change

Introduction and objectives

UN has proposed to focus on global and local inequity in the Post-2015 period, under the principle of "Leave no one behind". Already, governments, philanthropists and research agencies are scrambling to support "innovative approaches" for equitable access to water, sanitation and energy. But what do we mean by innovation? And can a pilot project here and some seed money there make any difference for the billion people without access? Has "innovation" just become another buzzword? The aim of this presentation is to provide a broader framework for understanding change and innovation in socio-technical systems for water and energy.

Methodology approach

With point of departure in History of Technology and STS this paper discusses water and energy provision systems applying theoretical concepts such as recombination, recursive structures, internal replacement and structural deepening. Why do the dominant systems look the way they do, how were they formed by societal, scientific and environmental conditions? How does "innovation" happen within a large technical system? Using concrete examples from water and electricity provision from the past and the present, the paper discusses under what circumstances socio-technical change is likely to take place, and how innovation could lead to a closing of equity gaps.

Analysis, results, conclusions and recommendation

Closing the equity gap requires increased diversity in the setup of systems for providing water, sanitation and energy services. The dominant modes of providing these services have developed to match the hydro-environmental, economical and socio-cultural conditions in early 20th century Europe and USA. While these modes have their advantages, in many contexts in the South they will not serve the purpose of closing the equity gaps, without further innovation and modification.

As shown by historical examples, local context-specific innovation activities are likely to generate configurations tailored to local preferences, needs and resources. The local-level innovation could be characterised as 'horisontal recombination'. However, local innovation activities must also fit into the large socio-technical system. Two changes in local innovation environments are critical:

- First, creating space for local experimenting and innovation. Instead of regulating minimum service standards and streamlining technological solutions, system builders may need to develop a modular approach where different – but compatible - technological solutions are engaged depending context.
- Second, socio-technical change can accelerate if local innovation is combined with dialogues between users, operators and policymakers, dialogues that inform search activity, system optimisation and build social capital. This requires a higher degree of accountability and transparency. Ultimately, these are products of power structures in society.

Toward Sustainable Solution for Wastewater Disinfection Using Solar Energy in Gaza Strip

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Keywords: solar, energy, water, treatment

Introduction and objectives

Water is one of the important issues especially for irrigation and food security. Water and energy are very limited in Gaza strip. This research project provides a sustainable solution for water and energy sources in small area in Northern governorate. The area was selected based on several criteria to apply this project. A first criterion is limited sources of energy and water sources in the area. A second criterion is acceptance for people in this area for the concept of project.

Methodology approach

This research was performed in Bait Lahia. Collecting waste water from pilot area of 3 km^2. Solar energy has been used to generate electricity to operate the disinfection unit. The UV system treats 4,000 litre of water in 5 hours using solar energy which is collected by mirrors.

This research presents an applied framework for sustainable water and energy in remote area.

Analysis, results, conclusions and recommendation

This research presented a new technique that can be used in difficult situation like Gaza Strip and especially in area with limited water and energy. Solar energy is an important source to be used in disinfection process of wastewater to be used in irrigation. Disinfection was performed based on WHO standards which is less than 1,000 MPN/100 ml. This method is accepted by farmers to be used in wide range in the future.

Atotonilco WWTP: A National Effort for Reaching Access to Energy for Sanitation in Mexico

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Keywords: cogeneration, crop diversification, greenhouse gas emissions, resilience, sanitation coverage

Introduction and objectives

In order to deliver sustainable water to Mexico Valley (Mexico City and its metropolitan area) and wastewater services to Mezquital Valley (main irrigation area of Hidalgo State), the Mexican Republic Government, through the National Water Commission (CONAGUA, by its Spanish signals), builds the Atotonilco Wastewater Treatment Plant (WWTP) with an investment of nearly 1 billion USD (started in 2008).

The main objective of this facility is to expand the sewerage system capacity for the benefit of almost 20 million inhabitants and protect the people of Mexico Valley from floods.

Methodology approach

The Atotonilco WWTP capacity of treatment will be of the order of 35 thousand liters per second. With its inventive design, it will be able to work for short periods of time with an overload of 20 percent to reach 42 thousand liters per second.

With 12 motor generators of 2,716 kWe each the Atotonilco WWTP may be able to satisfy up to 70 per cent of its electrical power demand through the consumption of the biogas generated by its sludges.

Analysis, results, conclusions and recommendation

Quantitatively, Atotonilco WWTP will be capable to sanitate most of the wastewater volume -from Mexico Valley- that is delivered to the Mezquital Valley, through East Outlet Tunnel and Central Outlet Tunnel. Thus, once the Atotonilco WWTP be completely functioning, the sanitation coverage regarding municipal wastewaters generated both in Mexico Valley as well as in whole country will be of the order of 60 per cent.

This, to improve the quality of life of more than 700 thousand inhabitants; and to provide the Mezquital Valley irrigation districts of treated wastewater with the necessary quality for a non-restrictive seeding in order to foster crop diversification. So, it will be possible to plant more profitable products such as vegetables.

Moreover, in a year, the consumption of the biogas generated in the Atotonilco WWTP will permit the reduction of greenhouse gas emissions corresponding to 0.5 million metric tonnes of CO_2 equivalents.

The biogas recovery, which will be the cogeneration input for most of the own electrical consumption of the Atotonilco WWTP, allows the whole project to be considered as a Clean Development Mechanism (CDM), susceptible of being given of saleable certified emission reduction (CER) credits, each equivalent of one tonne of CO_2, which can be counted towards meeting Kyoto Protocol targets.

With the coherent implementation of this project, along with the necessary measures in order to reduce water use, increase water recycling and be open to new ways of sourcing water, the basis for a common path towards climate resilience in Mexico Valley would be settled down.

Water, Food and Energy: Adaptable Technologies for Coping below Poverty Budgets in Nigeria

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Keywords: communities, improved water, sanitation, biogas, smokeless charcoal

Introduction and objectives

Nigeria celebrates its centenary in 2014. In the words of African Development Bank, Nigeria's prospect of halving poverty by 2015 is weak. "The proportion of people living below the national poverty line has worsened from 65.5 per cent in 1996 to 69.0 per cent in 2010; in rural areas poverty is at 73.2 per cent and in urban area at 61.8 per cent. This paper analyses the impact of poverty on basic needs such as water, sanitation, waste management and low cost energy, and finding viable technological solutions to adapt to mitigate the poverty and hunger within their low budget.

Methodology approach

The study was carried out in various communities in south-west Nigeria and addressed water supply, sanitation, waste management, waste to energy and linked with community needs. Some of these communities were involved in testing these technologies for acceptability and sustainability. The technologies tested in particular were: rain water harvesting using a sand filter, extracts of Moringa oleifera seed for water flocculation, solar disinfection, community based 'pay and use toilets', urine harvesting, biogas with household degradable wastes and composting, and smokeless charcoal production using 'bush' and grass clippings which have no value otherwise. These technologies integrated as a model for adoption.

Analysis, results, conclusions and recommendation

The current scenario on Nigeria's water and sanitation situation as of 2010 is: improved sanitation 31 per cent, improved drinking-water 58 per cent, sanitation facilities in schools and hospitals, basic education through Primary schools, 32 per cent, and Secondary schools, 48 per cent. The percentage of WASH related deaths and injuries stand at 16.2 per cent.

The following innovative solutions were developed involving low income communities:

i. Improved water supplies with rain water harvesting with sand filters, using Moringa oleifera seed powder to flocculate particulate matter, household sand filters and exposure of drinking water in polythene sachets to solar radiation before consumption.

ii. As traditional pit toilets are accepted along with VIP toilets, community toilets were introduced with training and hygienic use, composting toilets, and pay and use toilets with revolving funds. Urine harvesting for backyard vegetable cultivation is added.

iii. Low income communities generate waste at the rate of 0.3 to 0.4 Kg/head/day. Waste segregation with sale of non-biodegradable components, organic waste conversion to biogas, conversion of spent slurry and other biodegradable wastes into organic fertiliser were tested. Organic fertiliser produced is further used for growing greens, okra, tomato etc. which are a part of regular Nigerian food. Further, manual composting technology was adopted in communities as a cooperative venture.

iv. A novel technology introduced is the conversion of 'bush' or 'grass clippings' 'agro-wastes' etc. into smokeless 'biochar pellets', which can replace wood charcoal or kerosene for their cooking needs.

A used drum is improvised into a pyrolytic chamber and the charcoal produced was pelletised manually. This is shown to generate employment and do not need any specialised skills. Women can be engaged effectively.

These technologies which are developed along with the communities are integrated into a model which can be adopted in needy communities. State governments are showing interest in taking to the grassroots for sustainable adoption.

Framing the Water-Energy Nexus within the Post-2015 Development Agenda to Address Global Development Challenges

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Keywords: global problems, post-2015 development agenda, sustainable growth, water-energy nexus

Introduction and objectives

At the core of on-going discussions on the Post-2015 development agenda is access to water and energy, two intertwined resources that are crucial for addressing global development challenges like poverty, hunger, health and climate change. The need to carefully manage water and energy in an integrated way has never been this urgent and important as world leaders seek new approaches and institutional arrangements for proper policy development and sound decision-making. This article frames the water-energy nexus within the Post-2015 development agenda as a crucial management instrument to improve coordination across different sectors in search of synergy and opportunities.

Methodology approach

In response to growing global interest on the relationship between water and energy, UNIDO commissioned a scoping study on the water-energy nexus to interpret the connections and mainstream water into the activities of SE4All as world leaders consider new energy policies and options they want to follow. A systems analysis approach was followed to illustrate the benefits and opportunities of following a nexus approach for the Post-2015 Development Agenda and identified the main challenges and management constraints of doing so. Some of the results will feed into SE4All Global Action Agenda to guide policy and sound decision making.

Analysis, results, conclusions and recommendation

The findings showed that several proposed SDGs are very closely interrelated and the nexus perspective can be leveraged to set nexus targets that are interwoven and jointly achievable; for making more informed decisions on goals, targets and indicators that will ensure integration across sectors and clarify how best to allocate resources between competing needs; to make development goals more efficient and cost effective by facilitating coordination and reduce the risk that actions for achieving one goal will undermine one another. It is therefore crucial to look at the nexus as being more than just the links. Much more can be achieved in finding solutions to eliminate inefficiencies and optimise resource use by exploring synergy and gaining insights into the domains and plans of other sectors and actors. However, the concept is quite complex and difficult to operationalise. For instance, the boundaries of different dimensions are not clearly defined and it is rare that they align with established management/administrative boundaries. Furthermore, policy is still very much sector-driven,

with unequal visibility and interest among dimensions. Also there are serious concerns over a lack of regulatory mechanisms to ensure proper nexus implementation. In addition, it is still difficult to access and synthesise information concerning the intersections of the nexus dimensions. The bulk of modelling approaches on natural resources planning are routine analysis of individual sectors or systems, often focused only on a single resource on an aggregated scale at the global level. Nevertheless, a number of opportunities and benefits exist to justify a nexus approach, with good case studies and supporting evidence that a nexus approach can support sustainable development, with stronger integration across sectors to manage trade-offs and uncertainties. Such outcomes can be appealing to the private sector, civil society and governments or international organization seeking to incorporate the concept into their development strategies.

Stockholm International Water Institute

The Stockholm International Water Institute (SIWI) is a policy institute that contributes to international efforts to combat the world's escalating water crisis. SIWI develops and promotes future-oriented and knowledge–integrated policies, towards sustainable use of the world's water resources leading to sustainable development and poverty eradication.

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