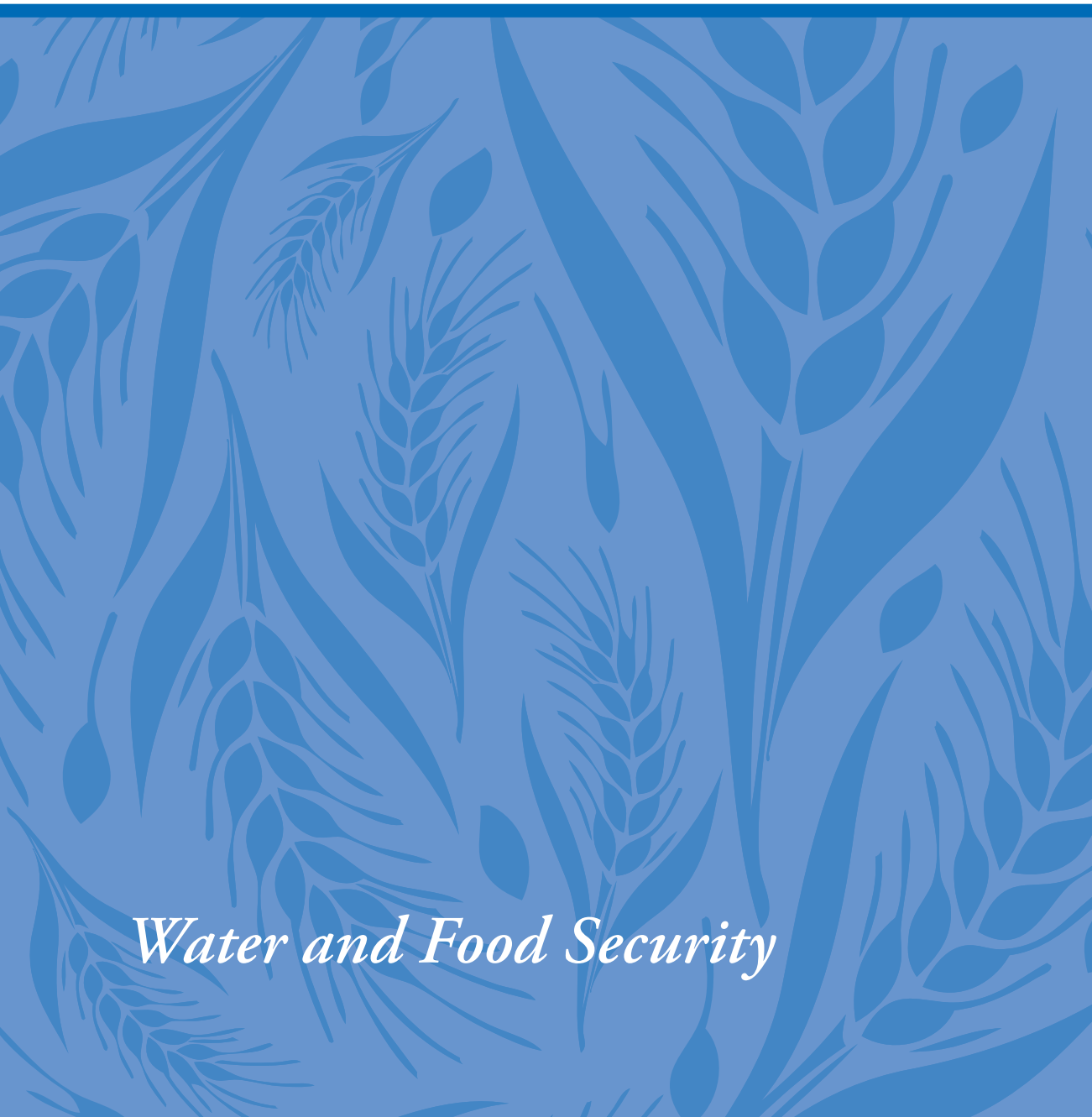
Abstract Volume

World Water Week in Stockholm
August 26–31, 2012



Water and Food Security

Published 2012 by
Stockholm International Water Institute, SIWI
Drottninggatan 33
SE–111 51 Stockholm
Sweden

Design by Elin Ingblom, SIWI.
Edited by Ingrid Stangberg, SIWI.

Printed by Elanders, Mölnlycke, Sweden.
The printing process has been certified according to
the Nordic Swan label for environmental quality.

ABSTRACT VOLUME

World Water Week in Stockholm
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Contents

Workshop: Best Use of Blue Water Resources for Food Security

Water Resources Safety in Samarkand: Current Condition, Risks and Recommendations

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Keywords: water safety, well fields, water resources management, new technology, effieciency

Introduction and problem identification

This presentation will address the need for water resource management by improving water well's capacity and rational using issues in Samarkand city of Uzbekistan. The field of investigation is Samarkand city's water supply safety. Samarkand is the second biggest and the first oldest city in Uzbekistan with population about 500 000. According to the law potentially environment unfriendly facilities should be under special control for rational use of fresh ground water resources and protecting them from contamination. Samarkand's water supply system reconstruction is doing during the last 10 years by local municipal department of who is responsible for water and waste water system operations. Aged water supply system needs replacement and reconstruction however, security of drinking water and water services are the priority number one in Uzbekistan. Water wells operation and water distribution system's safety is in the the main agenda.

Analysis, results and implications for policy and/or research

The main intake facilities for household water in Samarkand are Chupan-Ata and Dagbit well fields (WF). Zaravshan River is the main source for the ground waters for Chupan-Ata and Dagbit WFs. The depth of the wells is between 47 and 70m. The structure is changing according to the relief. The ground water is usually found at the depth of 10-20m. The ground water at the WFs is usually recharged by atmospheric precipitation, by Zaravshan, Karadarya, and Akdarya rivers as well as by irrigation channels. As it is known the process of society development is impossible without influence upon nature and such influence leads to changes in natural balance. Solution of the problem of society development is becoming more urgent influence of improvement of social condition of population and preservation the environment. It requests modernization of water supply technologies and devices. The first and very important part of the water supply system is water intake and lifting equipments such as water wells. This presentation is about Samarkand's ground water resources, where they are the primary source of quality drinking water. It represents 85-90% of the general water budget. Existence of a water supply source, constructions for getting and lifting water (water wells) to the consumers is not always sufficient. This brings about necessity of the better founded approach to operation structure to rational use of water resources. However, some of these wells are not in a good and operable condition. It is very common for a well to have years of operation prior to experiencing loss of capacity. With age it is common to see these lost capacity problems frequently. The increased frequency of lost capacity and the need for well rehabilitation treatments is due to the incomplete removal of plugging deposits from prior rehabilitation efforts, thereby not maintaining the original pore volume of the gravel pack, well screen, or fractured formation. There are lots of deficiencies in the well pumping system ranging from the wells themselves to the equipment and switchgear installed.

The main reason for ineffective and insecure operation of wells is clogging of filter screen and filter area (gravel zone's surface) by salt deposits and corrosion products of metallic elements. The clogging deposits consists mainly salts calcium and iron oxides. When wells lost more than 40% of original productivity they need to be rehabilitated (restoring as a cleaning up filters and gravel zone). This situation requests groundwater use management by improving efficiency and increasing of secure using of the existing water wells.

From the economical and ecological points of view the regular water supply of the population should be based on the active structures of a system of water supply as there is a considerable potential of increasing the efficiency of use of investments which they can provide. As a result of our researches we offer the new developed water well rehabilitation technology and devise. The developed technology is combined (blend-ed) for water well rehabilitation by using complexions as chemicals and solid dioxide carbonic as an agent for pressing of the selective solvent into filter area and helps make a process as cyclic. The combined rehabilitation method can restore the capacity of clogged water well by salts and corrosion products and economic value is equal 15-20% from the overall value of construction of new wells. If our abstract could be accepted we'd like to demonstrate more detailed information on our posters and also it would be a great chance to cooperate with the companies and water experts.

Successful Implementation of Large and Small-Scale Drip Irrigation Projects Among Smallholders

Author: Mr. Naty Barak, Netafim, Israel

Keywords: smallholders, productivity, capacity-building, drip-irrigation, agriculture

Introduction and problem identification

Our main goal in the two projects was to achieve sustainable productivity - maximizing food production among smallholders in rural farming areas, while minimizing environmental impact.

Currently, the world is facing numerous challenges including water scarcity and aquifer depletion, arable land reduction and soil erosion, climate change and greenhouse gas emissions, and energy constraints. Drip irrigation holistically addresses the point where all of these challenges meet. Smallholder improvements are critical to address global hunger and poverty In developing countries, 80% of growth in crop production will come from higher yields 60% of extra food required to sustain the world in future must come from irrigated agriculture, which needs sustained efforts at expansion and improvements. Our experience shows that drip irrigation, particularly when combined with training, increases productivity, improves yields, and positively impacts on individual farmers and their region.

Analysis, results and implications for policy and/or research

Results of two drip irrigation projects – one in the Indian state of Andhra Pradesh and the other in Kitui, Kenya – clearly underscore their positive economic and socio-economic impact among smallholder recipients, and demonstrate the intensified productivity in the use of irrigation water. Launched in 2003, the Andhra Pradesh Micro-Irrigation Project (APIMP) brought micro-irrigation to 250,000 ha of land in the southern India state. Partnering local government, NGOs and the private sector, the project showed that drip technologies lead to significant productivity and economic gains over traditional surface irrigation methods. Farmers who adopted drip irrigation enjoyed yield improvements, expanded their plots, increased their income, and upgraded their quality of life.

Accompanied by irrigation technology, fertigation and agronomy training, along with capacity and knowledge building, the APMIP gave poorly educated farmers and those belonging to low caste groups equal opportunities for success. Creating several additional ancillary jobs, the project also empowered farmers to become entrepreneurial and shift from subsistence farming to commercial agriculture. Water savings and yield increase were significant: 26% to 75% water saving among 71% of the farmers, 26% to 75% yield increase among 62% of the farmers. The Kitui project, launched in Kenya's Eastern province in 2010, involved deployment of Netafim's Family Drip System™ (FDS™). A gravity-based drip irrigation system requiring no electricity or energy source, FDS provides growers with the know-how and means for achieving self-sufficient agricultural production. Targeting 200 poor, small-scale vegetable growers, primarily women and elderly individuals, the project involved extensive agronomic and technical training, as well as capacity building. Based on a partnership among the government, NGOs and the private sector, the project significantly increased not only harvested yields and income, but also vegetable growing capacity and farm management know-how. In addition, the project empowered women, while freeing them up for daily family tasks.

Going well beyond technology transfer, these drip irrigation projects represent viable socio-economic opportunities by helping subsistence farmers build up their agribusiness capabilities and become commercial growers. Based on our research, the key success factor for such projects is the combination of providing tools and building capacity. Partnerships were essential for the success of these two projects: Local Governments through incentives and regulations, Private sector with technology, know-how and innovation, NGOs with financing, organization and recruitment, local banks with financing and local farmers.

Water Constraints to Future Food Supply and an Assessment of Potential Adaptation Measures

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Keywords: global water resources, irrigation, food security, climate change, adaptation

Introduction and problem identification

To feed 7 to 12 billion people that will live on this planet by 2100, the global food and feed production will need to increase substantially from present 2600 Mton dry matter harvestable products towards 4500 to 5500 Mton. The question often rises whether there will be enough water to produce this amount of crops. And if not, what are the options to make better use of the available water resources in order to secure production. This study tries to answer these questions by using a model that links water availability to crop production with sufficient spatial and temporal detail.

Analysis, results and implications for policy and/or research

By applying a global hydrology and crop model, in combination with state of the art climate, socio-economic and land use change scenarios we show that in many regions the required increase in crop production cannot be realised because of a severe shortage in irrigation water. Even if assumed that groundwater extractions can be continued at present rates, approximately 30% of the global irrigation water demand in 2100 cannot be met, resulting in a loss of global (irrigated) crop production of around 400 Mton. With groundwater already depleting in many regions, the supply from this source is very uncertain, which might lead to even further crop production losses. Of course, those water shortages and crop production losses do not occur everywhere. In this study, different sources of blue water are accounted for explicitly (rivers and lakes, artificial reservoirs and groundwater). For each river basin it is assessed how the total irrigation water can be extracted from those different sources, now and in the future and where shortages will occur. Unless many efforts are made to increase water storage capacity and to increase water use efficiency in both rainfed and irrigated agriculture, water will put a serious constraint on food security by 2100. In the second part of the presentation we present a case study region to evaluate the potential effect of those water saving options. One of the most densely irrigated regions facing a great challenge in managing their water resources and to feed their growing population is the Indian subcontinent. Therefore, expansions of agricultural area combined with yield increases will be necessary to still be able to produce the food needed in the future. However, pressure on water resources is already high, and potential effects of climate change are still uncertain. In this case study we use a hydrology and crop model to make a spatial explicit quantitative analysis of water availability for future food production in five South Asian basins (Indus, Ganges, Brahmaputra, Godavari and Krishna) in the absence or presence of two different adaptation options: an overall improvement of the irrigation efficiency and an increase of storage capacity of large reservoirs. It was found that the Godavari and Krishna basins will benefit most from an increased storage capacity, whereas in the Ganges and the Indus water scarcity mainly takes place in areas where this additional storage would not fill up completely.

Increasing the irrigation efficiency will be beneficial in all basins, but most in the Indus and Ganges, as it decreases the pressure on groundwater resources and decreases the fraction of food production that would become at risk because of water shortage. A combination of both options seems to be the best strategy in all basins.

Water Scarcity and the Impact of Improved Irrigation Management

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Keywords: computable general equilibrium, irrigation, water policy, water scarcity, irrigation efficiency

Introduction and problem identification

Increasing water scarcity combined with an increasing demand for food and water for irrigation call for a careful revision of water use in agriculture. Currently, forty percent of the world's population face water shortages regardless of whether they live in dry areas or in areas where rainfall is abundant. The largest consumer of freshwater resources is the agricultural sector – globally around 70% of all freshwater withdrawals are used for food production. However, less than 60% of all the water used for irrigation is effectively consumed by crops. This article therefore analyzes the extent to which improvements in irrigation management would be economically beneficial for the world as a whole as well as for individual countries and the amount of water savings that could be achieved.

Analysis, results and implications for policy and/or research

In this article, we use a new version of GTAP-W, a global computable general equilibrium (CGE) model, to analyse the economy-wide impacts of enhanced irrigation efficiency. The new production structure of the model introduces water as an explicit factor of production and accounts for substitution possibilities between water and other primary factors. The new GTAP-W model differentiates between rainfed and irrigated crops, which allows a better understanding of the use of water resources in agricultural sectors. The model allows us to calculate the initial water savings (when world markets would not adjust) that could be achieved by improving irrigation efficiency. This is what has been mostly done in the previous literature although not at the global level. We extend this approach by comparing the initial water savings with the final water savings taking into account adjustment processes in food and other markets. This is more interesting since it is very likely that regions will adjust differently to the initial water savings. We find that global water savings are achieved and the magnitude increases when more regions achieve higher levels of irrigation efficiency. We find that initial water savings represent between 12-21% of the total irrigation currently used. Final water savings are much lower, between 5-10%. Therefore, ignoring adjustments in production patterns and food markets would overstate the expected amount of global water savings. Improving irrigation efficiency promotes irrigated production, which partially offset rainfed production. This implies regional welfare losses, mostly in non-water scarce regions. However, these welfare losses are most than offset by the gains from increased irrigated production and lower food prices. Improving irrigation efficiency worldwide generates new opportunity costs, which reverse regional comparative advantages in food production. Regions with relatively poor irrigation performance experience positive impacts in food production and exports when improving irrigation efficiency. At the same time, food-exporting regions are vulnerable to positive impacts induced by enhanced irrigation efficiency elsewhere.

International trade of food products is not only the main channel through which welfare impacts spread across regions, it is also seen as a key variable in agricultural water management. As water becomes scarce, importing goods that require abundant water for their production may save water in water-scarce regions. We find that exports of virtual water are not exclusive of water abundant regions.

Quantifying the Potential Water Savings Associated with Irrigation Efficiency Improvements

Author: Dr. Juliet Christian-Smith, Pacific Institute, USA

Keywords: conservation, efficiency, regulated deficit irrigation, irrigation scheduling, irrigation technology

Introduction and problem identification

Agriculture is a major water-user worldwide and due to growing pressures on global water resources, there is increased interest in improving the efficiency of agricultural water use. While it is clear that agriculture has become more efficient over time, it is often unclear exactly how much additional water could be saved through water use efficiency improvements. This study analyzes the potential for water savings from irrigation efficiency improvements in California, USA. We chose California since it has large agricultural economy, it experiences frequent water stress, and it has invested heavily in agricultural water use efficiency improvements over the last two decades. We model the potential for increased water savings associated with agricultural water efficiency improvements in wet, average and dry water years.

Analysis, results and implications for policy and/or research

This study analyzes three scenarios of improved agricultural water use, as compared to a baseline scenario. The 'efficient irrigation technology' scenario shifts a fraction of the crops from flood irrigation to sprinkler and drip systems; the 'improved irrigation scheduling' scenario uses local climate and soil information to more precisely meet crop water needs; and the 'regulated deficit irrigation' applies less water to crops during drought-tolerant growth stages to save water and improve crop quality or yield. The three scenarios evaluated here each conservatively show the potential for significant water savings. Despite claims that there are no additional water savings possible through water efficiency improvements in advanced agricultural settings, such as California, this study found that the combined potential applied water savings of the three scenarios are between 560 billion cubic meters (4.5 million acre-feet) in a wet year and 740 billion cubic meters (6.0 million acre-feet) in a dry year. In total, these scenarios could reduce water applied to California agriculture by 17% or reduce water consumed by California agriculture by 13%. The results also indicate that water conservation and efficiency improvements are particularly effective in dry years, when agricultural water demand is greater and conflicts over scarce water resources are more severe. These approaches can reduce vulnerability to increasingly uncertain water supplies.

Ground Water Exploitation and Food Security Issue – A Case Study of Moga District, Punjab State, India

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Keywords: overexploitation, punjab, recharge, energy, decline

Introduction and problem identification

Advent of tubewell technology has completely transformed the way irrigation is done by utilizing ground water and has resulted in mixed blessings for the farming community. But a number of problems have come to the fore because of excessive dependence on ground water irrigation for growing crops requiring assured water. Huge stress on ground water has caused decline of water levels even after monsoon rains and availability of annual replenishable ground water resource has become negative in 75% area of Punjab. This has resulted in increasing the depth of new ground water abstraction structures for sustaining ground water based irrigation. The consequences of water level decline have been severe especially for marginal and small farmers (falling in low income groups) in Punjab state, which is dependent on farming and related activities. Thus capital investment by the marginal and small farmers is taking its toll on the fragile socio-economic structure.

Analysis, results and implications for policy and/or research

The state of Punjab, India has a total area of 50360 Sq.km. A total of 83% of the area in the state is under agriculture.The area sown more than once had increased by 250% – from 16250 to 36770km^2 since onset of green revolution in the late sixties.This phenomenal increase has been made possible only because of extensive ground water based irrigation.The area irrigated by government canals covers only 29% of the total irrigated area of the state. On the other hand, net area irrigated by wells covers 71% of the total irrigated area of the state. The tremendous growth in the tube well irrigation has ultimately contributed to increase in food production of the state resulting in self sufficiency in food grains for the nation also.The production of rice in Punjab state has increased from 688 to 10138 thousand metric tons whereas yield has risen from 1765 to 3868 kg per hectare. Similarly, production of wheat in the state has increased from 5145 to 14596 thousand metric tons whereas yield per hectare has risen from 2238 to 4210 kg. Moga district represents an area where the benefits due to green revolution have been observed.In this area too, like in entire state, the grain production in terms of per hectare production has increased manifold. The enhanced use of irrigation water, especially ground water, for the high yielding variety of crops, has adversely affected the ground water regime. As per Ground water resource estimation, all the blocks in the district are categorized as over exploited where ground water withdrawal has exceeded natural recharge by a whopping more than 200%. Water levels have declined by 20-25m in last 3 decades. The ground water levels for the last few years have been declining at a rate of 50-80 cm/year. The decline of water levels has severely impacted the farmers of the area especially those having land less than 2 hectare (Marginal and small farmers). The decline of water levels has resulted in increase of cost input for farmers towards assuring ground water based irrigation. The inputs in which farmers have to invest heavily are deepening of dug cum bore well, drilling of new tube well, new submersible pump sets, investments on account of new backup diesel sets etc.

Farmers have also started migrating to non-farming activities such as dairy farming or even selling off their lands to big landlords having adjoining farmlands. In order to augment the dwindling ground water resources, a plan for artificial recharge has been prepared for Punjab state. This plan has been prepared while considering the hydrogeological parameters and hydrological data base considering the following. 1.Identification of areas suitable for artificial recharge to ground water.
2.Estimation of subsurface storage space and quantity of water needed to saturate the unsaturated zone.
3.Quantification of surface water requirement and surplus runoff availability for artificial recharge in each district.
4.Working out suitable recharge structures, their numbers, and capacity to recharge with available resources.
5.Cost estimate of artificial recharge structures required to be constructed in identified area.

Based on the above, a project was taken up for augmenting the depleted aquifer through artificial recharge in Bassian Drain in Moga district and to examine the impact on farming in the area. Two trenches having 170 m length each were constructed with three recharge wells in each trench with 3 piezometers on both sides of the trench. Total quantity of water recharged annually through the two trenches was 5.58 million cubic meter (MCM). This additional recharge lead to installation of 18 additional shallow tubewells in the area. In the area there are 108 shallow tubewells owned by the farmers that were benefited due to rise in water level. In an area of 11km^2 the rise in water level observed was 0.20m that could also save 15 mega watt of energy due to reduced lift of pumps. The farmers of the area also reported that there is appreciable increase in discharge of their shallow tubewells due to artificial recharging of aquifer system of the area. This project , if implemented on large scale, may bring back the marginal and small farmers who are now migrating to other sources of livelihood or selling off their lands, back to agricultural activities and lead to a better food security scenario.

Modern Irrigation Systems Improve Water Efficiency and Generate Wealth for the Farming Communities

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Keywords: irrigation systems, innovations, plastic materials, water saving, financial benefits

Introduction and problem identification

In most countries but especially in developing countries, a large portion often up to 80% of available water resources is used to irrigate crops, mainly by inefficient flood irrigation methods fed by open water channels. At the same time, global challenges such as water shortage and increased food demand arising from the World's growing population is putting pressure on these unsustainable irrigation practices. Modern irrigation systems however, e.g. drip irrigation produced with plastic materials are more water efficient and deliver water directly to the plant through a network of pipelines – main lines and lateral lines with emission points along their length. The use of drip irrigation systems results in increased yields whilst using considerably less water, which is of benefit to individual farmers around the world and essential if countries such as India are to feed their growing populations.

Analysis, results and implications for policy and/or research

Borealis recently joined with other companies to fund a study by Professor Alessandro Marangoni, of Bocconi University in Italy, to define the cost benefits of using modern irrigation systems in agriculture. The study estimated the financial benefits of different water management strategies within the Italian agricultural industry including the cost savings due to reduced water usage, the environmental savings due to the reduced exploitation of water and the social benefits from an improved environment and a more competitive agricultural industry. These same arguments apply in other countries such as Turkey or India and can be used to demonstrate the greater water efficiency and the financial benefits derived from the use of modern irrigation systems.

Borealis together with joint-venture company Borouge are working with the complete value chain, irrigation production machine suppliers, irrigation system producers and installation specialists to develop the most efficient range of materials for the production of modern drip irrigation systems. These materials enable high quality systems to be consistently produced at higher output rates resulting in less scrap and lower overall costs for the producer and ultimately for the farmer, making the systems a more attractive investment. This programme has also included the specialist manufacturers of the mobile sprinkler systems used in the tea plantations in India, where plastic systems are now taking over from old metal systems. Work is also ongoing together with the International Development Enterprises of India (IDEI) to reduce the costs of producing simple systems for the small subsistence farmers, which will enable them to improve their crop yields and help to lift them out of poverty.

Increasing Economic Value of Water in Hydropower Reservoir through Multiple Use Scheme

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Keywords: multiple, use for, higher, water, value

Introduction and problem identification

Allocation of water during water shortages is an important decision, which not only needs to be better coordinated across the possible multiple water users within any given legal jurisdiction, but needs to be better coordinated across provincial jurisdictions in the case of the Yali Reservoir, a trans-boundary reservoir located across 2 provinces of Kon Tum and Gia Lai in Viet Nam. Such decision must also be based on clear allocation criteria including economic criteria with the aim of optimizing the economic value of the water resource. The Yali Reservoir, in Central Viet Nam, is located in a trans-boundary watershed across the Kom Tum and Gia Lai provinces. Water allocation decisions made independently by these two provinces thus impact water use in the basin and consequently water flow into the reservoir. In a context of water abundance, water use by different sectors is non-competitive and does not necessarily warrant careful and clear planning and allocation.

Analysis, results and implications for policy and/or research

The research assesses the economic benefits of multiple-use of reservoir water. It aims to provide decision-makers with information pertaining to the value of water in the reservoir and to consider alternative allocation. Moving to a world of increasing water scarcity (resulting from both increased water demand and changes in water supply brought upon by climate change), allocation of the water resources based on clear criteria becomes of utmost importance. Allocation decisions based on the recognition of the economic value of water, both use and non-use values, is increasingly recognized by policy-makers as being important. As such, economic efficiency is one of these important criteria which may guide the allocation of the water resources. The use of such criterion indicates that multiple-use of the water of the reservoir would optimize the economic value of water as opposed to its existing single-use. The paper indicates that multiple-use of the water of the reservoir would provide not only greater economic benefits in aggregate, but would also entail a more equitable distribution of these benefits in favour of local rural communities. However, this would need a more coordinated water management mechanism among local authorities. The paper recommends that a regional steering committee of Gialai and Kontum provinces should be established.

Traditional & Successful Practices in Water Scarcity in "Thar Desert", Rajasthan, India

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Keywords: Thar Desert, water scarcity, Tanka, Kund, Kundi

Introduction and problem identification

Rajasthan is an Indian state, to north-west of the country, very often referred as a desert. It is the largest state, occupying about 11% of the area. This whole region is divided into four parts geographically. Marubhumi (Thar Desert) is the western sandy plain or as arid zone (shushk kshetra). It is 58% of total area and made up of sand dunes, low infertile hills and land high in mineral content.

In the area one can see villages and fields everywhere, at least during the monsoons. This creates a different picture from other deserts that is in total contrast to the stereotype of desert. The different picture from classical desert is due to the way water is managed, received so parsimoniously. Down the centuries, the ingenuity and patience of people made it possible for life to be maintained in the desert, by applying their technical knowledge to collect each and every drop. It is to each precious drop that the local society dedicated its effort, its love, and its intelligence.

Analysis, results and implications for policy and/or research

The people of Rajasthan scaled the peaks of trade, culture, art and standard of living because of the depth of their philosophy of life which gave a special space to water. It is true that the new developmental strategies have somewhat altered this exceptional water tradition; however they have not been able to completely destroy it. 'Running water, pure water' In Rajasthan, this proverb stands on very shaky grounds, for conserving water. The principle behind this is to hold the drops of rain in a clean space and stock it. Be it kund, kundi, tanka, khadeen the names and form may change, but the function is to preserve for tomorrow the drops that have fallen today. Ponds are to be found everywhere. Inside the forts constructed atop mountains, in temples, at the foothills of mountains, in the courtyard of houses, on rooftops, in villages, outside the villages, in uninhabited places, in fields; everywhere, at any time, these can be made. On a nallah or a Khadeen is made. It is a sort of temporary lake. On two sides, a pal is raised and on the third side a strong stone sheet is fixed. The pal of the khadeen is called dhora. Its length is calculated according to the influx of water. Kunds are made wherever any space is available. People whitewash it and make a sloping angan. The slope can be from any side but it converges towards the middle portion. In this portion, a kund is made. The inside of the kund is lined in such a way that not a single drop from the water collected within is lost through seepage, and throughout the year the water remains clean and protected. The angan from where rainwater is collected is called agor. Throughout the year the agor is kept spotlessly clean. One cannot enter the agor wearing any kind of footwear. If there is a scarcity of space, then a very small kundi can be constructed. It is actually made in sandy regions where the water table is deeper and is normally salty. Kundis can be both private and collective. Private Kundis are made in front of houses, and the collective kundis are made on panchayati grounds.

Tankas are pretty much like kunds and kundis. The water collected in them comes from the roofs of houses instead of the courtyard. Each roof has got a slope. At the mouth of the slope, a clean drainpipe is made. The tanka is usually located in a room, a hall or a courtyard and it is also properly covered. On one corner, the aperture is covered with a clean lid, which can be removed to fill water in a bucket. Throughout the year the water of the tanka is used for drinking and for kitchen work. To ensure its purity, no one goes on the rooftop wearing any footwear. No doubt during summer months, the family members sleep on the roof top but the very young children are made to sleep in that part of the roof which is not linked to the tanka. Today desert regions exist in about 100 countries. Leaving aside developed countries, oil rich countries and Israel, there are several desert regions where there is a scarcity of drinking water. In fact it seems unbelievable that the people of these regions, even after many years of living there, did not evolve water saving techniques as was undertaken by the people of Rajasthan. In case of Kalahari Desert region the condition are more favorable than Rajasthan but this is an unusual example of international endeavors for providing drinking water. Experiments are going on in the sandy regions of Kenya to collect rainwater from the roofs of houses. Will the desert countries, such as Botswana, Ethiopia, Tanzania, etc., have to collect water for their usage in this way? If all the work relating to water keeps coming from outside, how long will it be sustainable? If the talent and the expertise of the village, emanating from its body, its spirit and its wealth, are not present in this work then how long will water be present? Compare this picture of desert countries to that of Rajasthan where it is since centuries that the society has evolved a tradition for collecting and preserving precious drops of water.

Sustainable Groundwater Management – A Key to Food Security in Gujarat State, India

Author: Dr. Ratan Jain, Central Ground Water Board, India

Keywords: food security, water stress, sustainability, overexploited, managed aquifer recharge

Introduction and problem identification

Proliferation in groundwater withdrawal in Gujarat has led to development of water stress in the near surface shallow aquifer, which sustains major component of groundwater draft for irrigation and domestic requirements. This is clearly evident from the seven-fold increase in number of critical and over-exploited assessment units, which have increased from 6 during 1984 to 43 as of 2004, over a period of two decades. The aquifers in these assessment units show decline in water levels and in certain situations sharp deterioration in groundwater quality. The coastal aquifers are also under stress where excessive groundwater development has led to progressive deterioration in groundwater quality. The sustainability of the groundwater resources in the highly stressed aquifers in these areas has assumed criticality and its capability to meet the basic needs for food security in its present status needs to be addressed through scientifically sound management interventions.

Analysis, results and implications for policy and/or research

Gujarat's agriculture has come to depend heavily on groundwater resources. It is estimated that over 80% of its irrigated area is served by groundwater; and less than 20% is served by small and large surface storages and irrigation systems. Besides, groundwater meets 82% of Gujarat's domestic water demand, 65% of industrial water demand and 50% of urban water demand. A large proportion of the food production in Gujarat is based on un-sustainable exploitation of groundwater that at the same time is threatened by increasing problems of depletion and quality deterioration. In addition, climate change is increasing the unpredictability of rainfall, the rate of evapo-transpiration and the occurrence of extreme events. In a situation where the competition for water is getting stiffer, these changes are making food production more uncertain. During recent years, prices of agricultural and energy inputs have risen and are becoming increasingly volatile, adding a new challenge to farmers and to food security aspirations. In view of rapid expansion of groundwater use for irrigation, domestic and industrial needs, planning of large-scale Managed Aquifer Recharge(MAR) assumes critical importance, as it would significantly improve groundwater availability and quality, massively reduce energy consumption in groundwater irrigation and in general pave the way for its sustainable use. For preparing the plan for MAR, the state was divided into 11 regional river basins and estimation of annual as well as accumulated groundwater deficits in each basin and analysis of the hydro-geologic features and recharge potentials of each basin was carried out. In particular, the methodology employed included: identification and prioritization of areas in need of MAR; estimation of sub-surface storage space and volume of water needed to saturate the unsaturated zone ; estimation of volume of water needed to arrest the declining trend of water level; quantification of surface water requirement and surplus annual run off availability for MAR in each basin , identification of areas of poor chemical quality of water and analyzing the scope for quality improvement through suitable MAR measures. It is inferred from the studies that out of eleven river basins, MAR is feasible in six river basins; of these four river basins are very critical wherein groundwater is over-exploited.

The first results of these calculations revealed that the availability of non-committed surplus run-off is the key constraint in shaping the MAR strategy for the four water-stressed basins of the state. It is estimated that 1650 MCM/yr of non-committed surplus run-off available in the six basins can be recharged by constructing 15,678 percolation tanks, 22,607 check dams, 14,712 injection wells and modification of 42,000 dug wells for recharge with an investment of approximately US$ 550 Million in MAR structures This paper incorporates a river basin-wise review with special reference to the water stressed aquifers in Gujarat. Measures are spelt out for the sustainable management of such aquifers through various interventions like recharge with canal water, recharge with rainwater, incentivising communities for accelerated recharge, groundwater demand management for augmentation of water stressed aquifers and regulation of groundwater development through people's participation for ensuring food security in the state.

Efficiency Evaluation of Water Users Associations for Assessing Performances of Irrigation Projects: A Case Study

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Keywords: efficiency evaluation, irrigation sector, water users associations, data envelopment analysis, policy

Introduction and problem identification

Effective utilisation of Water is a major concern as water is an essential input to food production, and is a limiting resource. Increasing crop yields and sustaining food production depend mainly on irrigation, and hence, efficient usage of water resources is crucial to the irrigation sector, and hence to imparting food security. The concept of measurement of efficiencies of Irrigation distribution services has so far not been investigated in India, and is limited to project level appraisals in several countries. The present paper hypothesizes that within any project there lie pockets of inefficiencies.

The paper further explores and establishes the need for measurement of performances within the project, and endeavors to develop a Data Envelopment Analysis (DEA) based framework for exploring efficiencies. The evolved framework is exemplified by a case study relating to a major irrigation project – the Samrat Ashok Sagar irrigation project, in the State of Madhya Pradesh, India.

Analysis, results and implications for policy and/or research

Efficient usage of irrigation water would imply that irrigation projects would need to be benchmarked for improving performances of services. However, despite the global emphasis on measuring performances, benchmarking still remains elusive for most irrigation projects located in developing countries including India, and the absence of a sector regulator further ensures that inefficiencies become a part of the project performances, and planning and policy has no rational basis in the absence of measurement of performances. Water Users Associations (WUAs) are constituted in Indian large Irrigation projects with an objective of promoting Participatory Irrigation Management that enables the farmers to come together and work. The Major Role of each WUA is to promote and secure equitable water distribution among its users, and ensure adequate maintenance of irrigation systems. The WUAs are constituted over a population of 100-1000 water users, and the associations have a general body that includes farmer and their wives as members. The demographic area covered by a WUA is a hydrological boundary ranging from 100 to 2000 Ha. In the present work, performances were measured at the WUA level by employing a DEA based approach. The methodology identifies appropriate DEA variables to explore benchmarks, computes the quantum of inefficiencies and investigates the potential for efficient levels of input usage and hence the quantum of possible savings. The results were then interpreted with regard to suggested policy measures that may lead to enhancement of Project performances of similar Irrigation projects. A major finding is that even within an apparently efficient project, there lie pockets of inefficiencies, i.e. the overall project may seem to be performing well, but may still have some WUAs that perform relatively inefficiently, thus necessitating the need for benchmarking at the WUA level, a policy that is non-existent currently. DEA conducted on six Models at WUA level in this study showed that 63% WUAs were performing at less than 70% efficiency, thereby highlighting the necessity of benchmarking at the WUA level for Irrigation services rather than the usually adopted practice of measuring efficiencies of project asa whole.

This indeed has significance from the viewpoint of a Sector Regulator, which unfortunately is still non-existent in the Indian context. DEA analysis also showed decreasing returns to scale (RTS) at the project level in most of the models, indicating that the services are overstretched. Therefore, even if inputs are increased, there will not be a proportionate increase in output. However, DEA at the WUA level showed a contrasting increasing return to scale in several cases, implying that increasing sizes of such WUAs would yield greater outputs. This therefore becomes a fit case for restructuring and resizing of WUAs to achieve efficiencies by reorganising differently from the present basis of hydraulic boundaries. Optimal sizing of WUA operations through restructuring is critical to harnessing scale efficiencies. The DEA results also show that there exist potential for savings in terms of staff deployed for irrigation services. The results show that at WUA level there exists a possibility of potential saving to the tune of 21-24%. These large values assume significance, since for several services rapidly increasing real wages may be the major contributory factors for unsustainable personnel costs. Such high staffing indicates profligate employment practices in the sector that may arise either due to flawed policies or political interference in the working of water services, and ultimately manifesting in misgovernance. It can be concluded that one of the potential areas that need critical evaluation would be the curtailment of deployed staff at the individual WUA level. Another important finding was with respect to possible savings on Operating Expenditures (OPEX). Significantl OPEX savings (as large as Rs. 4028875 (1US$=Rs 49.5) annually) are possible by following best practices. The resultant savings may be deployed to expand services and to invest in O&M, resulting in incremental increase of efficiencies and savings. This therefore forms a fit case to invest more enthusiastically in O&M, which also would require that tariffs be revised in order to ensure that at least operation and maintenance expenditures are covered by the revenues.

Currently, the Water rates are based on irrigated land area based on crop cultivated, chargeable specifically on per hectare basis differently for different crops as announced each year by the Government. This revenue has no linkage with the O&M expenditures. The absence of a sector Regulator further ensures that tariffs are not linked to OPEX requirements as efficiency analyses remain non-existant. It is suggested that tariffs be linked to OPEX needs and performances as a matter of policy.

Global Use of Freshwater, Cropland and Fertilizer Resources for Food Product Losses and Waste

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Keywords: food product losses and waste, water resources, cropland, nutrients, food security

Introduction and problem identification

The world is facing rapidly growing challenge to feed its people sustainably. Several measures have been suggested to meet the increasing challenges of feeding the world's population and increasing food security in a sustainable way, such as: halting farmland expansion, in particular in the tropics; closing 'yield gaps' on under-performing land; increasing cropping efficiency; shifting diets; and reducing waste. In this study we concentrated on the last of those measures, i.e. reducing waste, since about one third of the food produced globally is lost or wasted, and reducing this could be an important measure to increase global food supply. Such large food losses also affect our use of other resources, such as freshwater (blue water), cropland, and fertilizers. In this study we estimated the global use of these resources in producing food products that are lost and wasted, and quantify the potential resource savings that could be made through a more efficient food supply chain.

Analysis, results and implications for policy and/or research

We first put together a global database of the food supply chain (FSC) at the national scale by using the FAOSTAT's food balance sheets. Then we estimated the food product losses and waste based on the recent study by FAO of global food losses and food waste. By using water footprint and FAOSTAT's ResourceSTAT databases we were able to calculate the used freshwater, cropland and fertilizer resources for the food products in total and for the part of food products that were either lost or wasted within the FSC. We found that one quarter of freshwater resources (i.e. 270km^3/yr or 42 m^3/cap/yr) used in food production are used in food products that are never consumed. The production of these lost and wasted food products accounts for approximately one fifth of the total global cropland area (235 Mha/yr; 36.2X10-3 ha/cap/yr) and one fifth of total global fertilizer use (33 Mt of nutrients; 5.1 kg/cap/yr). The per capita use of resources for wasted products is largest in North Africa & West-Central Asia (freshwater and cropland), and North America & Oceania (fertilizers). The smallest per capita use of resources for wasted products is found in Sub-Saharan Africa (freshwater and fertilizers) and in Industrialised Asia (cropland). We estimated that approximately half of the FSC losses, and their associated resources, could be saved by applying everywhere the current minimum loss and waste percentages in each FSC step. The means of applying such loss and waste reductions will differ per region, and should be tailored to local conditions and cultures. In medium/high-income countries the consumption part provides the most potential for savings, whilst in other countries the agricultural and postharvest steps are crucial. In all countries of the world, political will and public awareness should urgently be raised to reduce FSC losses. EU is showing good example in this by aiming to halve food waste by 2025 and take measures, such as the roll-out of dual-date labelling, to prevent the generation of food waste. Although reducing the FSC losses cannot alone solve the challenges of resource scarcity, it could be a significant step towards a more sustainable use of these resources.

Moreover, reducing losses would also have several important secondary benefits, such as reducing greenhouse gas emissions, conserving energy, protecting soil from degradation, and decreasing pressure for land conversion to agriculture and therefore also protecting biodiversity and carbon sinks. If the reduction of FSC losses was applied efficiently, we believe that these reductions would lead to a significant increase in water and food security in many parts of the world.

Is the Rebound Effect (Jevons Paradox) a Useful Metaphor for Water Management? Insights from the Irrigation Modernization process in Spain

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Keywords: irrigation efficiency, rebound effect, Jevons paradox, irrigation modernization, Spain

Introduction and problem identification

The Jevons Paradox or Rebound Effect (JP/RE) is based on the fact that the use of a technology which allows to improve the efficiency in the use of a resource (that is to say less input to produce the same output) finally results in a higher overall use of this resource in the whole society. This effect and its explanation were first described for the case of coal by the economist Stanley Jevons at the end of the 19th century in England. There are many examples of the application of this paradox for resources, like energy or even time. The objective of the paper is to present how this paradox could be applied in the case of water and, more particularly, to assess the reality of the JP/RE in the case of irrigation water application efficiency.

Analysis, results and implications for policy and/or research

The efficiency in the use of water is usually presented as a way to obtain huge water savings in the agricultural sector. However, in many cases the effort in modernization is not translated into consumption reduction at basin scale (Lecina et al., 2010). The literature on JP, applied to energy for instance, presents many associated measures and rules which should be promoted along with efficiency improvement to be sure that the possible savings will be effective once the efficiency improvement is realized. It may be useful to adapt these recommendations to the case of irrigation water to make sure that the water savings are effective and not used to promote new uses on the basis of the calculated water savings. The traditional explanation of the Jevons paradox is that conserving resources thanks to efficiency leads to an expansion of the offer, which makes the price of the resource drop, allowing for more demand to be satisfied. However, it is not fully applicable in the case of water. The paper will present why: it may be related with the fact that water is usually not a tradable good; there are very few water markets and thus the incentives for conserving or wasting water are different than for many types of resources. Moreover, in many situations, water which is not consumed by a particular use (i.e. return flows) may be available again in the basin for further use downstream, contrary to energy, for instance, that is hardly retrievable if applied in excess. In addition, the reality of the paradox should be assessed completely by looking at the impacts (costs and benefits) for society as a whole, its sustainability and its particular components. Who bears the costs of efficiency? Who is benefiting of this improvement? Etc. The case of irrigation modernization Plans in Spain serves as a practical example of the effect of irrigation efficiency improvement (Lopez-Gunn et al., 2012): applying the water accounting methodology (Molden et al., 1999) before and after modernization reveals that even if the water consumption rises as the JP/RE suggests, the reasons and explanations

for this phenomenon are different to the ones of the JP/RE. Thus the paper will question the efficacy of irrigation improvement, but will argue that the metaphor of JP/RE is not fully justified. Moreover, the term of efficiency and its current use is questioned, as what is in fact irrigation water application efficiency is only a factor among many others that allows for assessing the general efficiency, interest and justification of an irrigation modernization plan. A special attention is dedicated to energy, as the transition from a "traditional" to a "modern" irrigation system implies a rise in energy cost for the farmer (Rodriguez-Diaaz et al., 2011); thus, the efficiency of application of a particular resource seems to be obtained a the expense of the rise in the use of another one. Therefore, the conclusions of this paper are of great interest in relation with the assessment of the reality of the water savings from irrigation efficiency improvement. Moreover, it questions the similarity of water with other resources and the opportunity to make comparisons such as JP/RE, that can raise the interest of people but might also reproduce wrong views.

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Kitchen Gardening Solves the Problem of Malnutrition & Making Best Use of Water Resources for Food Security

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Keywords: high infant mortality rate, fruits and vegetables, kitchen garden waste water, water security, food

Introduction and problem identification

The malnutrition problem is the root cause of high infant mortality rate,maternal deaths and deaths due to common diseases like pneumonia,malalria,thyroid,d iarrohea etc. in the villages of Rajasthan.

The Save the Children project "Our Health is in our hands" focused on ways to enable people to fulfill their nutritional deficiency by making best use of available Land and water resources.Most of Indian population is vegetarian and best way they can tackle nutrional deficiency is to use Land and water resources most efficiently. The kitchen gardening at household water sources/near handpumps/stand posts is the answer to this problem.The kitchen gardening contributes to the food and water security in the villages of Rajasthan thats how they tried to prove "Our health is in our hands".

Analysis, results and implications for policy and/or research

The purpose of the kitchen garden is to grow nutrient fruit and vegitable plants for fostering of children and reducing malnutrition.The fruits and vegetables gardens have been developed near household water sources/ hand pumps/stand posts to utilize waste water from hosehold water sources/ handpumps/stand posts. The solution has been implemented in 123 villages/wards in three districts viz Tonk,Banswara and Churu of Rajasthan state of India by Save the Children,Rajasthan State Office,Jaipur With the support from Pepsico Foundation,Save the Chiildren,India has implemented an integrated health,nutrition,water & sanitation project & kitchen gardening was one of the components of the project.The project has been implemented in partnership of three local NGOs,two technical support agencies and several local partners. The Village Health and Sanitation Committee and local NGOs proved strategic in the implementation. They were brought during the implementation of the project .Village Health and Sanitation Committee has ensured the follow up of the solution at local level. They were brought during the implementation of the project. Village Health and Sanitation Committee has ensured the follow up of the solution at local level.

The key outputs of the solution are fulfilling the requirements of fruits and vegetables of a family through kitchen gardening. Save the children provides for developing a kitchen garden in the form of vegetable seeds and fruit seeds costing Rs 50/-(US$1)to provide food security at household level.

The development of kitchen gardening and its running and maintenance is done by the family. The development of a kitchen garden for each family was a household affair.The nutritional deficiency amongst women and children is being eliminated by eating fruits and vegitables of their own kitchen gardens.

The women and children would be most interested in this solution as it reduces the malnutrition among them.This solution could work in rural/urban areas where sufficient land is available for kitchen gardening. The awareness creation for malnutrition reduction would create demand for kitchen gardens.

Rice Bowl of Myanmar: The Ayeyarwaddy Delta and Its Water Management Developments through the Ages for Paddy Production

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Keywords: water management, flood protection, reclamation and polders, tidal irrigation, paddy and fish

Introduction and problem identification

Nowadays,Ayeyarwaddy delta is facing development challenges due to the climate change impact in the region and the lack of effective integrated management of water resources in river. The possible threat of damming the upstream Ayeyarwaddy and the growing population of the future Mega City,Yangon,adjacent to the delta are major threats to Myanmar with increasing water users and increased demand for food supply. In these situation,Ayeyarwaddy delta is a strategic place to increase paddy production for food security of the country's growing population and for the region beyond its border. There still remained areas in delta with lack of proper water management schemes to be developed. In some areas, gravity tidal irrigation for crops can be applied without using power. In some areas fishing industry with sustainable approach can be done wisely for food supply in the region. It calls for an optimum solution to benefit for all the water users considering the future climate change impact.

Analysis, results and implications for policy and/or research

Ayeyarwaddy Delta as a rice bowl of Myanmar is one of the largest delta in Asia ,with an area of 13,500 mi2 (35,000km^2) and average annual flow of 15,200 cubic meter per second in Prone at the apex of the delta. The river with a length of 1,350 mi (2,170km) flows through the centre of the whole country from north to south and finally discharges into the Bay of Bengal and Andaman Sea through nine river mouths in the vast land area of delta .Like most deltas of the world it is a very fertile land for agriculture ,especially for wetland rice paddy cultivation as a staple food supply for it's ever growing population within the country and in the region beyond it's borders. Paddy cultivation in Ayeyarwaddy delta was traditionally accomplished by monsoon rain since ancient times. The upper reach of the delta is predominantly affected by seasonal river flood caused by upland flow and downstream tidal flow. No considerable land use for agriculture by proper water management and flood control schemes was made until (1881) before the colonial period .Large scale flood control embankments in horseshoe shape were first introduced in the upper delta in (1882) for paddy cultivation in vast areas of 612,000 acres of waste lands then in Henzada district in upper delta . In later days after independence ,from 1977 to 1987 , more than 200,000 acres of fallow and waste lands in different parts of lowland area of the delta were reclaimed and transformed to agricultural land again especially for paddy production with the introduction of polders projects throughout the middle and lower delta. The projects named as the Lower Burma Paddy land Development Projects, Phase 1 and 2 were implemented and financed by World Bank. During 1990 s ,modern day concept of fresh water tidal gravity irrigation was introduced in strategic places throughout the middle delta to boost paddy rice production again and thence changed from rain-fed paddy cultivation normally done in monsoon season in the delta to irrigated paddy cultivation in summer season by tidal gravity irrigation methods.

There still remained potential areas in the delta that can be developed by empoldering works for paddy cultivation and there also remain areas with tremendous potential for tidal gravity irrigation in Ayeyarwaddy delta. Based on the past experiences of water management schemes in the delta, improved and future extension of the areas for paddy production can be established by best uses of land and blue water resources in Ayeyarwaddy delta of Myanmar.

Enhancement of Water Productivity of Wetlands of Eastern India for Achievement of Food Security

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Keywords: water, productivity, food, wetland, IFS

Introduction and problem identification

Eastern India has water productivity of 0.37kg/m^3 compared to 1.01kg/m^3 in north-western states. Groundwater utilization is also low (33%) compared to national level (58%). Out of 150 disadvantageous districts in the country 69 districts are confined in the region where food is not yet secured for the huge population. Many of these districts are dominated by saucer shaped wetlands formed by chains of rivers intersected with many tributaries, low-lying areas and canals. They are bounded by land frequently waterlogged during wet months for differnt periods. These swampy submerged, fertile and unproductive lands have very high potential for the production of valuable, nutritious and popular aquatic food crops (deep water rice, fish, water chestnut, makhana) and food cum ornamental and medicinal plants. It is imperative now to harness untapped resources of wetland and convert the adversity of excess water to opportunity of producing more food through integrated farming system (IFS)approach.

Analysis, results and implications for policy and/or research

Concerted efforts were made to improve the livelihood of small farm holders taking 100 households of wetland (chaur) at Purnia block in Purnia district (Latitude 25o13'80" to 27o07'59"N, longitude 86o59'06" to 87o52'35"E) of Bihar in eastern India through multiple use of abundant water for enhancing productivity to improve upon food security, health and environment for ultimate improvement of livelihood of the resource poor farmers whose well being, by and large, depends upon this fragile but potentially productive ecosystem. Average annual rainfall of the area is 1470.0 mm. Traditionally, the farmers cultivate the major crops like rice (av. production 2.0 t/ha), wheat (av. production 2.5 t/ha), and maize (av. production 3.0t/ha), in mono-cropping system. However, opportunities do exist in larger areas for raising more than one crop. Keeping these facts in view, four alternative farming activities
(i) Deep water rice-fish-vegetable system
(ii) fish culture in seasonal waterlogged areas
(iii) aquatic horticulture (Euryale ferox Salisb and Trapa bispinosa Natans) – fish and livestock production (khakicampbell duck) in pond system and
(iv) raising of fish seed from low cost eco-hatchery, were undertaken for demonstrations of integrated agro-aquaculture systems to achieve food security for rural poor. Study revealed that introduction of deep water rice varieties during rainy season and cultivation of fishes, rabi crops with the harvested water enhanced water productivity.From sole rice the net water productivity of Rs.1.55-1.6/m^3 was obtained, whereas net productivity of Rs. 6.98 - 7.26/m^3 was obtained from Rice + Fish + On-dyke horticulture + rabi crops. From constructed ponds (65% pond, 35% embankment for vegetable cultivation), net returns of Rs. 19850-23000/ha were obtained during 2009-10. In 2010-11, Rs. 28,300-30,000/ha net returns were obtained from the same field. Bottle gourd on the embankment of pond, yielded 20.0 t/ha as additional vegetable crop enhancing income of farmers by Rs.1, 00,000/-ha.

Further, traditional yield of fish of 2.0 t/ha from the pond got increased to 3.6 t/ha which resulted additional increase in income of Rs.1, 50,000/-ha. The makhana (Euryale ferox) as a primary crop gave a total net profit of Rs.8,00,000 with an employment generation of 9500 man days per year. The fish as a secondary crop integrated in makhana ponds showed an additional income of Rs.4,66,000 with an employment generation of 895 mandays /year, whereas water chestnut taken as tertiary crop generated an additional net income of Rs.25,000 with an employment generation of 350 mandays per year. The eggs produced through integration of ducks yielded an additional income of Rs.2, 62,800/-ha. Fish fingerlings raised through cage culture helped farmers in availability of fish seed for stocking of the wetlands. Fish seed production in ten days through eco-hatchery ensured fish seed availability to the farmers. They were benefited with 80 lakhs fish seeds with estimated income of Rs. 80000/-.In the embankment of ponds fruit trees like banana and cocconut along with vegetables were found to be highly remunerative and earned additional income of Rs. 80000 per ha. In the undulating wetlands replacement of conventional crops with high valued cashew and mango were found to be successful.Community stakeholders were convinced with the outcome of technologies and learnt technical know hows to replicate them in their own land and common property resources under the guidance of scientists of ICAR. They established IFS with local crops, vegetables, fishes and livestock and established commercial hatchery with a capacity of 40 lakhs spawn per day at Purnia in Bihar. Community building organisation helped in developing a supply chain for selling their products in the village itself. Location and farmers' resource specific integrated farming system were most sustainable for securing foods and enhancing income for inhabitants of the project area.The technologies of waterbody based integrated farming system has been scaled up to 50 more wetland villages of North Bihar in Eastern India. Officials of Government of Bihar have been convinced with the technology and its replicability. They agreed to take up the technology for its further dissemination through their extension set up to more villages of north Bihar in Eastern India. ICAR sponsored Krishi Vigyan Kendras have already included the technology demonstration in their training curriculum.State Bank of India has recognised these as bankable technologies and many farmers of the neighbouring villages already received loans for development of pond based integrated farming system for achieving millennium development goal of "more crop per drop" and advancing this Eastern India further towards rainbow revolution in total foood production in 21st century.The success of the project gave new direction to research of ICAR and Govt. policies towards development of land holding-based IFS.

The Role of On-Farm Water Storage in Irrigation – A UK Case Study

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Keywords: on-farm, reservoirs, storage, irrigation, England

Introduction and problem identification

In the UK, and in many places with similar climates, water is increasingly scarce during the summer irrigation season but can be plentiful or even excessive in the winter months. Climate change is expected to make this seasonal distinction even stronger, with more frequent summer droughts coupled with increased winter rainfall and more floods. On-farm water storage of the higher winter flows is one of the main options for securing a more reliable water supply for irrigation. However, most UK abstractors have been reluctant to build reservoirs, for a range of reasons. This study is investigating the cost-benefits of on-farm reservoirs, the constraints encountered, the role of reservoirs within integrated water management, and whether reservoirs would help resolve the water scarcity problems in the longer term.

Analysis, results and implications for policy and/or research

Methods and Materials: Information on the number and volumes of on-farm water storage reservoirs in England and Wales was collated from two main sources; abstraction licence records and statistics derived from the Defra Irrigation of Outdoor Crops Surveys. Monthly abstraction data was analysed to identify the proportion of licences that were "live" and the patterns of water abstraction. Semi-structured interviews with farmers who had recently constructed reservoirs were used to identify the costs of reservoirs and the benefits as seen by the owners, as well as the types of problems they had encountered. Similarly, interviews with reservoir design engineers, planners and other interested parties were used to investigate the technical and planning constraints to development, and the options for avoiding or overcoming barriers.

Results & Discussion: Nearly half the storage licences are located in the East of England, a region often described a semi-arid. Most are relatively small, although there is a trend towards larger volumes. So far, only about 5% of licences are for greater than 200,000m^3 annually. Of all the water actually abstracted for spray irrigation, about 17% is abstracted in winter months. There is a large variability in abstraction from year to year, and between months; for example, on average 18% is abstracted in January, but this has varied from 10% to 36%. Nearly half (44%) of all storage licences are located within catchments having summer abstraction regimes that are either 'over-abstracted' or 'over-licensed'; a further 36% are within catchments having 'no more water available'. This both reflects the reasons for constructing the reservoirs and the role they can play in resolving scarcity. Irrigation is a comparatively high value use of water when used for supplemental irrigation of potatoes, vegetables and soft fruit in Eastern England. Relatively small volumes are needed in the UK climate, yet these significantly increase crop value. Most irrigation is to improve crop quality and price rather than yield. Nevertheless, many farmers quoted high reservoir construction costs as a major constraint.

Reservoirs are not financially attractive to all farmers, because for example of:

- Lower cost alternative supplies.
- Above-normal construction costs due to site conditions, difficult access, and/or fragmented landholdings.
- Insecure land tenure.
- Uncertain long term cropping plans. The need for plastic linings increases costs considerably – most irrigated farms are located on light soils and may not have access to clay soil sites for cheaper reservoirs. Some government financial support is available, but only for shared reservoirs.

However, a range of other problems were also identified, some less obvious:

- Local planning constraints, e.g. on the movement of materials, skyline views, and noise;
- Local safety concerns (though most farm reservoirs are very low risk);
- The fear of archaeological remains, requiring expensive surveys with no guarantee of ultimately obtaining consents;
- Environmental constraints requiring expensive investigation and often remedial measures, again with no guarantee of ultimately obtaining consents;
- European single-market restrictions on government aid;
- Public rights of way;
- Expensive access to 3-phase electricity for pumps;
- Lack of access rights for pipelines.

The study found there are particular benefits in groups of farmers co-operating, to obtain benefits of scale and more flexibility in re-allocating water from year-to-year. However, there is a lack of confidence in how these arrangements might work in the long-term. Uncertainty about whether reservoirs can be refilled reliably is a major disincentive. In the 2012 winter, many farmers were still unable to refill their reservoirs by February. These restrictions have done much to undermine farmer confidence in farm reservoirs. Furthermore, long-term river flow changes under climate change indicate serious problems in the future. This raises the serious issue of whether on-farm reservoirs could become maladaptations to climate change in the longer-term. Implications: On-farm reservoirs will have a major role to play in supplying irrigation water in the UK and need to be an integral part of integrated water management policies, but support is needed to help farmers avoid constraints to development. Importantly, farmers cannot assume reservoirs will give total reliability, particularly as the climate changes. Higher benefits could be obtained within a more liberal licencing system where water could be traded more freely between reservoir owners and other users, an option the government is currently researching. Different ownership and management models need to be considered.

Workshop: Towards a Green Economy The Water-Food-Energy Nexus

Cradle to Cradle: Anaerobic Bio-Digestion of Abattoir Waste Generates Zero Emission and Creates Sustainable Bio-Energy and Bio-Fertiliser in Africa

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Keywords: abattoir effluent, bioreactor, bio-energy, bio-fertiliser, waste management

Introduction and problem identification

Food processing wastes from abattoir, dairy products, brewery and other agro-industries are a major source of water pollution and greenhouse gas emissions, especially in the developing world. Specific regulations for industrial waste do often not exist or are poorly enforced. This represents an immediate environmental problem, affecting among others the development of aquatic life. Slaughterhouse waste also often carries zoonotic diseases - animal diseases that can be transferred to humans. Communities depending on polluted water for consumption and agriculture therefore face significant health risks. Moreover, the anaerobic degradation of wastewater generates methane and carbon-dioxide and thus accelerates climate change. The way out of the dilemma was to find a way of capturing the gas emissions and turning them to productive usages. Relevant technology for achieving this was created by African Environment Research Institution in association with Thai Technology Innovator.

Analysis, results and implications for policy and/or research

Our pilot bioreactor dubbed "Cows to Kilowatts" is located at Ibadan, the largest indigenous city in Tropical Africa. About 1000 heads of cows are slaughtered daily with the wastewater discharged directly into open drains and faecal matters dumped in heaps. The waste potentially reaching 4,000mg/l of biochemical oxygen demand in local rivers, surpassing the international threshold of 30mg/l and 60% of the local population uses water from hand-dug wells vulnerable to contamination. The Cows to Kilowatts model pioneered a new model of waste management that treats slaughterhouse effluent at the source and converts harmful greenhouse gases into clean energy through social enterprise. The innovation deploys a cutting-edge anaerobic fixed film bioreactor technology to treat abattoir waste and produce low-cost biofuel, generating biogas more efficiently than conventional biodigester technologies. This also reduces water pollution and greenhouse gas emissions and provides a sustainable and cheap source of energy and fertilizer in Nigeria. The model also leapfrogged the need for effective governmental regulation for waste treatment by offering a profitable solution The captured methane is used to drive gas generators to provide electricity for power starved poor communities. The sludge from the reactor is upgraded and used as environmentally safe organic fertilizer for low income farmers. This result is more efficient fertilization of farm lands against chemical fertilizers and reduces non-point source water pollution.

This new waste-treatment model is revolutionizing traditional practice in slaughterhouses, contributing to safer living environments and boasting economic viability for the local economy. Operated as a social business, the profit is being invested into similar waste-treatment facilities in other locations, further increasing the beneficial impact. Operated as a social business with sound business model, the plant generates return on investment after 2 years.

With an estimated lifespan of 15 years, the plant creates substantial economic returns and virtuous cycle of sustainability. The innovation adopt environmentally-benign technologies and sound business model to create lasting solution to the problem of organic wastes which also minimises carbon footprint and creates green power in an economically self-sustainable and profitable manner, generating a classical win-win situation. The model is been replicated across Africa.

Enhancing Land Productivity of Degraded Land by Promoting Bioenergy and Fodder Crops in a Semi Arid Region

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Keywords: degraded land, semi arid, bioenergy crop, remote sensing, GIS

Introduction and problem identification

Drought is considered to be the most complex, but least understood natural hazard, affecting more people than any other hazard. Water stress is the phenomenon in drought prone areas. Water stress causes deterioration of fresh water resources in terms of quantity and quality. Droughts impose a serious threat to agricultural production and development of socio-economic activities in the semi arid and arid regions which are more vulnerable to the effect of drought. Agricultural production in semi arid and arid regions are constrained by low rainfall, poor or low nutrient soils, high temperatures, high solar radiation, and low precipitation, which renders them extremely vulnerable to inappropriate land use and exploitation resulting in converting most of them into degraded land. Targeting these degraded lands for raising food, bio-energy and fodder crops with the available water resource effectively can provide a ray of hope in providing food, fodder and energy security for the rural poor.

Analysis, results and implications for policy and/or research

India's energy security is remaining vulnerable until alternative fuels to substitute/supplement petrol-based fuels are developed based on indigenously produced renewable feed stocks. In biofuels, the country has a ray of hope in providing energy security. Potential of biofuels in mitigating climate change and enhancing energy security, countries have moved quickly to set up targets for fossil fuels substitution by biofuels. IPCC (2007) highlighted the large potential for biofuels to meet the growing energy needs as well as contributing to GHG emissions reduction, especially in the transportation sector. The targeting of marginal and degraded lands can mitigate land use change associated with bioenergy expansion and also enhance carbon sequestration in soils and biomass. As a guiding principle, bioenergy crop systems can potentially provide benefits if implemented on land that is currently under annual row crops or are undergoing uncontrolled degradation. Furthermore, bioenergy production could make use of perennial plants requiring less agrochemical and water inputs than traditional crops and could help reduce soil erosion. Using non-arable, degraded land for bioenergy feedstock production could avoid displacing food/feed crops and thus reduce pressure on fertile land and respective indirect land use change effects and offers potential soil carbon fixation benefits. FAO and IFAD 2010, says using the energy crop Jatropha for biodiesel production could benefit poor farmers, particularly in semi-arid and remote areas of developing countries.Diverting arable lands to cultivate such bio-fuel crops is not a desirable proposition, as it will directly affect the food security of a country, which may have further deleterious ramification. Better option would be to use the available wastelands degraded lands to cultivate bio-energy and fodder crops without affecting the areas under food crop.

Objectives of the study are:

(i) to identify and map the degraded and wastelands area using High resolution remote sensing imagery
(ii) To carry out soil sampling in the degraded lands to analyse the soil quality parameters
(iii) To create maps showing the spatial variation of soil parameters in the wasteland area using ArcGIS
(iv) to suggest the reclamation measures to improve the soil fertility for promoting food, bioenergy crops as well as fodder crops.

This study deals with mapping of degraded lands in Sindapalli Uppodai sub basin. Sindapalli Uppodai sub basin consists of many tanks which forms cascade of tanks. The maximum rainwater is collected and stored in these tanks and utilized for the needs of irrigation and drinking water demands through directly as well as recharging ground water aquifers. The entire Sindapalli Uppodai sub basin falls under semi arid region. The sub basin is located in Vaippar basin between Latitude of 9° 25' 00"N to 9° 30'00" N and Longitude 77° 45'00" E to 77° 55'00" E. Cartosat-1 data from National Remote Sensing Agency, was used to find various land use types and the land use map was created. From the land use map, wastelands and degraded lands were delineated. Soil sampling is carried out at various locations in the regions of degraded lands. The various soil parameters are tested in the laboratory and their suitability were analysed for growing food, bio fuel and fodder crops. Soil parameter maps were created using ArcGIS. Rainfall analysis and surface and ground water potential were assessed to find it suitable for raising food, bio-energy and fodder crops based on its requirement. GIS platform was used for integration and suitability assessment of the lands for the above crop. GIS can help pull together various types of disparate data such as remote sensing data, census data, records from different administrative bodies, topographical data and field observations to assist researchers, planners, project officers and decision makers in resource management. Soil reclamation measures are recommended for promoting Bio-energy and fodder crops.In semi-arid region, sorghum is found to be efficient crops,as its stalk is used for producing energy without affecting its food and fodder parts.Based on the water resource availability and land fertility the suitability of the land for food, bio-energy and fodder crops were suggested. Which will provide information for the villagers in bringing the non-cultivable degraded lands to effective use, so that their social and economic development can be made.

Induced Gravity Flow – Resolving the Deadlock Between Energy and Water/Food Security

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Keywords: Orissa, sustainability, sanitation, water, energy

Introduction and problem identification

In India although access to drinking water has improved, the World Bank estimates that 21% of communicable diseases are related to unsafe water. Diarrhoea alone causes more than 1,600 deaths daily. In Orissa less than 20% of the rural population has access to protected water, less than 5% has access to improved sanitation and less than 1% has access to piped water supply (Mackinnon, 2002).

The Government installs hand pumps and stand-posts but stand-posts are possible only in villages that are electrified as it involves pumping of water. Most of the tribal habitations have low population density and a majority depend on unsafe water sources. In summer, these villages face acute water shortage. Water supply to these areas through electricity is not possible as many villages in Orissa have no electricity or even where available, the power is unreliable. In order to address this problem Gram Vikas (GV), a grassroots NGO, uses an innovative approach of 'induced gravity flow'.

Analysis, results and implications for policy and/or research

Gram Vikas, a grassroots NGO working for more than three decades in remote rural and tribal villages in Orissa, has been providing safe water and improved sanitation facilities to more than 1043 villages and more than 65,000 families living in rural and tribal areas. With the Induced Gravity Flow, Gram Vikas is able to bring a 24x7 piped water supply to remote villages in rural Orissa. To date, 457 villages have benefited from a water supply fed by Induced Gravity Flow. The induced-gravity flow system can be implemented in areas with undulating terrain by ensuring the water-source identified is at a higher point than the village. A suitable point in the underground water-vein, which is higher than the water tank in the village, has to be identified. An 'intake well' is dug till the underground water-vein is ruptured. The intake well is lined with layers of stone and sand, which results in percolation of water and hence a maximum amount of natural filtering occurs. Then a pipe is connected to the trench and this is run all the way till the water tank of the village. The water column generates the pressure for the water to flow into the elevated water reservoir and thereafter to the individual households through the distribution pipeline. We have seen numerable social benefits and impact after implementing IGF water supply systems. We are able to reach the poorest and the most marginalized community who do not have access to electricity. Using water from IGF, we have implemented the water and sanitation programme, watershed management programme, irrigation and agriculture systems which have brought fallow land under cultivation and increased social forestry. The IGF water supply system has been successful in eliminating the dependence on the availability of energy from non-renewable or renewable energy forms for food and water security. By resolving the deadlock situation, we are now able to provide the most marginalized and isolated communities with food security by the various irrigation and agriculture initiatives, and water security with many watershed activities that ensures access to continuous and safe piped water supply.

Induced Gravity Flow based water supply and irrigation systems can ensure green economy as it addresses several issues:

1. Health needs of the community through 24 hours safe water supply and piped water sanitation facilities
2. Irrigation/ agriculture through overflow of water tank which impacts the nutrition levels and income levels of the community
3. This solution incurs no recurring costs for water supply as the induced-gravity flow system does not depend any form of electricity (non-renewable/ renewable energy) or energy source.
4. The IGF systems only use the water which is recharged into the 'intake well'. This means the community can use only as much water it can recharge the water table. The community develops an understanding of the importance of water management and water recharging since they can only use as much as they recharge. This understanding is very essential to establish water-equity.

Sustainable Development at Risk in DRC, the Eve of Rio+ 20 in June

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Keywords: water, biodiversity, sanitation, water, bio methane gas, water, biodiversity, protected

Introduction and problem identification

In DRC, the situation is less dramatic: In 1995, 48.4% of households in cities in the DRC had sanitary latrines or defined as such (Toilets evacuation in the urban network, in septic tanks and toilets improved ventilation called traditional covered). But in 2001, they were only 27.2. In rural areas the situation is even worse with only 0.5% of households were equipped (to 0.4% in 1995). These figures also do not account for the deteriorating quality of public infrastructure consolidation. In most cases, these were not regularly maintained, are outdated, unsuited to current living conditions and insufficient. When population pressure was not due to existing infrastructure they are often simply not adapted to current conditions. This is reflected by the unhealthiness which is the newspaper of the majority of the Congolese population.

Analysis, results and implications for policy and/or research

Access to safe water and sanitation represent a significant economic progress, a gain that can be evaluated between 3 to $ 34. Every dollar invested in a direct effect between 2 and 4% of GDP. The combination of these problems related to access to water associated with poor hygiene are responsible for most deaths in children under 5 years (2.2 million dead including 1.5 deaths only for problems of dysentery). The DRC is little affected by air pollution, with an emission rate of carbon dioxide (CO_2) of only 0.05 tons per person in 2002, and a downward trend instead. However the situation could rapidly evolve and take on the appearance of a disaster if nothing is done. It is also important to note that if the presence gas from Lake Kivu is a hope of raising the standard of living for local residents, it is a terrible short-term threat. Indeed, in addition to methane, the lake contains carbon dioxide in the deep strata. Significant pressure maintain these two dissolved gases. But these gases accumulating by the action of fermentation, they will one day soon to saturation. Bubbles will form and then ascend to the surface. In doing so they will cause a mixing of deep waters and other appearances of bubbles of carbon dioxide and methane, and this is the beginning of a chain reaction like that occurring at the opening of a bottle of champagne. Huge quantities of gas ascend to the surface. Methane is lighter than air, will be lost into the atmosphere without other direct damage. Carbon dioxide, however, heavier than air will then flow around the lake, suffocating the surrounding populations. This phenomenon occurred in Cameroon on the night of August 21, 1986 around Lake Nyos asphyxiating over 1800 people, not including the livestock, over a 30km radius. When you know that Lake Kivu contains over a thousand times more carbon dioxide than Lake Nyos, we realize the magnitude of the disaster that threatens the towns of Goma, Gisenyi, Bukavu, Cyangugu, even Bujumbura. The consequences would be cataclysmic. For all these reasons, it is high time that economic actors are in favor of rural ways of living peacefully around the Great Lakes while providing an important part of our independence in energy by the use of methane resources of Lake Kivu. thus, Through this study, want to involve all stakeholders in sustainable development (public, private, associative ...) of the country and abroad to pool our efforts with a view to effectively accomplish the objectives of millennium in the DRC for the prevention of Congolese ecosystem in peril, by 2015.

Bridging Poverty Eradication, Business Innovation and River Basin Development – A Way to Enable Green Economic Growth

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Keywords: water productivity, co-creation process, green economic growth, WRM, sustainability

Introduction and problem identification

Green Economic Growth can be defined as the effective initiation of economic growth in rural and urban areas, to ensure poverty eradication and food security for all without overexploitation of the natural resources soil, water, biodiversity and energy. Green Economy by itself does not inherently include the People component of PPP, where one might think of issues like wealth distribution or wealth sharing that ultimately lead to poverty alleviation and equitable societal development at large. This lack of an implicit focus on People may imply that efforts to spur a Green Economy may contribute to in-equitable growth where the distribution of benefits from growth and of the associated risks may become more skewed. Population growth and other global change processes are driving the world-wide will be living in ever-growing metropolises. We need to arrive at stronger integration of land and water use and management in relation to the prevailing conditions.

Analysis, results and implications for policy and/or research

In this model of Green Economic Growth we integrate our understanding of the spatial and temporal variability's of climate and water resources, in combination with our expertise on spatial planning, sustainable development and innovations in the context of the emerging bio-based economy. Not only will this help our global cooperation partners to facilitate a better intertwining of governmental strategies and actions on the management and wise use of our natural resources, but also it will facilitate efforts by the private sector to develop business under conditions of competing claims on scarce resources. How can water help to sustain Green Economic Growth? To cover the human and ecological needs for water, and to embark on sustained economic activities, water must be available in the quantities and qualities demanded over time and for a given location. The need to provide safe and sufficient water is a basic prerequisite for development. If water security is insufficiently covered, investments in both capital and labour are at risk. In land use planning at river basin level there is a need to balance the competing claims on water as asserted by the different water uses. In this context the question for planners is where to accept which consumption of water and how to allocate the resources accordingly? Developing approaches for increasing food security without taking into account of critical water needs as well as to develop water resources planning without taking into account emerging additional agricultural developments will fail. From this point of view, a strong integration of land and water management is not only a prerequisite for enabling new economic development. It will also ensure that economic development is sustainable within the temporal and spatial scales pertaining to planning at multiple country river basins, or at regional and local levels. Therefore, agricultural development policies need to include water policy, and vice versa.

What are the instruments available? Innovating water use – Launching local innovation platforms, involving small holders and marginal groups in the co-creation process (around golden triangle), can identify new product market opportunities, alternative high-value crops, and new cooperation with commercial farming. When this is accompanied by instruments to assure a sufficient participation in the value chain and other social development issues, an alternation and diversification of economic activities can be achieved. Water valuation-By focusing on the value of water, all benefits that can be obtained (i.e. private, public or socio-political) can be optimized explicitly among the nations and regions that share rivers and between competing water-use sectors. The economic analyses of water resources allocation should contain other issues such as compensation payments in benefit-sharing - Water pricing- and Equitable distribution of income from growth. Economic water productivity-can be considered as an analytical tool to show trade-offs between different scenarios of water use. Ways should be exploited to demonstrate its use at basin management organizations and to guide the planning process for optimal allocation of water in space and in time. Spatial Planning-targets at understanding and guide spatial developments. Spatial planning can help to identify new market opportunities for supplying the growing urban population, but also to specify bottlenecks for a future support. By this concrete measures to counteract problems of abandoned rural areas or uncontrolled urban sprawl can be defined. Spatial planning can help to reserve areas for nature development and ecological corridors. Basis-Boost-Balance In order to enable Green Economic Growth we need to maintain the production basis (basis) – to stimulate the participation of small holders in agribusiness innovations and to boost local development (boost) – and to regulate the allocation of natural resources as well as to make a fair share of benefits (balance). These key domains need to be managed together and in a dynamic way. Economic water productivity-can be considered as an analytical tool to show trade-offs between different scenarios of water use. Combining the analyses with an environmental and social assessment of possible scenarios for agribusiness development, it provides an important input to guide the planning process for optimal allocation of water in space and in time. Green Economic Growth calls for a stronger integration of spatial planning/ development and river basin management. Putting joint co-creation processes central and to balance upcoming request within available resources can provide a framework for the paradigm change required. We need to transform river basin management (as a merely administrative task) towards river basin development with a strong mandated for sustainable local development. Adequate capacity and institutional building is required.

Vector of Green Economy Development in Ukraine as a Factor for Food, Energy and Water Security

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Keywords: green economy, food, water, energy, green growth

Introduction and problem identification

Recently Ukraine belong to the most polluted and environmentally problematic countries. The level of burden to the environment in Ukraine is 4.5 times higher than in other countries. In proportion of the territory, which 2.7 per cent from the world territories, the emissions to the atmosphere reaches 18 percent, wastewater discharges into surface waters – 12 percent annual storage of waste – 19 percent. In the same time Ukraine below to the water scarce countries. Water resources availability is less than 1000 cubic meters per capita, in some regions less than 300 cubic meters per capita. Despite this, Ukraine is one of the largest world exporter of grain and electricity to the world market, using for its production the significant amount of water resources of Ukraine. Energy intensity of Ukraine's GDP is 0.89 kg of fuel per dollar, which is more than 2.6 times bigger than in developed countries.

Analysis, results and implications for policy and/or research

Modern threats in Ukraine and around the world are quite real and are able to prevent not only achievement of the Millennium Development Goals, but also to the progress and even survival of humanity. This causes the search for innovative strategic model of social development, which today is a model of "green" growth, announced by UNEP as a practical expression of major government initiatives. New ideas are always undermining the established tradition, but the worldwide shortage of drinking water and fertile land on the background the climate change, extreme natural events and processes increased degradation of natural resources, there is much more damaging. The "green economy" initiative is based on three main principles:

- Assessment and promotion of environmental services at national and international levels;
- Providing employment through the creation of "green" jobs and the development of appropriate policies;
- Using market mechanisms to achieve sustainable development. In addition, supporters of the concept of "green economy" believe that the prevailing current economic system, which, incidentally, is called "brown economy" is imperfect, though it gave some results in improving living standards of people in general, and particularly the individual groups. However, the negative consequences of the functioning of this system is quite significant: the environmental problems (climate change, desertification, loss of biodiversity), depletion of natural capital, widespread poverty, lack of fresh water, food, energy, inequality of people and countries. All this is threatening the present and future generations. The key conditions of the Ukraine transition to "green" economy we see as the next:
- creating strong legal background of the transition to the "green economy";
- prioritize the investment and spending in areas, that stimulate conversion sectors in the "green";
- limiting costs in areas that deplete natural capital (food, water, energy);
- the use of taxes and market-based instruments to change customers preferences and promote "green" investment and innovation;

- investment in capacity building, training and research
- strengthen international cooperation and partnership.

Ukrainian model of "green" economy we need to build in consideration of the main problems such ac water scarcity, energy inefficiency and energy dependency from resources of foreign countries. Today, "green" policy of Ukraine is the main dominant on the road to sustainable growth. The basic postulates of the «green» development are widely used in the European community. At present the current issues that need the urgent solution is the development and approval at the state level, the "Doctrine of green economy of Ukraine" In indicated "Doctrine" should to be done the definition of priorities, objectives and target goals of "green" growth. This, in accordance with international instruments approaches include:

-Definition of the institutional factors in the development of "green" economy in Ukraine;
- Development and adoption of indicators of "green" economy,
- Initiating the preparation of the first national report "Global Green course in Ukraine"
- Practicing the ideology of green growth at the regional level Formation of the "Doctrine of green growth" is seen as a system of long-term actions, detailing the resource capabilities and justifies the validity of the "green" economic growth in Ukraine and creating a favorable business environment, both at national and regional levels. The above Doctrine is based on an analysis of opportunities to more effectively use available natural benefits on the basis of inter-regional (transnational) cooperation and mutual compensation of damages, as well as more efficient use of reserves "green" growth. The priorities of the "Doctrine of green economy of Ukraine" should to be next:

- transition to the renewable energy resources;
- introduction of resource saving technologies and cleaner production;
- investment in the development of green infrastructure;
- recycling of resources;
- spreading prosperity at home and abroad and promoting social inclusiveness.

In the same time there is a need more research and discussion to determine how "green" economy will help to accelerate the transition to sustainable development.:

- First, you need a clear conceptual clarity in regard to relations between the "green economy" and sustainable development;
- Second, there is a need to conduct further analysis of each political "recipe" in terms of the influence and impact in the context of linking economic, social and environmental goals.
- Third, in addition to conducting research at the national level to ensure the development of global models and scenarios to assess national strategies "green" growth in global terms. For survival and human development requires a new jump - jump to the principles of the "green" economy.

Using Solar Power Pumps for Lifting Groundwater for Irrigation to make Bihar the 'Granary of India'

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Keywords: irrigation, goundwater, food security, solar pumps, 10 crores food for 2% world population

Introduction and problem identification

Bihar (India) is a state with a population of over 10 crores.It accounts for nearly 2% of the world population which is a mammoth account in itself. The state of Bihar with a geographical area of 94.2 thousand square kilometers is divided by river Ganges into two parts – the north Bihar with an area of 53.3 thousandkm^2 and the south Bihar with an area of 49.9 thousand km^2. The percentage of population employed in agricultural production system in Bihar is estimated to be 81%, which is much higher than the national average. Nearly 42% of the GDP of the state (2004-2005) comes from the agricultural sector. Most of the irrigation in Bihar is done through use of groundwater which is available in abundance. But its adequate use is hindered by many factors affecting the agricultural productivity of the state. This is the reason why Bihar has remained at the bottom of all the states in terms of economic growth.

Analysis, results and implications for policy and/or research

BACKGROUND OF BIHAR'S GROUNDWATER RESOURCES: Groundwater has rapidly emerged to occupy a dominant place in Bihar's agriculture and food security in the recent years. Groundwater availability plays a vital role in the agricultural production in the state. It has become the main source of growth in irrigated area over the past 3 decades, and it now accounts for over 40 percent of irrigated area in the state. Since the development of groundwater irrigation has not largely been government driven - this revolution has gone unnoticed. The share of ground water in total ultimate irrigation potential is 37.1%. In Bihar the number of villages having irrigation facility per 1000 villages is 895. Out of this 68.6% of the villages have tube well irrigation. (Source: India, Ministry of Water Resources 2007). This gives us an idea of the mammoth use of groundwater required for increasing the agricultural production of the state. The total groundwater resource of Bihar is approximately 27 BCM, according to the reports of the Central Ground Water Board (2009), India. Nearly 2.389 million hectares of groundwater is available for irrigation, that is, after accounting for drinking water and other uses. Using this reserve at present, the stage of land development has been about 39% only. This indicates a huge untapped prospect of further development. All over the state, groundwater is used inefficiently resulting in low proportion of double or multiple cropping, despite abundant groundwater supply in the state. The major constraints for the same are:

1. SHORTAGE OF POWER SUPPLY The current electric scenario in Bihar accounts for 27.6% of peak deficit and the energy shortage is about 16.4%. (Source: 3rd North east and east power summit 2010, CEA and PFC). Thus Bihar with approximately 600MW of its own generation capacity , is heavily dependent on the power supplied by the Central Generating Stations. This lack of power supply poses a major hindrance to irrigation in the state.

2. DIESEL PUMPS Most of the groundwater is lifted with the help of low efficiency diesel pump sets, thereby raising the cost of well irrigation. By their very nature, diesel pumps pose a large financial burden on the state's financial resources.

RECCOMMENDATION: To improve the agricultural productivity in the state of Bihar, use of solar pumps is highly recommended in lifting groundwater. The State of Bihar has about 280 -300 sunny days and there is negligible development of solar power in the state at present. Bihar is an ideal place for SPV pumps. The capacity for solar pumps is assumed to be 0.6 kW per hectare (Source: energy.bih.nic.in).

WORKING OF SOLAR PUMPS SPV water pumping systems works on the principle of photovoltaic conversion of solar energy into DC electricity. The pumping system draws groundwater up to 50feet (which is suitable for a state like Bihar). The system requires a shadow-free area for solar panel installation. A system of 1800 watt PV array capacity and 2 HP pump can give a water discharge of 1.4 lakh litres per day from a depth of 6 to 7 metres. This quantity of water is ideal for irrigating about 5-8 acres of land for multiple cropping.

Implications of Yunnan's (China) Aggressive Hydropower Development (LHP & SHP) on Regional Food Security, Changing land Utilization and Livelihood

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Keywords: Yunnan, PR China, hydropower development, small hydropower projects, food security, changing land utilization

Introduction and problem identification

China is aggressively developing its energy sector in which hydropower plays a crucial role. With more than 220GW China has by far the largest installed hydropower capacity worldwide. Within China, Yunnan province has a key role for hydropower development, making it even a global core region for hydropower. It is based either on often controversial large projects (LHP) along major rivers or on smaller projects (SHP), both creating hydroscapes. SHPs are often considered a priori as an environmentally and socially sound renewable energy. But in Yunnan they are falling into one of the richest bio-, geo- and ethnic diverse regions. Despite the considerable relevance of Yunnan's hydropower development there exist only limited knowledge, mainly on selected large cascaded projects. But there is a notable lack of knowledge studying potential (cumulative) implications of SHPs, including its consequences on food security, changing land utilization and livelihood for the diverse ethnic groups.

Analysis, results and implications for policy and/or research

To sustain its impressive economic growth and to ensure its reduction of carbon emissions, PR China is aggressively developing its energy sector. Regenerative energy plays a major role in its present and future energy sector strategy. Within the regenerative energy the role of hydropower generation is substantially greater than any other renewable energy technology. China has by far the highest capacity worldwide which is almost equal to the combined hydropower capacity of Canada, the USA and Brazil, which rank globally second to fourth. The extreme rapid development of hydropower schemes is mainly based on controversial large dams, but also on the even rapid development of so called small scaled hydropower projects (SHPs), which have as per Chinese categorization a capacity of up to 50 MW. Contrary to large dams SHPs are often considered a priori as an environmentally and socially sound renewable energy. China's hydropower development is mainly based on cascaded projects; either large or very large hydropower projects along major rivers, but also on centers (hubs) of small hydropower development. Both are creating hydroscapes in which hydropower is in direct interaction with often irrigated agriculture (food production), nature protection or regional industrial development. Yunnan province of SW-China plays a key role for hydropower development due to its (physio) geographic suitability. In about 15 years it will have an installed hydropower capacity of more than 90 GW and makes the province one of the global core areas of hydropower generation.

This development makes Yunnan not only one of the key suppliers of electric energy in PR China, supplying the economic centres of both eastern and southern China but also a major exporter of electricity to Southeast Asia (e.g. Thailand, Vietnam) as well as an importer of hydropower from

Myanmar. Therefore Yunnan is referred as Southeast Asia's watertower, China's (hydro)powerhouse or battery, etc. This rapid expansion of the hydropower sector in Yunnan is falling into one of the richest bio-, geo- and ethnic diverse regions within China. Yunnan's complex geography results in an outstanding geodiversity. This, combined with a diverse climate, ranging from tropical to temperate, has led to a unique diversity of ecosystems, from tropical rainforests to shrub and grasslands in the alpine mountainous. Yunnan hosts about half of China's biodiversity, it is part of two of the world's major biodiversity 'hotspots' and several important ecoregions. Beside its rich bio- and geodiversity, Yunnan has also a remarkable ethnic and cultural diversity, making it the ethnically richest province in China. Some of the world's largest rivers and their tributaries flow through Yunnan. The province has part of six major watersheds (Jinsha/Upper Yangtze; Lancang/Mekong; Red River; Nanpan/Upper part of Pearl River; Nu/Salween and Irrawaddy). Despite the considerable relevance of Yunnan's hydropower development there exist only a few papers focusing on the development of selected large cascaded projects within the province. But there is a notable lack of papers studying potential (cumulative) implications of smaller projects, including its consequences on food security, changing land utilization and livelihood for the diverse ethnic groups. Within this setting the presentation provides in its first part an overview over China's aggressive hydropower development in general and of Yunnan in particular focusing mainly on large hydropower projects (LHP). Their development is studied in the context of its regional distribution and expansion, its institutional aspects (e.g. water-governance) as well as its implications on agriculture (food security). The implications on food security is analysed both near the projects as well as further downstream, mainly in their transboundary context (in particular to Myanmar, SE-Asia and India). The second part of the presentation is more regional focused (on Yunnan's Irrawaddy watershed) and it is more focused on the consequences of small hydropower stations (SHP). First it gives an introduction in the concept of SHP-hubs, which were mainly favoured during China's last Five Year Plan (2006-11). Then it analyses in detail the development of the Yingjiang-SHP-hub in SW-Yunnan. Since 2004 more than 70 hydropower projects, mainly below 50 MW, were constructed in a very small region on the western extension slopes of the Gaoligongshan mountain range; another 35 projects are in the pipeline. This remote part of the Gaoligongshan is draining into the Irrawaddy basin and it is a famous biodiversity hotspot. This second part of the presentation analyses resulting arenas of conflicts as well as identifies their drivers and the instrumentalization of their interests. It is focusing mainly on agriculture/food production, (non-) protection of nature reserves and livelihood of a mainly ethnic diverse population (e.g. Lisu, Jingpo/Kachin, Dai, Han-Chinese, etc.).

Competition for Water Resources: Agriculture and Unconventional Hydrocarbon Development (Shale and Hydraulic Fracturing) – An Example from Texas

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Keywords: competition, unconventional, hydrocarbons, water, stakeholders

Introduction and problem identification

Water has emerged as one of the top planning concerns of operators in the Texas Eagle Ford oil and gas play. Over a thousand new unconventional (horizontal drilling plus hydraulic fracturing) wells are planned in 2013 in an arid and currently drought-stricken area of southern Texas. Each well is planned to be hydraulically fractured with up to 6 million gallons of fresh water derived from the regional aquifer. Surface water in the region is scarce and most agriculture and ranching rely on water from the same aquifers.

Analysis, results and implications for policy and/or research

Many oil operators currently have sufficient water supply, and water operations management, transportation, and final disposition plans in place. However, with significant increases in capital investment and aggressive drilling programs planned for the next few years, most operators are concerned that water issues will cause delays in scheduled operations, or in a worst case scenario, cause interruption in the execution of capital programs. Agricultural uses of the water supply are concerned about competition for fresh water may leave them without sufficient availability for crop security and animal support. In addition, potential contamination of ground water by oil and gas operations could exclude impacted water from agricultural use. This presentation will provide an overview of water issues in the Texas Eagle Ford, including recent information on supply, current management strategies, and options for disposition including strategies for reuse and disposal of flowback/formation water, needs of regional agriculture, local and state efforts to manage water issues, and options for collaboration between stakeholders.

Rising Prices, Rising Environmental Regions? Constructing a Multi-Level Governance Framework for the Water-Energy-Food Security Nexus

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Keywords: food pricing, commodity production cycles, water pricing, multi level environmental gove, Southern Africa

Introduction and problem identification

The degree to which the interconnectedness of water, energy and food production cycles translates into the interdependence of water, energy and food pricing, has caused much debate among researchers and policymakers alike. Stated differently, what is the exact relationship between the availability of natural resources such as energy and water, and pricing mechanisms for water and food? This paper interrogates this question and investigates how energy and water costs influence food costs, whether energy inflation is the primary cause of food inflation or whether there are other factors at play as well. For a water and energy-scarce region such as Southern Africa, these questions are critically important if the trade-offs in the water-food-energy nexus are to be addressed. The paper therefore explores the multi-levelled complexity of the water-energy-food security nexus as an example of the region's ability to cope with the growing challenge of water, energy and food security.

Analysis, results and implications for policy and/or research

During the past few decades, new theories have been formulated regarding the ability of people to transform ecological systems from unwanted and unsustainable stability domains to more desired trajectories of development. These new theories, together with an in-depth understanding of the local context of the topic and study area, including its socio-political and historical development can contribute to a better understanding of the interface between natural ecosystems, climate change, food security and livelihoods in vulnerable agro-ecosystems (Bhatt et al., 2006). In an examination of the complexity of the water-energy-food security nexus and its impact on commodity prices in Southern Africa, this paper explores how economic dynamics related to commodity production cycles generates a "new economic regionalism" based on water, food and energy with its own unique challenges. The paper examines case studies in the Southern African region that have engaged in non-traditional green economy oriented water and energy solutions. The key case study is based in rural KwaZulu-Natal in South Africa. While the area's average rainfall per annum is acceptable, both the seasonal distribution and the lack of storage capacity means that there is a continual water challenge. In addition the location is far enough away from the electricity grid and insufficiently dense with respect to both population and economic activity to justify an investment in the extension of the grid to afford this community access. A project funded by the Water Research Commission of South Africa and project managed by the University of KZN designed a series of interventions to develop an integrated green water-energy-livlihood solution that is independent of both the water supply and electricity grids. For this pastoral community the needs in both these domains are modest in comparison to equivalent urban settings but very real none the less.

The project also factored in the self-sustainablity and longevity of the solution, so the pastoral character of the community through primarily cattle farming provides the substrate for the energy solution through cattle waste. The water solution was rainwater harvesting and safe storage. This was for domestic use, agricultural use as well as providing water for the energy solution. The energy solution was through bio-digestors (locally produced) using the cattle waste as substrate and energy source and water from the rain water harvesting. During the course of the project there were many cultural and social barriers to engage. While the technological solution is an exciting one, perhaps the largest lessons in te project came from the cultural, social and governance learnings. A second case study in Thaba Nchu involving a community that subsists on cash crops is also examined. Both these projects have entered an upscaling demonstrator phase.

Integrating Water and Energy Policy for Hydropower Development in the Amazon Region

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Keywords: hydropower, Amazon, nexus-approach, infrastructure, decision making

Introduction and problem identification

Rapidly increasing pressures on water resources challenge the effectiveness of conventional policymaking. In Brazil, 70 per cent of the electricity production comes from hydropower. National policies for the Amazon still project hydropower as the main source of energy for the next 30 years, despite projections of droughts and hydrological variations that will affect hydropower production and lessen energy security. The disjointed understanding of the water and energy nexus is the result not having an integrated decision-making framework. This paper will use the Amazon basin as a case study to determine the effectiveness of an integrated decision-making framework and will propose a roadmap for incorporating new tools and information to the process. This will better integrate water and energy management and promote more informed stakeholders' participation.

Analysis, results and implications for policy and/or research

The Amazon has crucial importance for the economic stability of South America. Productive economic sectors dependent on water resources from the Amazon are hydropower, navigation, subsistence fishing, agriculture, and eco-tourism. Ecological services are also contingent on water availability for activities such as sediment transportation. The basin is located within eight countries in Latin America: Brazil, Bolivia, Colombia, Ecuador, French Guiana, Guyana, Peru and Venezuela. The variety of cultures and political systems involved within the eight countries calls for innovative models of governance that go beyond the classical method of river basin committees used in Europe and some parts of Latin America (Braga, 2011). More than 70 percent of Brazil's energy matrix comes from hydropower. More importantly, hydroelectric power represents over 90 percent of the electrical energy consumed in Brazil. This power comes from 838 hydroelectric plants that produce close to 80.704 megawatts. The hydropower potential of the Brazilian Amazon is estimated at 107,143 megawatts, and several planned projects seek to harness this potential. A recent forecast for 2070 by Brazil's CREAS Project stated that an increase of 4 C in temperature will be translated to 15-20 percent reduction of rainfall levels. Decreasing rainfalls mixed with increasing dry spells will diminish the Amazon's hydroelectric capacity by 25-50 percent depending on river flows. This paper proposes an integrated approach for the use of water resources in the Amazon Basin to address energy demands. At the same time, the paper diagnoses conflicts between different water uses, environmental services, socio-economic developments and anthropogenic pressures that affect water availability in the basin. The existence of basic elements as national water legislation, recognition of the water basin as the planning unit, public participation, water-market tools and conservation mechanisms facilitate the implementation of the integrated approach in the Amazon basin. However, this study found that issues such as available funding at the local levels, lack of water-risk management, distorted relationship with urban centers present barrier for its implementation. These issues weaken the possibility of having strong local institutions, consequently, the decision making power is outsourced to national entities that do not

consider the implication of policies in local water users. At the national level, the decision-making power is fragmented because decisions regarding soil use and conservation are taken in isolation from water resources ones. The overall goal of the paper is to identify and map institutions that have the ability to implement the proposed integrated framework. Using indicators for water availability, hydrological variations, land use, socio-economic constraints and environmental impacts, this paper develops a matrix for environmental management that accounts for impacts of natural resources demand. Among the policy recommendations are improving long-term forecast to reduce the impact of the climate variability, developing capacity building trainings for water basin managers, developing a transboundary basin agreement with other Amazon countries, and identifying areas prone to flooding.

Innovations in Managing the Agriculture Energy and Groundwater Nexus: Evidence from Two States in India

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Keywords: agriculture, groundwater, electricity, Punjab, Karnataka

Introduction and problem identification

India is the world's largest groundwater user estimated to use 200-230km^3 annually. Many factors explain this extraordinarily rapid growth low cost of pumps and drilling equipment, institutional finance, high population pressure on farm lands, Green Revolution technologies and massive investment in rural electrification. However, arguably by far the most important factor is the regime of power subsidies that India has evolved to support groundwater irrigation. The genesis of unique energy-irrigation nexus in India was the policy decision in many states to supply unmetered power to the agricultural sector. Agriculture, groundwater and electricity sectors in much of India are now bound in an invidious nexus of mutual dependence where the growth of one sector (agriculture) is being supported by unsustainable trends in the other two sectors (groundwater and electricity), so much so that even growth in agriculture is now threatened. Are there ways to manage this nexus?

Analysis, results and implications for policy and/or research

This study was conducted in two Indian states of Punjab (in the north) and Karnataka (in the south). An analysis of long term trends in groundwater development and agricultural growth in Karnataka shows two things. First, the growth in irrigation was largely contributed by expansion of groundwater irrigation. Second, with the groundwater development, the state experienced a quantum jump in electricity supply to agriculture. In 1981, electric tubewells were de-metered and a flat tariff regime was introduced. This led to rapid increase in tubewell connections. Electricity was made free in 1998, further perpetuating this crisis. This in turn brought its own share of problems such as difficulty in accounting for agricultural electricity consumption mounting losses of electricity utilities and deterioration of quality of supply to farmers over the years. The Karnataka Electricity Regulatory Commission was formed in 2000 and since then it has urged the electricity distribution companies to improve their agricultural energy consumption estimates, but their methodologies remain as fraught with problems as before with the result that agricultural electricity consumption is likely to be grossly over-estimated as are the number of electric pump sets in the state. The farmers in turn resort to illegal connections and under-reporting of their pump capacity making it even more difficult to arrive at independent estimates of agricultural power consumption. Overall, there is anarchy below the feeder level – an anarchy that leaves farmers, utilities and the state government much worse off than they need be. A collateral damage of this anarchy is the deep level of mistrust between the farmers and the utility staff. An analysis of groundwater development and agricultural growth in Punjab shows two important trends. First, growth in irrigation extent and irrigation intensity was largely contributed by expansion of groundwater irrigation. Second, with the groundwater development, the state experienced crop specialization to bi-crop rotation of rice-wheat which further increased the demand of groundwater. Since the increase in groundwater irrigation was made possible with tube-well energization, Punjab's agriculture got highly dependent on electricity supply. This in turn brought its own share of problems such as difficulty in accounting for agricultural electricity consumption in the absence of metering, mounting losses of state utility due to non-payment of subsidy amount by the government and deterioration of quality of supply to farmers over the years.

The Punjab State Electricity Regulatory Commission (PSERC) was formed in 2000 and since then it has taken a number of steps to deal with these problems. For example, over the years, PSERC has managed to convince the utility to improve their system of accounting for agricultural electricity supply. There has been an evolution of agricultural pumpset (AP) consumption methodology from residual method – which was fraught with all kinds of problems, to metered reading based on a larger sample. Meter readings of sample tubewells have now been outsourced and the Commission also uses independent third party verification to cross check the results. It has also convinced the utility to bring its T&D losses under control. Since 2008, the Board has taken a number of measures to reduce T&D losses and these are bearing effect. Some of these measures include HVDS, capacitors, ABC cables in theft prone areas etc. In addition, the state has also embarked upon and almost completed feeder segregation. The Commission has also convinced the Government of Punjab (GOP) to release subsidy amount in a timely and regular manner. All these measures on the part of the Commission and the Board have started bearing results with the result that quality of power supply to farmers has improved as has the efficiency of the utility. This paper compares and contrasts the case of two Indian states – states faced with similar predicament as far as agriculture, groundwater and energy were concerned in the 1990s. However, since then, one state (Punjab) has been able to improve the situation substantially, while the other (Karnataka) still keeps grappling with the same problems. We ascribe this to the pro-active role of the Regulatory Commission in one state and its absence in the other. These regulatory commissions were created in early 2000s with the mandate to provide independent regulatory oversight over the government owned electricity utilities. It is our contention that in those states where regulatory commissions are indeed independent and can carry out their functions without interference from the government and political entities are more likely to instill discipline among the electricity utilities than those who have been subjected to regulatory capture.

Maximising the Benefits; Water, Food and Energy, Matrix

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Keywords: Energy, DTF, Dewats, Biogas, income

Introduction and problem identification

Water and sanitation Zambia is the third most highly urbanized country in sub-Saharan Africa with a total population of about 40% estimated to live in urban areas. During the 1960s and 1970s, the production and export of copper led to an expansion of the urban economy particularly the Copperbelt province which experienced high levels of rural-urban migration, as the people migrated from the rural areas to seek the benefits of the then booming economy through employment opportunities, new infrastructure and amenities as well as a well organised and subsidized housing schemes. However, when the price of copper collapsed on the world market a commodity on which the country had largely depended on for export accounting for 90% of foreign exchange earnings. Majority of the population lost employment as copper mines were closed and the support industries re-located to other regions of the continent. The infrastructure soon became dilapidated due to operation and maintenance costs.

Analysis, results and implications for policy and/or research

The Devolution Trust Fund is an organization established by the government of Zambia through the National Water Supply and Sanitation Council (NWASCO), the national regulator for the water and sanitation sector. It primary mandate is to assist water utilities extend and improve water supply and sanitation services to areas under the jurisdiction of the licensed commercial water utilities(CU). Increased food access through improved water supply: The DTF undertook a nationwide baseline survey in 2004/2005 which established that the poor households were paying relatively more for water than wealthier (middle to high income) households. The residents in peri-urban and low income areas pay as much as much as US$ 0.2 cents for a twenty litre when the approved tariff is US$ 0.01 The project implementation framework takes into consideration matters of affordability of services by the target community and provision of alternatives for household income generation. This is as a result of the realization that lack of water is closely linked to poor income and lack of food for households. Without access to a minimum of 15 to 20 litres of safe water per person per day, a household would be subjected to life threatening situations that takes away their time from taking part in other income generating activities. The DTF Project approach entails construction of water kiosks spread across a community and commensurate with the population density so as to allow for sufficient cash collections by the water vendor through commissions. The Water Kiosks are designed to allow vendors earn an income through a commission agreed with service provider particularly in densely populated areas and areas with no alternative sources of water. The vendors here usually earn enough to supplement their food demand for their households. Areas with low sells from water supply can increase their household food needs by selling other prescribed goods and food stuff packaged in smaller quantities so as to enable majority of the community afford it. This flexibility of the Water Kiosks in enhancing family food needs has been well received by the majority of the women who are household bread winners. Kiosks use security proof materials that allow vendors to keep their products without fear of losing them. Increased food access through improved sanitation: The DTF has supported projects to improve sanitation in areas were water projects have been undertaken as well. In order to the close the loop in

the water, food and energy nexus, DTF has been constructing biogas plants on the reticulation system for sanitation and the approach has followed a flexible sustainable framework.

i. Partial Decentralised Wastewater Treatment systems (DEWATS) Principle Sanitation projects that have been constructed in closely populated areas with little or no space for meaningful agricultural activities have being designed to discharge their effluent in any nearest sewage pipeline connecting to either a conventional or stabilization treatment. The design incorporates a Biogas plant that allows households connect to the system and use the gas for their cooking. This has translated into huge savings for the cost of energy at household level. This works out as follows;

- Without the projects, households spend daily an equivalency of US 60 cents on charcoal translating into US$ 18 on monthly basis.
- With the DTF funded biogas plants in the system, household have sufficient energy for cooking and lighting. They only make a contribution of US 10cents daily or US$ 3 on a monthly basis.

ii. Complete Decentralised Wastewater Treatment systems (DEWATS) Principle In tandem with the theme for securing food for the urbanizing world, some sanitation projects have been constructed as complete DEWATS with the final effluent used in the irrigation of banana plantations and some selected crops. In this regard, the DTF is transforming the mechanisms for food production used by most households by puncturing sewer lines using raw sewage for crop irrigation exposing them and the public to health hazards to the use of treated sewage effluent rich in nutrients. Aside from utilisation of the effluent, the systems contain biogas plants that provide the much needed energy for cooking giving them ample time to spend on income generating activities as well savings earned from use of gas energy.

Greening the Nile Basin: The Nexus, the Key to Cooperation

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Keywords: Nile, water, energy, food, nexus

Introduction and problem identification

The Nile water is used in different forms and cuts across most development functions in society. With growing populations of over 300 million Nile citizens and economies, the demand for water for food production and energy production, and water for industry and domestic use is steeply increasing at the local, national and regional levels. This population will double in the next 25 years. Recent data indicates that a global 40% water supply gap of accessible and reliable water supply for economic development is expected by 2030. The Basin faces tremendous challenges in provision of safe drinking water for over 160 million people, proper sanitation and providing food to market for 74% of the rural communities suffering from under-nourishment. There is need for broad-based water service interventions in water supply and energy utilities, water and sanitation and irrigation services taking into account climate change. This ensures a basket of benefits for improved sustainable livelihoods.

Analysis, results and implications for policy and/or research

With the advent of the Cooperative Framework Agreement that has not been signed for a very long time due to one clause that touches on resource allocation to the respective states; it is clear that the political economy behind the allocation of scarce water resources for different purposes, including for vital ecosystem functions has been a key determinant of the Nile Basin policies. The low riparian countries are diversifying their economies away from over reliance on agriculture and are putting in place water demand management systems to save water for higher value use with focus on horticulture and water for industry. Through the cooperative arrangement under the Nile Basin Initiative (NBI) it has become evident that broad-based water service interventions in energy utilities and irrigation services benefit everyone and play a major role in improving sustainable and dignified livelihoods. Through various designed multi-purpose projects like the Joint Multi-purpose project, NBI has clearly indicated that it is better to approach one project with the aim of reaping a myriad benefits that should not only accrue to the riparian states but should have a local component that addresses the needs of the affected community and ensure that the community is in a better state after the project. Energy is required in all the steps along the water value chain, from providing water services such as pumping water for water supply and sanitation systems, to the delivery of irrigation water for food and bioenergy production, to the construction of large scale water storage for flood protection. As water resources become scarce, water will be pumped long distances, or be produced through alternative means, such as energy intensive desalination processes. Modern water management, including establishing monitoring networks and data centers, is dependent on reliable access to electricity. To achieve water security, which means the provision of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, energy must be available.

The links between these two key assets for building societies, water and energy, need to be further explored and strengthened. The Nile River does not conform to borders, not to mention boundaries within the eleven riparian states. Nile cooperation is sometimes weak and civil strife and tensions prevent cooperation on these shared assets. Competition for water resources between states, within states and between different sectors is increasing.

This is partly because of the upstream and downstream dimension where water flows from high to low lying areas which provides opportunities for upstream countries or users to have some control over both the quantity and quality of downstream water flow. The cooperative management of Nile Basin and the sharing of benefits from development has posed serious challenges, since all states in the basin depend on each other. However, NBI has proven that the aggregate benefits from common use of water are larger than those of systems in which water allocations and management take place at the unilateral level, then there are incentives for cooperation, driving regional integration. There is need to remove the barriers to trade in the basin and increase interactions between Nile Basin states so as to experience a relative increase in prosperity and stability in the Basin. Clear evidence based information to show the nexus between water, food and energy is the key to moving away from the water allocation debate in the Nile Basin towards greater regional integration and cooperation. The development of hydropower, including irrigation and flood control, in multipurpose schemes provides tangible benefits that can be distributed at the regional level. Other benefits include industry, food and health outputs, as well as environmental services for biodiversity conservation and tourism that all can be generated at the local or regional level. Benefit sharing schemes based on water and energy bring opportunities for small and isolated economies and stimulate growth in larger economies.

Dams on the Mekong River: Lost Fish Protein and the Implications for Land and Water Resources

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Keywords: dam, fish, protein, water footprint, land footprint

Introduction and problem identification

Most of the 12 million households in the LMB would be affected by alterations to fish availability, as fish is the main source of dietary protein (MRC, 2005). Estimating the water (water footprint) and land area (land footprint) that would inevitably increase in order to replace lost protein from fish catch, is one of the most important challenges in terms of addressing key impacts of the Mekong River basin dams. In particular, the Lower Mekong Basin (LMB) nations, Cambodia, Laos, Thailand and Viet Nam, will have to plan and respond to this loss of calories and protein from reduced fish catch within their food security strategies. To date, these consideratiojs have been anecdotal at best and this paper provides approximations for the task ahead based under 2 scenarios.

Analysis, results and implications for policy and/or research

Research highlights

- Eleven hydropower dams are proposed on the mainstream of the Lower Mekong River with another 77 dams forecast in the Basin by 2030.
- Requirements for substitute protein supply for the 10%-42% loss of protein from migratory fish are modelled.
- The water required for domestic protein production from livestock in order to replace lost fish catch ranges from 4% to 17% but is considerably higher in Cambodia and Laos.
- In addition to inundation of 1,350km^2 by the 11 main stem dams, the additional pasture land required to replace the protein with domestic livestock ranges from 5,772 to 28,327km^2 (15% to 74%).
- Imports from countries like Argentina, Brazil and India of one livestock feedstuff, soy bean cake currently have a land footprint of 19,895km^2 and water consumption of 9.05 Bm^3/yr.

Our research examines the 11 planned dam projects on the main stem of the Mekong River in Laos, Thailand and Cambodia as detailed by ICEM (2009) (Figure 1), and another 77 dams planned in the Basin by 2030. The LMB countries have been chosen for the more consistent data available due to their common institution, the Mekong River Commission (MRC); additionally these states are likely to experience the greatest impacts from the proposed dams (Osborne, 2009). We focus on the likely human food supply impacts of the dams via decreased fish catch, the key source of protein in the region. Using the fish loss estimations from the SEA, we estimate the additional land and water needs that would be required to replace lost fish protein. Some estimations of this shift have been made before (Baran and Myschowoda, 2009; ICEM, 2010b) but have been relatively anecdotal. Here we employ land and water footprint methods to attain more specific and realistic knowledge of the protein shift in order to highlight these potential impacts. The history of documented local reductions in fish catches on the Pak Mun, Sesan and Nam Theun and Hinboun river tributaries of the Mekong

vary from 30%-90%, and generally at the more severe end of this range following the completion of dams (ADB, 2001; Baird and Mean, 2005; The Theun-Hinboun Power Company Limited, 2000). In this context, the estimates of loss of fish production in the Mekong Basin in 2030 compared to a 2000 baseline due to dam development by the SEA (Table 4) appears conservative. The assessment concludes that basin-wide development of 77 dams is expected to reduce fish production by 210,000 to 540,000 tonnes or 10%-26%. It further states that if the 11 main stem dams were also built, the total loss in fish resources would be 550,000-880,000 tonnes or 26%-42% (ICEM, 2010b). Thus the losses directly attributable to the 11 main stem dams would be 340,000 tonnes: a 16% reduction (Table 1). It might be suggested that the diminution of fish from the main stem of the Mekong could be replaced by aquaculture projects, yet the MRC Secretariat's international Expert Group assessed this option and concluded that "On the basis of this evidence, compensation for loss in yield from river fisheries is impossible to achieve through development of reservoir fisheries" (Dugan, 2008). The SEA estimates that new reservoir fisheries would replace only 10% of the capture fisheries losses (ICEM, 2010b). The key questions explored here are: a) to what extent would the proposed 11 LMB main stem and 77 other planned dams reduce the production of fish as a major source of dietary protein, and b) what are the land and water requirements for potential alternative protein sources? In this assessment the size of the flood pulse and resulting fish recruitment is assumed to be unaltered by the run-of-river dams (even though some additional impacts are likely). The main impact is assumed to be the prevention of migration for the fish that depend on this and a concomitant reduction in recruitment and catch. Our research suggests that significant land and water use changes would be required to produce the protein needed to replace lost fisheries across the LMB. The 1,350km^2 of land proposed for inundation due to the LMB dams would have impacts on the riverbank gardens of 450,000 households (ICEM, 2010a). We calculate that an increase in water footprint for the four LMB countries will be an average increase of 4% to 7% but considerably higher for two specific countries: Cambodia (30%-66%) and Laos (13%-26%). On top of the inundation of the 1,350km^2, the additional pasture land required to replace protein with livestock is estimated at 5,772-12,134km^2 (15%-32% increase) for the 11 main stem dams, or 8,305-28,327km^2 (22%-74% increase) for all dams. These numbers present significant challenges given that high quality agricultural lands in the region are already under use with low or negative rates of land use conversion to agriculture.

Future Challenges in the Northeast Thailand: The Nexus of Energy, Water and Food Investments

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Keywords: Northeast Thailand, water-food-energy nexus, biofuel, WEAP, BBN

Introduction and problem identification

Northeast(NE) Thailand is the most impoverished agriculture; it now faces challenges in directing future development as put forward by regional economic cooperation and dynamics within the national development. The aggressive pursuit of ethanol and biodiesel production as part of the national renewable energy development plan 2008-2022 is leading local farmers to alter their food cropping regimes by instigating conversions from rice to the cultivation of energy crops: sugarcane and cassava. It has also altered source of local livelihoods as they become increasingly dependent on food production for a market-orientated food production system, which requires more input resources. Meanwhile, there is no common understanding of interconnected food-energy-water issues across actors. Also, anticipated climate change occurrences believed to result in the climate variability, directly foster a feeling of insecurity for farmers, in terms of their agricultural production and natural resources.

Analysis, results and implications for policy and/or research

The present study in the Huay Sai Bat (HSB) catchment in NE Thailand forms part of ongoing research of the Stockholm Environment Institute (SEI) and its partners to introduce the multi-objective oriented planning in order to create planning scenarios and the design of reasonable policy through ongoing planning processes led by the River Basin Committees (RBCs). The study approach features participatory scenario processes within NE, framed by larger-scale scenarios. The NE-level scenarios taken these larger processes into account and would add uncertainties at the local level. Key information has been derived from both quantitative and qualitative data collection methods, with participatory inputs by a wide range of stakeholders. The qualitative scenarios have been used to inform integrated quantitative scenarios using a combination of physical and social science models. A combined top-down physically-based model (Water Evaluation and Planning System or WEAP) and bottom-up livelihood model (Bayesian Belief Network or BBN) have been used. Although several activities were completed, the hydrological and livelihood analysis and modeling by WEAP and BBNs are still under the finalsation stage. The results from local livelihood survey suggested that HSB households are relatively poor with a lower than average household income for the whole NE region.

The main livelihoods relate to agriculture, under which land is mainly used for rainfed food crops. Recently, increasing irrigated areas in dry season has led to water use competition among users. In addition, climate variability has compounded drought and water shortage issues. The questionnaire respondents which are local communities believe that land use, either from growing food to biofuels or any crops, will not be significantly changed in the long-term future. While several stakeholders from the governmental agencies, NGOs and leaders of local communities believe in the opposite way.

Nevertheless, it was well agreed that on-farm labors are likely to decrease due to the migration of those attaining a high level of education; a further challenge for farmers in farm production. While the energy demand tends to increase in both farm and household consumption, more earnest continued support on the renewable energy is therefore strongly suggested. Three initial scenarios are being simulated by WEAP: Baseline scenario, Land use change scenario, and Climate change scenario. The preliminary results suggested very little effect on water availability and demand for water in the HSB when land use is only changed as much as is predicted (2-5% of total land) in the current Land Use Change Scenario. In fact it appears that, even when the rice farming area is decreased, the demand for agricultural water does not significantly decline. Although by the same reasoning, more extreme changes of land use could possibly have an effect on water uses in the catchment. This may not be the case if new water-efficient crop types are introduced to the growers in the catchment, which could have greater impact on water scarcity than changes in crop coverage. It appears that climate variability and change will have a negative impact on sustained agricultural production in the area in the next few decades because higher temperatures and different precipitation patterns can lead to increasing unsatisfied demand for water, especially in the winter (Oct-Dec). Climate changes may also lead to downstream catchment areas having more unsatisfied water demand in the summer (Feb-Mar). To this stage, we can confirm that difficulties relating to water supply will arise in any future that is similar to the Climate Change Scenario, unless measurements and effective management planning are in place to mitigate the effects of rapid climate change. The future projected changes (regarding either land use or climate) modelled in this project only encompass plausible futures; therefore there is a need for further development of the model to address the uncertainty of the long-term changes and required evaluation of various comparisons with other driving factors. At present the linkages between the BBN and WEAP model are partly built to investigate land-water-energy dependent livelihoods as evidence for future changes in the HSB. The model is built via income distribution in response to the question relating to the poverty level as a consequence of different development options. The resultant model calculated by the key inputs of 20% of the population within five income groups, which are very high, high, medium, low and very low.

The preliminary results suggested that:
(1) the poverty level for HSB is higher than the national average, and even in the high growth scenario does not reach the current national average for several years;
(2) changing in the land use is significant, but not dramatic;
(3) the medium income group breaks from the general pattern of increasing average landholding with income that could be found in other income groups. We treated this as a temporary and unusual feature, and estimated average landholding in the scenario, assuming a steady increasing in land holding with income; and (4) with an increase in the availability of irrigated water, many farmers will not respond at all, while some may decrease their use of irrigated land, presumably for reasons having nothing to do with the availability of irrigation water. During the project implementation, the project has been engaging with the regional government agencies (e.g. NESDB, RBOs) by informing project activities and inputs, and presenting findings and outputs for validation of results.

Comparison of Water Footprint for Production of Algae Oil for Biofuel Under Indoor and Out Door System

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Keywords: biofuel, water footprint, algae oil, energy

Introduction and problem identification

As world is marching towards the energy crisis, alternative energy sources should be invented. Biofuel are the better energy source for internal combustion engine when compared with convention petroleum fuel as it will be diminished in few decades. It is estimated that the biomass productivity of microalgae could be 50 times more than the fastest growing terrestrial plant. High photosynthesis yield that is about 3-8% of solar energy can be converted to biomass by micro algae as compared to terrestrial plants where it is approximately 0.5%. Unlike other oil crops, microalgae grow extremely rapidly and many are exceedingly rich in oil. Microalgae commonly double their biomass within 24 h. Biomass doubling times during exponential growth are commonly as short as 3.5 h. The oil yield of palm oil is highest among the oil crops.

Analysis, results and implications for policy and/or research

The objective of the study was determining the water footprint of algae oil production for biodiesel under different environmental conditions. The experiment was carried out during the August-October in 2011 in the Department of Agric Engineering, Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka. The climate of the area is tropical monsoonal, with an annual rainfall of around 2,500 mm. Annual mean air temperature of the area is 22-30°C and the relative humidity is about 80%. The experiment was conducted in indoor and outdoor environment conditions with micro algae species Nanochloropsis using Guillard and Rythers modified F nutrient medium. The oil yield and harvested dry matter content was observed as 16.75% and 0.46 g /l respectively in indoor system and 24.15% and 0.41 g/l respectively in outdoor system. According to the observed results, water footprint for producing algae oil was observed as 1.0x104 and 1.3 x 104m^3/ton respectively in outdoor and indoor system.

Changing Lifestyle for Green Economy: A Nepali Experience with Community and Private Sector Partnership

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Keywords: lifestyle, Nepali, communityy, green, partnership

Introduction and problem identification

Despite very vibrant and hard-working farming communities in Nepal, the country is facing a huge problem of the breakdown of farming life, livelihoods and food scarcity. The massive uses of chemical fertilisers and pesticides have also made them more vulnerable as they cannot grow foods anymore organically or biologically. The cost of production has gone very due to the cost of imported fertilisers and pesticides. This had led to the migration of working age youth to cities and foreign countries as migrant workers under severe forms of violence and exploitation. This paper highlights a success story of unique initiative taken by the communities of Melamchi Valley and the activists and entrepreneurs of Kathmandu Valley towards developing a private-community partnership to provide local employment, coordinated organic and biological farming and co-operative-based marketing for green economy through water-energy-food nexus under the leadership of Nepali Lifestyle Pvt. Ltd. led by women.

Analysis, results and implications for policy and/or research

A group of young, household and professional women activists from Kathmandu visited a Palchowk village community in Melamchi Valley several times over the past two years to find out whether a private-community partnership for development can be developed based to promote green economy though community water management, healthy food production and organic Nepali lifestyle. After series of meetings, we realised that it can be done if there is a market in the city and the communities ready to work for it with financial support from outside. We then formed a private company, called Nepali Lifestyle Pvt. Ltd. together with the Palchowk community women farmers also as shareholders. We came out with an investment plan for local food production and marketing in Kathmandu. The results of this initiative just in six months of time are:

1. Women of Palchowk village in Melamchi Valley have been provided with a week-long training and exposure tour near-by relating to the management of organic farming, co-operatives and private company. We have selected one area of agricultural land for a cooperative farming free from the use of chemical fertilisers and pesticides.
2. We have also invested in a dozens of cows, buffaloes and goats for organic manure and dairy products. They also formed a co-operative by including other women and local farmers from the village in which all the company shareholders are also members.
3. We included one farmer in the team as a member and shareholder who has the farming land with sufficient amount of wasted spring water sources for drinking water supply and irrigation.
4. We are constructing a three-story house by using traditional materials such as mud, stones and local woods which will be used for office, training, food collection centre and also guest house with Nepali style of cuisine for extra income-generation.
5. We also have invested some money for Rainbow trout farming in the Melamchi river flowing through their village.

6. Back in Kathmandu, we set up a co-operative store mainly for the sale and supply of food (vegetables, gains, milk and trout fish) produced and/or collected by their own company from Melamchi. Initially, we made 100 members from among their own relatives and friends who are dying for organic food and safe products in their kitchen. We also made a home delivery plan by purchasing a pick-up van from bank loan which also generating extra income for the company.
7. Their plan is to employ at least 20 people in Melamchi and Kathmandu Valleys who are generally desperate to move to the cities for employment or go to the Middle East as migrant workers by deserting their traditional farms and plenty of other locally available economic alternatives.
8. One main goal is to lunch a massive campaign against the massive use of chemical fertilisers and pesticides in Melamchi Valley and the surrounding districts which has become a chronic problem of health hazards in recent years.
9. In the next phase, we plan to invest in herbs plantation, processing and export as well as the collection of wild berries and fruits for wine production which are being wasted all over the hills and forests in the absence of sills and knowledge for using them to produce wines.
10. Establishing bio-fuel plants for energy is the fourth stage plan. The policy implications of this initiative are:

1. Understanding water-energy-food nexus at community level through community participation led by them with the help of activists and professionals with the scattered money we/they all have.
2. Connecting cities with villages and vice versa so as to establish links and collaborations through private companies and cooperatives.
3. Providing a model of community development and city marketing with secured investment, self-employment and development.
4. Encouraging the government, the banks and credit agencies as well as Nepal's friendly donors and international lending agencies in such initiatives.

Green Water Credits – An Innovative Investment Mechanism to Reach Sustainable Soil, Water and Energy Resources Management in a River Basin

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Keywords: soil and water conservation, green and blue water managemen, investment mechanism, transdisciplinarityscience and,

Introduction and problem identification

This paper supports a recent plea of the United Nations Environmental Program for a green economy by focusing on an integrated approach concerning three of their "growth engines": water, agriculture and energy. In many locations worldwide soil and water resources are now – after 40 years of sustainability projects and programs, and with a double world population – still in an alarming state and under high pressure and risk of further degradation. Proper soil and water management in river basins optimizing green and blue water flows remains essential and awaits investments and implementation at a large scale. The apparent inability of societies at international and national level to reverse the described trends towards unsustainable development is one of the key issues at this time. New approaches are needed to break this apparent deadlock demonstrating the added-value, viability and space for new, innovative business models in Research & Development for Natural Resource Management.

Analysis, results and implications for policy and/or research

Green Water is water in the unsaturated zone of the soil which is available for crop growth and can be increased by proper soil and water conservation measures. These measures, in turn, reduce human induced accelerated surface run-off, erosion, river peakflows and siltation of water reservoirs for urban and industrial water, to generate electricity and for irrigation. Simultaneously, the subsurface groundwater aquifer is fed, thereby increasing water supply downstream and regulating stream flow. Green Water Credits (GWC) is a benefit sharing approach involving compensation by public and private water users to support investments by upstream rainfed farmers in better soil and water management practices. Four drivers determine the practicality of the GWC approach:

(1) the need for improved soil and water management;
(2) the possibility of active linking of upstream livelihoods and downstream business development,
(3) functional enabling institutions and regulations, and
(4) an easily accessible, fair compensatory (financial) mechanism. Design studies in these four domains were made to show developments of a field application of the GWC approach in the Upper Tana basin in Kenya.

1. Soil and water management: Eleven locally practiced soil and water conservation measures were evaluated in terms of their local effects for the entire area on the enhanced availability of Green and Blue Water and its associated environmental impact and likely consequences for livelihoods and business development through agro-ecohydrological models.

Results are in summary:

(i) increase of the quantity of green water and the associated higher plant production;
(ii) a reduction in erosion;
(iii) an increase in water recharge and regulated base flow; and
(iv) a comprehensive cost/benefit analysis. The case-study presents quantitative data to predict these effects for the area as a whole and, if required, for subareas. For example:
(a) Bench terraces, Fanya Juu terraces and ridging are particularly effective in reducing erosion and sediment inflow into the hydropower and urban water reservoirs;
(b) Soil evaporation is particularly reduced by conservation tillage and mulching, thereby increasing the volume of green water;
(c) Ridging has the biggest effect on increasing groundwater recharge;
(d) Besides, adoption of improved green water management practices can also help to restore soil organic matter levels towards their natural level, contributing to CO_2 mitigation and enhance production, presenting additional options for investments for environmental services. Linking modeling results with a geographical Information System allows their spatial expression.

2. Livelihoods aspects were investigated through on-site and off-site cost/benefit analysis of better soil and water management practices. The on-site study analyses the installation and the maintenance investments by the farmers and the local benefits that will result from these in the long term. The off-site study focuses on the benefits of the downstream water users subject to better upstream soil and water management. Water users are the hydropower generating companies, the urban and industrial water users and the irrigators.

3. An institutional survey analysing the institutions and regulations supporting the land users to improve their soil and water management practices, shows the strengths, weaknesses, opportunities and threats of the private and public institutions in offering land users communities the required technical, financial and institutional support. It also looks at gaps, for example where cooperation between institutions is required and it also includes the institutions that will monitor the green and blue water flows.

4. Financial mechanisms focusing on production, protection and profit aspects of the envisaged investments in better soil and water management practices are set up, and the required entities put in place that will handle the required funds, i.e. the collection from private and public funds, distribution to the communities, monitoring and evaluation of the performance of the contracts. The study reports are available at www.greenwatercredits.org.

Linking Water and Sanitation to Energy and Agriculture – Two Case Studies from Georgia and Kyrgyzstan

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Keywords: sanitation, ecosan, re-use, marketing, solar collectors

Introduction and problem identification

Georgia and Kyrgyzstan are two typical post-Soviet countries where the infrastructure, especially water supply, adequate sanitation and wastewater management have been deteriorating. The situation in rural areas is dramatic and the people are left alone with insufficient support from the local authorities to ensure their infrastructure. Households in rural and peri-urban communities largely suffer from energy poverty.They rarely have enough energy to produce heating and warm water in the house in the rural areas. The lack of fuel has caused localized environmental problems such as deforestation for fuel, cutting of windbreaks, burning dung instead of using it for fertilizer, resulting in soil degradation.Their food security and incomes are based on subsistence farming. There is a high rate of unemployment and people lack of ideas for business and marketing, and alternatives solutions for sustaining livelihoods.

Analysis, results and implications for policy and/or research

The holistic approach to link water, sanitation, energy and farming through a community based system is innovative. Through capacity building programmes, the trained craftsmen have the opportunity to set up their own businesses (constructing toilets, solar collectors, solar dryers for fruits and vegetables or providing equipment for the technologies).

(1) Sustainable and productive sanitation systems developed in both countries save water and energy, contribute to energy security, through use of renewable energy resources (biogas, bio-oil), and contribute to food security through decentralized and cost-efficient provision of fertilizer (urine) and soil conditioner (faecal compost). There is a good acceptance for UDDT in the rural areas and the people appreciate this alternative to the traditional pit latrines. In the last years more than 300 UDDT have been constructed. In some villages, almost all households are already equipped with a UDDT or are willing to construct one. The success in these villages is first of all due to setting-up a Service Center in the village which provides advisory serviceson construction, operation and maintenance People have the choice of different UDDT designs, a concrete UDDT toilet seat, slabs made of tiles, and even a ceramic UDDT seat is available. E.g. in the villages Khamiskuri and Kheta in Western Georgia the toilet design was more and more improved and adapted to make the UDDT more affordable for even the most poor people.

(2) The second factor is the link to gardening so that the villagers are informed about how to use the toilet products - sanitized urine and faecal matter- in their garden for subsistence agriculture. Source separation and safe handling of nutrients from the UDDT system is one way to facilitate the recirculation and use of excreta in crop production. Food security is being increased with a fertilizer that is readily available for all regardless of infrastructure and economic resources. Urine is a well-balanced nitrogen-rich fertilizer which can replace and give the same yields as chemical fertilizer in crop production.

In addition the service center provides access of rural people to the solar dryers where the fruits grown using the organic fertilizers (urine and faecal compost) is dried and sold at the markets. Solar driers represent an affordable opportunity for local households, to generate additional incomes.

(3) The third factor is the link to energy in terms of solar collectors for hot water. The service center also supports the construction of solar collectors for the households built with local material. People appreciate very much to have a full bathroom including a UDDT and a shower with warm water from solar hot water collector integrated with UDDT. The greywater is treated in a simple soil filter and infiltrated into the ground. The success in the villages is resulting in a replication and up-scaling which takes place without external funding but the strong support by the local NGO RCDA and financial scheme (leasing). The first steps to make sanitation as business in the communities. In both countries the NGOs have successfully opened up sanitation and renewable energy markets for the private sector. Today RCDA and small business offer the households, kindergatens and schools different types of UDDT in addition to developing semi centralized logistic system for the collection of urine and faeces from UDDT, pit latrine content and other organic waste in the villages. The approach and system system in Kyrgyzstan are similar; however in addition there is the link to drinking water, sufficient quality and quantity, which is provided to the stand pipes in the streets through the existing water-sanitation-agriculture-energy comitees. The comitees are democratic institutions which are trusted by the communities. In the Kyrgyz case, small businesses have been developed, e.g. constructing UDDT, constructing solar collectors and solar dryers, providing the doors and windows for the toilets, producing the toilet seats, maintaining the toilets and solar collectors, selling dried fruits.

Moving the Water-Food-Energy Nexus Forward with an Ecosystem Services Perspective for Sustainable Political Decisions

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Keywords: ecosystem services, water-food-energy nexus, hydropower, benefits sharing, poverty

Introduction and problem identification

Despite significant progress, security of water, energy and food supplies remain far from being achieved globally. Basic services are not available to the "bottom billion" deprived of their human rights and are trapped in poverty: about 1.1 billion are without adequate access to safe water, close to 1 billion are undernourished and 1.5 billion are without access to electricity. And for many others who do have access to a very basic level of service, the system does not yet offer the resources needed to raise their livelihoods and emerge from poverty. With 70% of the global population of 9.2 billion people living in cities by 2050, demands for water, energy and food will increase exponentially; there are projections of a 70% increase in agricultural demand by 2050 and energy demand increase of 40% by 2030. Water demand projections to satisfy agriculture and energy production are a similar order of magnitude.

Analysis, results and implications for policy and/or research

Conventional planning and decision-making often fail to address what are inherently inter-linked and inter-dependant processes. They limit our ability to provide basic water, food and energy services and generate sustainable growth. A new 'nexus' approach is needed, one that better understands the inter-dependencies across water, energy and food: an approach that identifies mutually beneficial responses and provides an informed and transparent framework for determining benefits and risks. The Bonn2011 Conference clearly demonstrated the need to go one step further and consider all three sectors together. A number of private sector and international organisations similarly see the imperative of moving towards a more interconnected approach to planning and management in response to the challenge of resource scarcity and also because it makes good business sense. The Water-Food-Energy Nexus High Level Panel organized during the 6th World Water Forum in Marseilles aimed to transform a set of successful technical and institutional solutions into innovative and effective policy recommendations facilitating the transition to a greener economy and identifying the enabling conditions and incentives to trigger the desired changes. At its heart was a recognition that resource scarcity is not the limiting factor, but rather it is the institutional commitment and capacity to manage scarcity by sharing resources and enabling them to be used sustainably. Sharing resources means both innovating in search of mutually beneficial solutions for water, food and energy provision, but also being able to take political decisions to adapt models of development when trade-offs are unavoidable. This High Level Panel (Ministers, CEOs of private companies, Mayors of Local Authorities, Senior Executives of NGOs and international development agencies) discussed across two aspects: We need a balanced development that increases the productivity of water, food and energy production and provision (with respect to water, energy, land and other scarce resources) while recognizing the contribution of ecosystems services and the urgency to sustain them. Indeed, although scarcity of resources exists, productivity and efficiency in many areas are far below potential and prospects to improve do exist.

But they require more effective governance, technological innovation and a proactive and balanced 'nexus' approach that accounts for the interdependencies and ensures that development in one area does not impede others or put ecosystems services at risk. River basins and landscapes support development through a diversity of ecosystem services, such as water for domestic or industrial supply, food, fibre and fuel and hydropower, and perform essential regulating services to sustain vital processes. It is retaining a balance in the mix of ecosystem services that is often overlooked; a balance on which future well-being depends. New models of development and new business models are needed to expand access to basic services (water, food, and energy), enhance the productivity of scarce resources, lift people out of poverty and protect important ecosystems. A collaborative behaviour will be key to support the sharing of benefits and risks. Taking a broader view based on the sharing of benefits rather than strictly looking at the allocation of scarce resources can open up new solution spaces at various levels. These can be through negotiations within regional cooperation bodies, or within the hydrological boundaries of a shared river or aquifer, or a discussion on the distribution of benefits between project developer and local communities. Evaluating the impacts of one sectoral policy or strategy on the other two security objectives is a first step but needs to go further to trigger the search for mutually benefical outcomes. A wide range of approaches and benefit sharing mechanisms are being tried and tested involving policy and legislative reforms, new business models and collaboration among multiple stakeholder groups. More open, transparent and accountable systems also limit adverse and risky individualistic behaviour.

Crossing Water-Food-Energy Nexus in the Middle East: Integrated Resource Planning and Trade-Offs to Meet a Green, Sustainable Economy

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Keywords: resource management model, water-food security, water-food-energy nexus tradeo, sustainable cities, Middle East

Introduction and problem identification

Middle East countries are investing heavily in developing sustainable, livable, water and food security, leading edge greenfield cities and retrofitting brownfield cities with latest technology innovations that focus on a holistic view toward "total" resource management of water-food-energy nexus. This region is in water scarcity, is heavily invested in outside sources for importing most of their food supplies, using fossil fuels for water needs through desalination, and spending their own fossil fuel resources to secure both water and food. This paper presents an integrating model and resource management thinking that addresses in financially and carbon footprint viable infrastructure and building designs for water and energy demand reductions, innovative, in-country food security strategies being explored and their water-energy tradeoffs, and visions to meet a sustainable water-food-energy nexus future. Integration modeling and business case data will be provided.

Analysis, results and implications for policy and/or research

Saudi Arabia (KSA) currently uses over 60% of their domestic fossil fuels for potable water production and will see this percentage increase as population continues to grow and new, planned cities come on line over the next 20 years. KSA is looking at how to minimize water-food-energy nexus impacts in a new, green-field city that looks at the water-food security needs and the actual imported "virtual water-footprint" needed by the city and strategies on how to capture solutions today that make this city sustainable. Qatar is looking at a water-food security program that will require significant investments in new, in-country food supply sources, new support infrastructure, and new food growing innovation facilities over the next 10 years. UAE is pioneering two sustainable greenfield developments aimed at very high sustainability goals. UAE is also exploring and demonstrating several innovative food supply technologies from medical/biomass algae harvesting to innovations in both vertical and green house farming. These countries are looking for a global reputation needed to attract and retain new businesses, workers, tourists, and general population. To meet these goals in a financially viable manner, both horizontal infrastructure and vertical building designs must be considered for water-food security related activities. This consideration is necessary to optimize the combined infrastructure elements, greatly reducing water and energy demands, and resulting in the lowest "cost viable", energy footprint, and carbon footprint. This consideration also allows for a comprehensive system evaluation of the cost impacts for sustainable designs and key performance indicator (KPI) attainment when picking a food-water security program, approach and/or strategy. For three planned cities on the Arabian Peninsula, an object-oriented dynamic simulation model (VoyageTM) was developed to integrate infrastructure, food-water security solutions, and building supply and demands across the water-food-energy-carbon nexus.

The model is designed to calculate LCA and energy, water, and carbon footprints, and provide an optimized technology solution to meet business case economic considerations, incorporating total water management principles to manage the urban water and food cycle. Tools and strategies applied in these planned cities show how the water – food-energy nexus and supply and demand relationships can be optimized to meet an economic goal, carbon footprint reduction, and how powerful an integration model can be for completing scenario planning and developing phasing strategies to investigate cost and infrastructure needs over an extended development period. The model is backed by process models and databases that are region specific, but applicable to other locations. Most water-food-energy nexus programs have not truly estimated costs that account for the full cycle needed to supply food and water, cost range within a technology innovation for both water and food security schemes, nor the overall Life Cycle Costs Analysis (LCA), CapEx and OpEx impacts for each program and the various options within those program levels. In one costing example, significant variation exists between two green food-water security programs as well as wide variation in level costs and the cost premiums above business as usual (BAU) in the Middle East. The comparison to BAU is important, since many green programs and desires can cost out of being part of the sustainable city when looking at BAU. Cost premiums were looked at for waste management, as well as the water-food-energy-carbon nexus for decision on a path forward both now and in the future as these technologies see cost reductions or new innovations. Several "what if" costing, carbon and water-energy-carbon nexus examples from case studies will be presented that optimize LCA and other key development decision making needs.

Workshop: Governance for Water and Food Security

Model-Based Optimization of the Blue Nile River Basin

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Keywords: transboundary water, model, Blue-Nile, Sudan, Ethiopia

Introduction and problem identification

The Blue Nile River is a trans-boundary water source shared by Ethiopia and Sudan, where Egypt is the most benefiting country. The importance of the Blue Nile basin can be summarized in the huge percentage of its water contribution to the Main Nile River (52.8%), while it is also unique on problems of erosion upstream (i.e. lost more than 250 million m^3 of topsoil) and sedimentation downstream (i.e. silt accumulation in the reservoirs). Due to the population increase and water scarcity suffered during the last ten years in the Blue Nile basin, it is necessary to develop new reservoir/river simulation models. Pressure on water resources in the Blue Nile Basin is likely to increase dramatically in the near future as a result of high population growth in all the riparian states, and increasing development related to water needs in Ethiopia and Sudan.

Analysis, results and implications for policy and/or research

Problem formulation for model-based analysis requires a good understanding of the real problem and acquired data, that are:

1. The collection of Data:
   a. Existing and future water projects in the basin.
   b. Water resources and climatic data
   c. Nile agreements as well as similar agreement abroad.
   d. Water policies in the Blue Nile basin countries
   e. Similar cases of water polices of shared river in the world (e.g. Mekong river, etc)
   f. Relevant water resources management models.

2. Adapt and simulate an existing trans-boundary water management model(e.g. WEAP and DSS) and apply it in the case of the Blue Nile River basin.

The water resources of the trans-boundary river basin represent a single entity, and must be treated as a whole to avoid conflicts over the utilization of this limited resource.

The Blue Nile River, originating in Ethiopia's north-western plateau, has about 12 headwaters. The catchment area of the basin is about 324,500km^2, with an average annual flow of 52.62km^3 to the Nile River, which reaches about 85% in the flood period (July-August-September).

An effective trans-boundary water management model of the Blue Nile Basin will be constructed and used to simulate the alternative future scenarios, the current uses of shared water and to assess the impact of different development and management options.

The outcomes of the research will select and adapt effective tools and models of appropriate and sustainable development for the Blue Nile waters, and to simulate water management scenario for Blue Nile considering the existing and potential water projects for Ethiopia and Sudan, therefore the research will build Blue Nile Basin model.

The research will help the decision-makers to adapt their water and land management policies by making use of the new management interventions in the upstream watershed, upstream-downstream water availability and management in the Blue Nile basin. The simulation model was tested for three scenarios (current situation, proposed dams in 1964 "Mandaya, Karadobi, Beko-Abo, and Border dams", the proposed dam in 2010 "Grand Ethiopian Renaissance dam").

Securing Peri-Urban Water for Food Security: A Case of Hyderabad, India

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Keywords: peri-urban, water security, agriculture, urbanisation, climate change

Introduction and problem identification

According to the United Nations, the share of global population living in cities surpassed 50 percent in 2008. Between 2005 and 2025, the global urban population will swell by 1.6 billion with about 85 percent of the development process taking place in the urban hinterlands widely referred to as the 'peri-urban' and considered to be a transition zone between rural and urban. As cities rapidly urbanise, they exert intensive pressures on peri urban environmental resources leading to loss of natural wetlands, forests, farmlands, as well as important common property resources like grazing lands, tanks etc. and hence, threatening livelihoods that depend and sustain on these resources. There is a constant flow of resources between the urban centres and the peri-urban areas or villages and one important flow is that of water. Peri urban water is not just used for meeting the needs of the village but is also supplied to cater to the needs of the city.

Analysis, results and implications for policy and/or research

This poster demonstrates the implications of urbanisation processes on the water security of peri urban areas especially in the context of farming communities dependent on the water that is decreasing in availability and quality and is being diverted for other means to meet the demands of the growing city. The need for securitising water in the peri urban areas is of utmost concern since securing water translates into food security. In case of agriculture in peri-urban Hyderabad, tank irrigation used to be the most common form of irrigation which is now almost redundant as the tanks are never full to the optimum level and canals do not get filled adequately – the primary reason, apart from insufficient rains being the encroachment of tanks or their recharge channels. Lands are encroached for construction of urban infrastructure, real estate development, development of special economic zones, expressways, housing colonies, industries which is leading to a drift in people practising agriculture to other lucrative urban occupations. Most of the farmers have sold off their lands entirely or have retained a portion of their land holdings. Thus, irrigation is now mostly groundwater dependent on bore wells that run on electricity which is usually erratic in these peri-urban areas leading to insufficient water for the fields. The richer farmers are able to install borewells in their fields, but it is the marginal ones who are generally dependent on rainfall and are most affected by changes in weather patterns. While 2002 was a year of extreme floods, three drought years in the last 10 years have severely affected the crops and this coupled with growing urbanisation has resulted in high rates of livelihood diversification, and practising of agriculture is a secondary occupation for many. With soil quality and water availability decreasing and under uncertainties of climate change large groups of traditional agricultural labourers have moved into working for the pharmaceutical and industrial units around these areas. A number of farmers keeping in pace with the development trends, find it much more profitable to sell water from their lands to the cities. Large quantities of ground water are abstracted from lands by installing high-powered pumps and supplied to nearby industries and housing colonies through private tankers.

Each tanker carries about 20-30,000l per day. Andhra Pradesh is the rice bowl of the nation, and paddy has been the primary crop cultivated, but reduced water availability over the years has forced farmers to make a shift in the cropping patterns and cultivate less water intensive produce like vegetables alongside paddy. But this is also not an easy step as costs of hiring agricultural labour is very high and the produce is not sufficient enough for them to recover their costs. Some traditional farmer groups have also devised the technique of step-farming for their fields which reduces the consumption of water.

Design of Aquifer Recharge Scheme of Treated Wastewater in North Gaza for Sustainable Agriculture

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Keywords: aquifer recharge, agriculture sustainability, food security, wastewater, North Gaza

Introduction and problem identification

Groundwater is the only available water supply source within North Gaza. Excessive groundwater abstraction to meet the high increase in domestic and irrigation water demand has lead to groundwater depletion problems and degradation of water quality. Saline intrusion becomes one of the main threats to Gaza coastal aquifer. This resulted in drop in agricultural production by more than 20% and have significan impact on food production in Gaza. The total projected water demand for domestic and irrigation purposes in Gaza is around 55 MCM by the year 2025. The estimated wastewater effluent of North Gaza by year 2025 will be around 17 MCM. This forms 30 percent of total water demand. The aquifer water balance is currently in deficit, and without intervention, the deficit is expected to increase significantly in the future, from about 5MCM/year to in excess of 27MCM/year in 2025.

Analysis, results and implications for policy and/or research

This paper investigated the potential of protection of Gaza groundwater aquifers from saline intrusion and depletion through design of aquifer recharge scheme from the treated wastewater at Beit Hanon Treatment Plant. For this purpose a water balance model had been developed, the model indicated that there is potential to recharge up to 67,000 m^3/day by the year 2025. This amount will provide the farmers in north Gaza with their water needs for irrigation and will contribute to the sustainbility of agricultural activities in north Gaza. The water quality of recharged water is expected to improve through infiltration process due to aquifer type (alluvial deposits).

The study recommended to use the filtration basins with boreholes filled with filter material to connect basin with the aquifer. The marine Kurkar forms a good aquifer and most of abstracted groundwater in Gaza from this aquifer. Marine Kurkar formation is composed of shell fragments and quartz sand which are cemented together by calcareous material and coarse calcareous sandstone that is hard to differentiate from overlaying Continental Kurkar. The thickness of this formation varies between 10 and 100 m and it becomes thicker near the coast. Underlying this layer there is a thick formation (several hundred of meters) of impervious shales (marine clay), known the Saqiya formation. It is clear from the geological section that clay layer is not very deep, its thickness varies from 7 to 10 m. In addition to top clayey layer there are clay lenses with different sizes. The most effective ones are near the coast, towards the eastern border these lenses are few and thin. The site where the treatment plant is located was identified as the site for aquifer recharge This is mainly due to proximity of the site to treated wastewater which minimises the transfer cost. Figure 3 shows the location of treatment plant and recharge site. In order to asses the suitability of this site for recharge, the following criteria are considered:

- topsoil (soil type and thickness) and topography
- depth to water table (unsaturated zone thickness)
- infiltration rate (vertical and horizontal aquifer permeability)

- groundwater flow direction & hydraulic gradient
- concentration of nitrate & chloride
- available area
- distance from border In order to understand the soil properties of the identified site, a soil investigation scheme was implemented, it includes:
- drilling 4 boreholes, one deep around 80 m until it reaches the water table, one mid-deep around 30m and two shallow around 8 m.
- describe the lithological units
- prepare sieve analysis for collected samples
- conduct SPT tests at top 10 meters of the deep and middle depth in addition to 8 meters boreholes conduct down hole permeability tests at both the deep and mid-depth boreholes
- collect information from the existing wells close to the site to establish the groundwater level close to the site and the groundwater quality (chemical analysis)
- Conduct evaporation tes

The estimated peak monthly effluent by year 2025 is 67000 m^3/day in year 2025 (2). If by this date the treated effluent is fully reused for irrigation, the maximum inflow rate would be approximately 34,000 m^3/day. This represents the expected range of uncertainty in the 2025 flow rate, and hence the infiltration capacity required for the scheme. The treated effluent will be subjected to disinfection and rapid gravity filtration as part of the treatment process. The resulting effluent will have very low suspended solids (average of 15mg/l). A short flooding period of 1 day together with a drying cycle of 2 days, tends to limit the operational efficiency of the scheme thereby increasing the overall area of the recharge basin. Increasing the flooding period to 2 days helps to improve operational efficiency. The total length of the flooding and drying cycle also influences the number of recharge basins needed to achieve a uniform inflow rate. Longer flooding cycles provide greater operational efficiency, but increase the number of ponds required. As the standard of treated effluent is high, a flooding cycle of 2 days has been selected. Depending upon the length of the drying cycle either 4 or 5 ponds will be required. For a range of treated effluent flow rates, the relative area is the proportion of the maximum area. Without reuse of the treated effluent for irrigation, the maximum site area needed by the year 2025 is estimated to be 125 x1000 m^2. With full potential reuse of the treated effluent for irrigation, the maximum site area needed by the year 2025 is estimated to be 73x1000 m^2. In both cases a total of 6 infiltration basins have been assumed. In summary; A combined system of ponds with filtration boreholes is the most appropriate and economical system for recharge of treated wastewater into alluvial deposits aquifer.

Challenges of Integrated Water Resources Management to Respond on the Increasing Demands for Water and Food Production in Indonesia

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Keywords: enabling environment, food production, institutional frameworks, integrated water resources man, management instruments

Introduction and problem identification

Population growth, urbanisation, intensive agricultural development, industrial growth and environment requirements are all increasing demand for water. Both the land conversions from forestry to agricultural use and from agricultural to residential use in Indonesia increase from the year to year because of the hardly controllable pressure of accelerating population and economic growth. Many negative consequences of unbalanced environment are more likely to be generated from manmade objects and can put severe pressures on all water users. The fact that the increasing demands for water and food production accelerate due to the economic development is a policy intervention endeavor with aims of economic and social-being of increased people. As challenges that integrated water resources management (IWRM) should cope with complex issues of water and food security and will ultimately need to implement a comprehensive set of reforms in the water sector.

Analysis, results and implications for policy and/or research

Several recommended actions are suggested for the improvement of the future IWRM in Indonesia. The challenges to improve capacity building for IWRM related to enabling environment, institutional frameworks and management instruments are verified to contribute to the problems solving of water pressure and food security in future, such that:

1. Challenges of the enabling environment are at least eleven pillars of sustainable WRM (SWRM) approach that must be highly scrutinised by local and central government. These pillars are grouped into the two management approaches, i.e.,
(i) IWRM approach consisting of watershed and forestry, agricultural lands, flood and drought, water quality and pollution control, soil erosion and sedimentation, as well as seawater intrusion puts under supervision of a river basin agency; and
(ii) partial WRM approach consisting of water and wastewater treatment, chemical and activated sludge, solids waste/garbage, groundwater and lands subsidence, as well as night-soil puts under responsibility of a district/municipal authority. All of these pillars can be thought of as activities and should be implemented to tackle actual problems at a river basin scale. One of the important activities will be firstly the set-up of a river basin IWRM plan (RBIWRMP) which is the guidance document officially adopted by the government. The RBIWRMP guides the governmental and private institutions and synchronises the programmes and activities whole the river basin to meet the SWRM targets.

2. The authority political control in Indonesia is divided into three administration levels that are national/central, provincial and district/municipal government. The Law No. 7/2004 stipulates that water resources should be managed on the basis of river basin territory.

With all the existing problems and constraints, the institutional arrangement must consider ways of trading-off between the river basin management authority and the political administrative authority. However, in many cases the programmes do not synchronise with each other. The acquisition plan should be provided to the dependable administration organisation to facilitate resource allocation, development and planning for IWRM. The proposed scheme to ensure the SWRM is that status of the environment before and after the development of a region should stay in the same condition. There is the three basic policies that must be to set up by the district, provincial and central government, such that:
(i) zero delta Q policy to maintain run-offs,
(ii) zero delta S policy to preserve erosion rate, and
(iii) zero delta P policy to safeguard the pollutant loads resulting from human activities. It is essential that these policies should be implemented by the related government agencies, private institutions and other stakeholders particularly for densely occupied river basins. This paper suggests that capacity building in Indonesia still requires urgent and vigorous actions towards a qualitative and quantitative of scientists for the coordination of the dispersed efforts made by various river basin and political administrative authorities and for the strengthening of individual and collaborative programmes aimed at developing human resources in Indonesia. Additionally, it is essential that the central government delivers on the socio-economic needs of the people, so that the top-level coordinator can assign more than one government agencies and private institutions in any registered plan with respect to cross-sectoral policies, strategies, programmes and activities for the entire river basin.

3. The water laws and legislative instruments are essential and powerful tools for formulation and implementation of IWRM plan. The planning process should result in an IWRM plan endorsed and implemented by government, detailed depending on the evaluation aims, the field of interest of the programmes and considering the existing economical and sociological theories. All the riparian districts of a river basin have elaborate structures and institutional arrangements to facilitate stakeholder participation in IWRM. The stakeholders should be made aware of the IWRM plan and agree to work through the decision-making process due to the frameworks for the programmes and activities proposed should be determined by the IWRM plan. Establishment of River Basin Water Council as coordinating board for each river basin territory is the best way to synchronise the programs and activities and to discuss the specific issues with the local or central government. The internalisation of external costs forms part of a package of initiatives aimed at making IWRM more sustainable. The polluter and user pay principles and appropriate incentives need to be implemented into the future water regulations in Indonesia and give a good illustration of the stakeholders' participation to reduce most important pollution problems and minimise environmental and social impact.

Promoting Local Watershed Governance for Water and Food Security

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Keywords: watershed, local governance, community, stakeholder, watershed council

Introduction and problem identification

A large portion of the watershed areas in the Philippines are in serious condition with almost 2.6 million hectares identified as critical watershed. Destruction of watershed areas is caused by combination of factors: social, political and economic-impacting negatively on the products and services derived from watershed areas-water and forest products, compromising further food and water security. The Department of Environment and Natural Resources (DENR) is the government agency responsible for the management and protection of watersheds. While laws, rules and regulations were formulated for effective watershed management, the implementation aspect is problematic. What is needed is improved watershed management approach that encourages watershed governnance at the local level with the active involvement of the different stakeholders such as local governments, communties, the academe and other stakeholders in the watershed area.

Analysis, results and implications for policy and/or research

The Department of Environment and Natural Resources (DENR) is mandated agency for watershed management. As such, watershed development and management policies and programs tended to be formulated from a top-to-bottom approach. Traditionally, the social perspective is seldom taken into account. Clearly, there is a disconnect between policies and programs on one side and stakeholders on the other side resulting in limited success of watershed programs. Changes started to occur in the 90's brought about by new development paradigms and the recognition of the fact that national government needs the help of local government units in environment and natural resources management. Empowerment of communities also played a important role in the shift in watershed management. In 1991, the Local Government Code (LGC) or Republic 7160 was enacted.

This legislation transferred certain responsibilities and powers relating to environmental management to the local government units (LGUs). Among the basic services that were devolved from the national government to LGUs is environmental management; in particular, community-based forest and communal forest management. The enactment of the LGC, and the recognition of the important of watershed areas, and that its management is not the sole responsibility of the government but rather a shared responsibility between the government and the community was instrumental in the paradigm shift in watershed management perspective.The shift in paradigm provided for watershed governance at the local level where the active players are the the local government and the community with guidance from national government. Central to this initiative is the Philippine Watershed Management Coalition (PWMC). The Coalition is composed of watershed multi-stakeholders who came together more than 10 years ago to promote watershed management in framework of local governance. As an agent of change, PWMC envisions to build and strengthen a responsive body of individuals and groups working together for the effective management of watersheds across the country.

It aims to develop a well informed constituency at the same time promote local governance to manage and protect watersheds, The Coalition is considered a venue for continuing education in the area of effective watershed management; a platform for discussion of various activities that promotes local governance of watershed areas; a strongly advocate of the concept of co-management of watershed by stakeholders and support local government units by strengthening local environmental governance. With the Local Government Code and the paradigm shift, PWMC helped shaped watershed governance at the local level. This was achieved by facilitating creation of partnerships among stakeholders to come up with a model and support mechanisms such as local watershed council and board responsible for management of watershed areas in support of water and food security. It provided capacity building, advocacy programs and helped institutionalize watershed planning at the local level. For example, the Bukidnon Watershed Protection Development Council integrates watershed management in the planning system of the province and paved the way towards building a strong partnership between local government units and people's organization. In the case of Iloilo Watershed Management Council, the local government formally created the Watershed Management Council to oversee the management of the province's watershed and take responsibility for its conservation, development, utilization and protection. It is composed of representatives from the local government, peoples organization and non-government organization, the academe and private sector. At present, there a a number of these watershed management councils at the local level, created with assistance from the Coalition and now managing of watershed from an integrated water resources management perspective. The local council puts emphasis on the linkages between the upstream and downstream areas of the watershed and their respective human and biophysical resources. These watershed management councils are responsible for local watershed governance, capacity building and fund sourcing to implement watershed management plan prepared. Today with watershed governance at the local level, watershed management has become a prominent concept in dealing with issues of land and water resources reinforcing the recognition that effective watershed governance will largely contribute to the attainment of food and water security. Community-based watershed management, the hallmark of localized watershed governance is an accepted process the involvement of local communities and local governance structures in formulating and implementing courses of action on the proper utilization of water and land resources of the watershed.

Which Way Water Security? Reflecting on Evidence Reported in DFID's Systematic Review on the Performance of Water Resource Management Institutions

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Keywords: water institutions, performance, systematic review, poverty, sustainable growth

Introduction and problem identification

In 2011 the UK's Department for International Development commissioned a Systematic Review of global evidence relating to the following question: What factors determine the performance of institutional mechanisms for water resources management in developing countries in terms of delivering pro-poor outcomes, and supporting sustainable economic growth? The exacting, transparent and impartial process of Systematic Review demanded scrutiny of over 25 000 articles and papers from the academic, NGO and grey literature on water resource institutions in Africa, Asia and South America. Papers were screened for relevance and accepted only where empirical evidence was presented linking institutional performance and pro-poor or pro-growth outcomes. Further analysis assessed the validity of findings, mapped and attempted a synthesis of the evidence base. Our paper reports the preliminary results of this work for discussion and reflection for the first time.

Analysis, results and implications for policy and/or research

Systematic reviews adopt a rigorous and transparent methodology to appraise the global evidence base for policy and practice. Although a relatively new approach in the domains of natural resources and development studies they have revolutionised the quality of research and translation of research-into-use in the health sector. The process of systematic mapping and review provides a comprehensive search, collation, quality assessment, organisation and synthesis of the available evidence base - documented in peer reviewed academic and grey literature - to generate an objective, unequivocal and contemporary response to a specific question. A key finding of our work is that the comprehensive collection, analysis and reporting of the 'outcomes' of water resource policy interventions is woefully lacking. This implies that if inadequate research, monitoring and evaluation continue, then society will remain unsure about:

1) the effectiveness of interventions and reforms aimed at furthering water and - by implication - food security, and

2), the factors which determine their success or failure and appropriate approaches to inculcating or overcoming these.

The implications of this work are expected to shape international research and policy on water security over the coming decade. In terms of research, we highlight the need for much greater rigour in tracking, tracing and reporting the linkages between water resource policy reforms and development initiatives and results in terms of poverty reduction and sustainable growth. Based on our review we propose research approaches and principles which can contribute to that rigour, navigate the implicit complexity, and so provide a stronger and more reliable spring board for research into well-informed

and effective policy making and action. For policy, we reveal that despite their often vociferous advocates, many institutional interventions on water resources are supported by a sparse or unconvincing evidence base. The implications for policy makers, development partners, governments and support agencies are articulated and argued to be significant. Drawing on our mapping of the evidence that is available, we characterise the literature on mechanisms including participatory, market, legal, bureaucratic and infrastructure based institutional change (and admixtures of these)and their links to desirable development outcomes. We thus provide a powerful platform for further analysis and evidence based policy making towards global water security. The further validation and deliberation of this work through presentation at Stockholm Water Week is a vital step in our outreach strategy and we look forwards to and anticipate rich and lively debate in response to our challenging findings

Water Harvesting to Augment Water Resources: Traditional Technology and Communities are Part of the Solution

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Keywords: water harvesting, traditional technology, social entrepreneurship, Johad, Chouka

Introduction and problem identification

India is the largest groundwater user in the world with more than 60% of irrigated agriculture and 85% of drinking water supplies on it. In terms of provision of safe drinking water, India has covered more than 90% of the rural households (NSSO, 2008-09). In the course of implementation of rural water supply schemes since the launching of the Accelerated Rural Water Supply Program in 1972 and Rajiv Gandhi National Drinking Water Mission in 1986 and the National Rural Drinking Water Program in 2009, a large number of successful models of providing sustainable and safe drinking water have been tried out throughout the country. Despite these initiatives, the increasing population and overexploitation of surface and groundwater over the past few decades has resulted in water scarcity in many regions of the nation. Growth of the Indian economy is driving increased water usage across sectors.

Analysis, results and implications for policy and/or research

The state of Rajasthan, the largest State of the country has also one of the most critical status of water. Rajasthan with more than 10.4% of the country's geographical area, supporting more than 5.5% of the human population & 18.70% of the livestock has only 1.16% of the total surface water available in the country. 2/3rd part of the State is a part of the Great Thar Desert and out of the total 142 desert blocks in the country, 85 blocks are in the State of Rajasthan. The per capita annual water availability in the State is about 780 cubic meter (Cum) against minimum requirement of 1000 Cum.

It is feared that the availability would fall below 450 cum by the year 2050. Thus increasing population coupled with erratic rainfall further aggravates the water crisis. With a scenario such as this, it is imperative to approach the issue with innovative methods and "social entrepreneurship" is one of the ways to address the crisis. Social entrepreneurs function as the agents of change, questioning the status quo, grabbing the new yet overlooked opportunities, and changing the world for the better. The popularity of SE is growing at a very high pace in India. This has been amply demonstrated by the successful experience of local communities in Alwar District in Rajasthan, supported by the NGO. It is possible to harvest and augment water resources through the construction of small water harvesting structures called Johads and the implementation of local water governance. Since 1985, 8,600 Johads have been built in 1,086 villages. This has resulted in the rise in water levels in the shallow aquifer, increase in the area under single and double crops, increase in forest cover and drinking water supply security. The water collected in a Johad during monsoon penetrates into the sub-soil. This recharges the ground water and improves the soil moisture in vast areas. The water in the Johad can be used directly for irrigation, drinking water by animals, and other domestic purposes. The other advantage of this structure is that it checks soil erosion, mitigates floods, and ensures water availability in wells

or boreholes used for drinking water supply, even for several successive drought years. Also, during the dry season when the water gradually recedes in the Johad, the land inside the Johad itself becomes available for cultivation.

Another new technique called Chouka System for ground water recharge is effectively working in Dudu block of Rajasthan. In this technique, small rectangular dykes with entry and exit points, are constructed. The rectangular dykes are called Choukas. The slope inside the Chouka is such that a maximum of 9 inches of water stands in it, which ensures moisture in the soil round the year. When after years of hard work, people saw the results of the Chouka system; they realized that all the effort was worth it. The trees inside the Chouka grow very fast, the ground water is recharged and there is no dearth of water for drinking purposes. The Choukas are constructed in pasture land and people have voluntarily removed encroachment from thousands of acres of pasture land. They have sowed different varieties of grass which has resulted in adequate fodder production for animals.

These two examples of social entrepreneurship in water conservation are appreciated all over world. Many other are using this techniques and the effectiveness have been proved. From the ancient time Rajasthan well was known for its water conservation practices and the devotion of people to save each drop of water. In recent time these examples again proved that still people of Rajasthan are very much aware about water.

Integrated Water Resources Sustain Food Security and Water Resources in Sri Lanka

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Keywords: water resources, food security, economic growth, agriculture, poverty

Introduction and problem identification

Water resources and adequate water supplies are essential for food security, energy health and human security. In Sri Lanka we have almost accessed these goals through (IWRM) approach in last 15 years. GDP grew by an impressive 8.0 per cent in all major sectors contributing positively towards overall economic growth. Value added growth in the Agriculture sector increased by 7.0 per cent during 2010 supported mainly by the favorable performance in domestic agriculture (Central Bank Report-2010). This is mainly adopting sound decisions that maximize, water's beneficial uses require partnerships and good governance based on comprehensive policies and gender balanced involvement of all stakeholders, in public and private institutions

Analysis, results and implications for policy and/or research

Sri Lanka has adopted many projects, to reach the sustainable development of food production. This paper provides the basic concepts of Leadership and Skill Development Project (LSDP) initiated by the Post Graduate Institute of Management in Sri Lanka amalgamating with the Ministry of Irrigation and Water Management. It describes the processes and procedures adopted by LSDP, in association with stakeholders to overcome water, food security and various requirements of the rapid increasing population. And also, reveals the coping mechanism adopted by the officials and stakeholders, in management of the water resources and related services with the fundamental structural reforms, ordinance and critical hard & soft components for sustainable management of water resources for food security, by strengthening institutional and management capacities under the umbrella of I W R M. Sri Lanka is an island state. It has tropical climate and divided into two climatic zones. Two monsoons bring rain to all parts of the country, and receive about 12 million hectare meters of water annually. The water scarcity situation is compounded by the major impact of climate change on the water resources, The demand for water in the country is on the increase in the food production sector as well as others, especially the domestic water supply, sanitation, industry, environment, fisheries and livestock, hydropower and wild life habitat etc. IWRM have been aggravated due to large number of ministries, therefore LSDP developed sound decisions that maximize water's beneficial uses require partnerships and good governance based on comprehensive policies, and gender balanced involvement of all stakeholders, in public and private institutions coordinating very carefully in a holistic manner to solve problems of irrigation, household and hydropower potential with protecting the environment. The coping mechanism adopted by the agency officials and communities, in alleviating the negative impact of the water stress situation was the both parties agreed decision making system and the higher management efforts done by the Stakeholder Cooperative Associations.(SCA) of the watershed. The SCA is an interdisciplinary team of experts incorporating the engineers, agronomists, economists, and with selected CBOs under the guidance of Cooperative Manager (CM) aims to provide authorities and governmental institutions with appropriate methodologies to improve long term development plans.

The SCA is the top level joint committee, chaired by the Cooperative Manager is the legitimate decision making body for water resource management in the project. Irrigation Department demarcated all the water sheds as Protected Areas, which were designed to secure water supply infrastructure and can serve as permanent spring source protection zones.

Protected Area Management performed all water sheds in Sri Lanka included
1). Socializing the establishment of the protected area
2). Land rehabilitation through selected tree planting
3).Posting signs warning people to stay away
4). Training a mobile patrol monitoring unit. through LSDs to ensure protected status of designated areas. In the water stress situation, the cooperation of the communities and the SCA leaders is essential in the paddy cultivation, their willingness to get maximum use of effective rainfall by carrying out land preparation with using rain water is must. These projects improved their performances up to 85% equity of allocation; water use efficiency was 80%-(IWMI), Systems turned over to SCA associations, to carry on operation, service delivery and management and they have reduced the 50% of state allocation. Companies own by the beneficiaries managed the system and provide marketing and other services to the people to improve their living conditions. The World Bank initiated Community Water Supply and Sanitation Project for drinking water and sanitation through a holistic and community based approach. Soft solutions like training and awareness programs, with the funding of LSDP, which improved the health benefits and living standard of rural community through personal, domestic and environmental sanitation. The project used participatory methods to promote the adoption of improved sanitation and hygiene, especially in women participating, Local women were trained to produce and install sanitation facilities, generate work and income and improve their status. Toilets and rainwater harvesting tanks build by local women masons, including lower cost. Altogether, Sri Lanka has been quite impressive in achieving most national targets at aggregate level, for example 82% and 92% country population has access to safe drinking water and sanitation respectively. Stakeholder participation is essential in the formulation and implementation of national and local water management plans to reach the food security targets.

Towards Water Security through Integrated Water Resource Management: The Case of the La Plata Basin in South America

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Keywords: IWRM, Institutional strengthening, La Plata Basin, transboundary water issues, strategic action plan

Introduction and problem identification

The La Plata Basin is one of the largest in the world covering an area of 3.1 million km². In 1967, during the First Meeting of the Ministers for Foreign Affairs of the La Plata Basin, the governments of Argentina, Bolivia, Brazil, Paraguay and Uruguay, established the Intergovernmental Coordinating Committee of the LPB Countries (CIC). Two years later the La Plata Basin Treaty was signed by the LPB countries, becoming the primary legal instrument of the basin (OAS-CIC, 2011). Variations in the hydrological system of the LPB, that have intensified existing issues in the basin are partly due to climate variability and change, and demand an integrated approach to address them (OAS-CIC, 2011). Water resources management in Latin America and the Caribbean tends to be fragmented, with responsibilities being dispersed among several entities (Lord, Israel and Kennedy, 1996). It is thus important to have intergovernmental bodies to obtain good management of water resources at a basin scale.

Analysis, results and implications for policy and/or research

Since its creation, the Intergovernmental Coordinating Committee for the La Plata Basin Countries (CIC) has focused on the five countries' areas of common interest, promoting the execution of hydrological, natural resources, transport and navigation, soil and energy-related studies, programs and infrastructure works. A comprehensive study of La Plata Basin's natural resources carried out by the Organization of American States (OAS) in the 70's allowed directing the countries' actions towards tapping energy and transport potentials (hydroelectric power plants and the Paraguay-Paraná waterway). As a result of these studies, environmentally critical areas were identified in the basin, such as the Pilcomayo and Bermejo rivers' sub-basins (OAS-CIC, 2011). The preparation of an integrated water resources management program in relation to climate change for the La Plata Basin was agreed upon in 2001 during the IV Inter-American Water Management Dialogue. An Action Plan, approved by the CIC during 2003, has guided the preparation of the Framework Strategic Action Program (Framework Program). Within this context, the CIC requested GEF support to identify the priority transboundary program elements and to subsequently the Framework Program. The design stage of the project took place between 2003 and 2005 and is currently in its Stage 1 phase to develop a Strategic Action Program (SAP) by 2015. The Framework Program for the Sustainable Management of the Water Resources of the La Plata Basin, with respect to the Effects of Climate Variability and change is being carried out by the CIC with non-refundable financing from the Global Environment Facility (GEF), other sources of co-funding and the counterparts of the member countries, with the technical and administrative support of the DSD/OAS, through UNEP as the implementing agency. The overall project objective is "to strengthen transboundary cooperation among the riparian country governments of Argentina, Bolivia, Brazil, Paraguay, and Uruguay to ensure the integrated and sustainable management of shared water resources of the LPB, within the context of climate variability

and change, while capitalizing on development opportunities" (OAS-CIC, 2011).
In the current stage, the project is subdivided into four components: I Strengthening basin-wide cooperation capacity for integrated hydro-climate management, II Integrated water resources management, III Hydro-climatic models and scenarios for adaptation and IV Transboundary Diagnostic Analysis (TDA) and Strategic Action Program (SAP) formulations. Component II includes four Pilot Demostration Projects (PPD), with the aim of providing experience at a local scale and testing the applicability of the methods proposed in other subcomponents (OAS-CIC, 2011). The objective of the project was established based on the fact that the LPB lacks framework plans to manage the diverse demands for shared resources. This is exacerbated by the fact that responsibility for various components of the system is distributed among different juridical structures in the federally and centrally governed LPB countries. Through the project it is ensured that all decisions are reviewed and approved by one or more members of each LPB country. Each country has named a representative to participate in each of the sub components of the current phase. This encourages participation of members of the private and public sectors of each country within a common institutional framework. In particular, the five countries have differing economic and technical capacities but are working together to develop a common vision of water transboundary issues and defining a common action plan. With the aim of obtaining good governance of the water resources in the La Plata Basin, disparities are considered when implementing a transboundary IWRM plan.

Individuals from the five riparian countries will be trained to equate the water resource management capabilities in all LPB countries. In addition, technology a good science transfer will be promoted in the basin to provide the less developed/capable countries with the necessary tools to complete the activities for the program and to reinforce their capability. Moreover, information will be made available through a Decision Support System (DSS). In this context, the Framework Program will lead to the riparian governments' ability to coordinate strategic actions in the LPB for the sustainable utilization of water resources within the context of climate variability and change, ensuring water security through the implementation of a SAP. References Lord, W. B., Israel, M., Kennedy, D., 1996.

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Achieving Food Security with Appropriate S,T&I Investments and Water Legislation: Lessons from Brazil

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Keywords: Brazil, water legislation, food security, s,t& investiments, socio economic growth

Introduction and problem identification

Policy-makers in many parts of the world are facing growing socio-economic and ecological pressures to establish water policies that provide multiple water use and at the same time, ensure food security for their countries. Brazil has had a river basin based national policy for fifteen years and has achieved self sufficience in food production over this time. It has considerable quantities of the planet's fresh water reserves. Nevertheless, the majority of these reserves are found in the scarcely populated northern region, whereas in other parts of the country, especially in urban and food production areas, population growth together with increasing water demand lead to shortages and differences in socio-economic development levels. An assessment of the Brazilian water and S,T&I policies clarifies some of the motives why the country was able to develop innovative legislation as a crucial measure towards water and food security - a movement that many countries still need to make.

Analysis, results and implications for policy and/or research

The process to develop the Brazilian Water Resources Policy began in the 1970s. These years were marked by environmental pressure from developed countries on developing and on middle-income countries such as Brazil. The 1980s saw the introduction of environmental legislation in the country. Sustainable development was very influential as a concept around the world and Brazil was no exception. As a result of international pressure along with rising levels of investment, a considerable amount of foreign capital was available to fund diverse environmental projects in the country, starting with those related to improve conditions in the urban environments of the big Brazilian cities. The 1992 Rio Conference also played an instrumental role in the creation of major pieces of Brazilian environmental legislation incorporating the sustainable development principles as well those for a more efficient use of water. Five other key factors contributed to the discussion of the urgent need of a Brazilian national water resource policy: the general contamination of the water bodies, serious water events throughout the country, such as floods in the South and droughts in the Northeast, conflicts among the water users all over Brazil, the necessity to foster S,T&I investiments in the water and agricultural sectors and the growing need to ensure food security in the country.

After five years of public hearings throughout the country, the Brazilian National Water Law was established in 1997 incorporating the principles of IWRM. During its 15 years of existence, many lessons have been learned, challenges overcome and progresses achieved. Food security has been a crucial target in the public policies in the late 15 years as well. Much progress has been achieved through the harmonization and integration among water, S,T&I and food security policies in the country. Much of the Brazilian experience in implementing theses national policies could be of interest in the process of creating similar legislation for many parts of the world.

Local Community Awareness and Use of Wetland Resources in Kyeizooba Sub County Bushenyi District, Uganda

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Keywords: awareness, wetland, local community

Introduction and problem identification

The most common type of wetlands in Uganda is the papyrus swamps dominated by the cyperus papyrus. MoWLE (1999)1 observed that these wetlands benefit people in 3 distinct groups namely; wetland products, wetland services and wetland attributes. It further stated that wetland products are visible, well known well understood and well appreciated by all Ugandans especially those living adjacent to the wetlands and harvest these products. Wetland services are invisible and are taken for granted, certainly, they are little appreciated until the service is derived (MoWLE 1999). Bushenyi wetlands used to contain important papyrus (sedges) and other resources but over the 20 years, much of these wetlands have been used for agriculture. In some areas where drainage commenced in the early 1970s, the majority of the papyrus wetlands have now been replaced with better pastures for grazing dairy cattle (Mafabi and Taylor 1993; wetland report Bushenyi district 1998).

Analysis, results and implications for policy and/or research

The Chi square test It is evident from table 4.3 that the 'agree' (68%) responses are greater than the 'disagree' (30%) and the undecided (2%). This means that to the community, wetland conservation is highly influenced by the level of awareness of the people. Chi- square observed is greater than chi-square critical value at 0.05 alpha level of significance and 2 degrees of freedom, hence hypothesis 1 was accepted. Figures in brackets denote expected frequencies; sig is significance at p â‰¤ 0.05 Table 4.3 shows the contribution of level of awareness, to the wise use of wetland resources in kyeizooba Sub County. It is evident from table 4.5 that the 'Yes' responses (92%) for the items are more than the 'No' responses (77%). After computing the chi- square test for the 'Yes' and 'No' responses, it was found out that the values of chi- square observed (209.4 and 126.4 respectively) are greater than the chi- square critical value of 5.99 at 2degrees of freedom and 0.05 alpha of significance. This means that both the massive use and benefits from wetlands do significantly lead to wetland degradation. The null hypothesis 2 was therefore rejected in the favor of the alternative; "uses of wetland resources do significantly lead to wetland degradation". Table 4.5 shows the chisquare test on whether benefits from wetland resources and massive utilization of wetlands do not significantly lead to wetland degradation. conlusion The findings from the study reveal that use of wetland resources for socio- economic benefits do influence wetland degradation. This is because the majority (98%) of the population in kyeizooba is engaged in activities concerned with wetland resources. In agreement with these results, NWCMP (1995)5 reported that economic benefits tended to overshadow environmental concern in a situation where a country is struggling against so many odds to take off economically Despite awareness raising programs and the activities of District Environmental Committees (DECS) and Local Environmental Committees (LECS), reclamation and burning still continue in wetlands. This means that although people are aware of wetland degradation, the appreciation of its services and functions is still low compared to the immediate benefits they obtain from the use of wetlands Recommendations The local government should supervise and regulate the use of wetlands in kyeizooba Sub County. The government should also streamline, manage and advise on the implementation of community awareness and mobilization programs.

The local government should also reinforce laws concerning wetlands without fear or favor in kyeizooba Sub County. Areas for further research Since the study has concentrated on local community awareness and use of wetland resources in one Sub County, there is need to conduct a comparative and further study in other sub counties in Bushenyi district. There is also need to conduct a study on each of the categories of wetland uses and examine their effect on wetlands and derive solutions to the problems.

Mapping Rainwater Management Strategy at Landscape Scale

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Keywords: suitability, integrated water management, rainfed system, decision making support tool

Introduction and problem identification

The concept of integrated rainwater management suggests that water management should go beyond single technological interventions and take the socio-economic and institutional context into account. Despite of these recent conceptual advancements, tools fail in combining technologies or taking the socio-economic and institutional context into account. As a consequence, there are nowadays no tools to inform practitioners about location specific feasible sets and combinations of rainwater management technologies. The objective of this paper is to present a mapping framework that allows modeling combinations of technologies and takes socio-economic and institutional context into account. It allows to a fast track context specific best bet rainwater management strategies. The framework is applied to the Blue Nile in the Ethiopian Highland.

Analysis, results and implications for policy and/or research

We define a rainwater management strategy at landscape scale a combination of rainwater management tehnologiesthat increase infiltration on the top-slope of a landscape, conserve soils and water in the mid-slope and that increases efficient use of water in the flatland. In order to model rainwater management strategies at landscape scale, we propose a two step approach. In a first step, single rainwater management practices are selected and conditions of success identified and mapped out. Bio-physical conditions, namely rainfall, temperature, soil, slope and elevation are usually well understood, and therefore thresholds for suitability can be defined through a literature review, completed by expert knowledge. For each suitability condition, a binary map, indicating location where the conditions are met, is created, based on the existing geographic layers. These layers can then be combined with an equal weight overlay into a bio-physical suitability map. This map is by construction a binary map that indicates locations where all bio-physical conditions are met. Socio-economic / institutional conditions are often less well understood than the bio-physical ones and it is difficult to define credible thresholds. Instead of trying to define arbitrary thresholds, the socio-economic / institutional drivers can be seen as contributing to the adoption of a practice, the values of which need to be normalized to a variable between 0 and 1. The approach chosen in this paper is to use a small area estimation technique. It firstly assesses adoption of a given practice based on a household survey (explaining which household is likely to adopt the practice). It is based on a probit estimation that contains identified variables for which geographical layers exist. The coefficients of the probit estimation are then used to extrapolate the adoption for the whole area. Values of the resulting maps range between 0 and 1 and can be interpreted as willingness to adopt, and is therefore referred to as willingness of adoption layer. Finally, the bio-physical suitability layer and the willingness of adoption layer can be aggregated with equal weight, into a single practice feasibility layer. This layer suggests not only locations where a practice is suitable but also the intensity of adoption given the socio-economic and institutional context. Step 2 aggregates the single rainwater management practice maps into a rainwater management strategy at the landscape scale by overlaying the three feasibility maps with a landscape delineation layer (or watershed map). Zonal statistics allows computing any more detailed statistics from the geographic overlay in each landscape: the total suitable area for each practice, the average

adoption rate on suitable area for each practice, the average number of potential adopters (computed by multiplying adoption rate and population density). The maps resulting from this framework show to what extend contexts are different in the watersheds; therefore what has worked in one location might not work in another one. These maps are a starting point for a dialogue with communities to improve water management. Community involvement is crucial for three main reasons. Firstly the uncertainty linked to the maps: it is a way to validate the map based on local knowledge. Secondly, some strategies might not be incentive-compatible: one farmer might not adopt a practice because he would encounter a short term loss, which is the case with the orchard for example. Involving communities in a participative way, will lead to find innovative benefit-sharing mechanisms from which the community as a whole can benefit. Thirdly, some strategies might not be implemented, because the area is missing a crucial element that could not be mapped and therefore not included in the modeling approach. These elements, like a missing access to a specific input market or lack of knowledge, are beyond farmers' decision making and generally require some intervention from other stakeholders, such as governments or NGOs. Involving the community will allow to identify these necessary interventions. Finally these maps can be fed into hydrological models such as SWAT or WEAP allowing the assessment of hydrological impacts within the whole basin while taking the socio-economic and institutional context into account.

Step-By-Step to Good Local Water Governance and Multiple-Use Water Services for Food Security – Reflections from far Western Nepal

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Keywords: Nepal, multiple-use water services, governance, community management, food security

Introduction and problem identification

The Mid and Far Western regions of Nepal are characterized by extreme poverty, remoteness, rugged terrain and difficult access, food insecurity and water scarcity. Mid and Far Western regions were also the hot spot of the decade-long internal armed conflict, which cut these regions out from the mainstream development. The post-conflict legacy can still be felt. In these poverty stricken rural areas it is essential to broaden the scope across conventional sectoral objectives and approaches to address the roots of poverty and food insecurity more profoundly. By addressing livelihoods through water resources management the community's well being, capacity, willingness and ability to maintain water infrastructure are increased, leading to sustainable and efficient use of the available water resources. This paper describes the tools and lessons learned in the Rural Village Water Resources Management Project (RVWRMP) in Mid and Far Western Nepal.

Analysis, results and implications for policy and/or research

RVWRMP works in ten districts and 53 Village Development Committees (VDCs). The VDC is the lowest administrative unit in Nepal, often representing sub-watersheds. RVWRMP is fully embedded into the local governance structure. RVWRMP technical menu of options includes sanitation, drinking water, community-based irrigation, micro-hydro power, improved water mills, environmental works, sustainable livelihoods and institutional capacity building, including multi-purpose cooperatives.

Seeking synergies across sectors, RVWRMP has signed Memoranda of Understanding at central level with a broad range of government departments and donors active in the region. This has provided further opportunities to address food security, sustainability and local resilience to climatic changes. Since 2007, 49 Water Resources Management Committees and 685 Water Users Committees have been established, registered and trained. As a result, 49 VDC-wide Water Use Master Plans have been prepared and 444 individual schemes benefiting 274,203 people have been completed. Another 220 individual schemes are under various stages of implementation as of February 2012. The following tools are used in RVWRMP to enable sound decisions and implementation of related community-based applications leading to sustainable and efficient investments in institutions, infrastructure and information:

1)Water Use Master Plans;
2) Step-By-Step Approach to community management and capacity building; and
3) Community-based Multiple Use Water Services for increased food security.

Water Use Master Plans translate the principles of the Integrated Water Resources Management (IWRM) into practice at local level. Local institutions have the key role to play in both preparation

and implementation. WUMPs are prepared to identify available potential water resources, present structures and existing plans, and to establish a five year vision. The WUMP serves VDCs in prioritizing, planning and budgeting. VDC-level Water Resources Management Committees with their representatives from each sub-committee ensure inclusion and holistic integrated planning. Over the past year they have also adapted the role of VDC WASH Committee as defined in the Nepal National Sanitation Master Plan. This integrates also sanitation and hygiene into the overall water resources planning context. The individual schemes identified in WUMPs are then included into regular local government work plans and budgets. Increasing access to information is inherently built into WUMP which is all about making information available for local decision making.

A Step-By-Step Approach guides multiple stakeholders through the planning, implementation and post-construction support phases. It translates the multi-layered complex principles of good local water governance and IWRM into do-able real steps backed up by capacity building. The very first phase is WUMP preparation. As the individual scheme is taken up for implementation, a Water Users Committee is established and registered. The District Development Committees approve the annual plans and individual schemes, and release the investment funds to Water Users Committees through District Water Resources Development Funds. The Step-by-Step approach facilitates the information management at the scheme level through Community Mapping, public hearings and public audits, bringing the principles of good governance into action. Both Step-By-Step and WUMP process are supported by the Gender Equality and Social Inclusion Strategy. The Community-based Multiple Use Water Services (MUS) approach is a participatory approach that pays attention to the multiple domestic and productive uses of water. MUS are of high priority in RVWRMP. The MUS paradigm is embedded into IWRM thinking, operationalizing the principles through multiple local applications. It is also about service delivery at the local level, building on the principles of good water governance and community management. Whilst all these add to benefits and potential sustainability of the system and its services, the overall complexity and costs are also increased.

Towards Universal Access to Drinking Water Service in Mexico: A Demographic Approach

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Keywords: overweight emergency, access to drinking water, micro watershed, right to food, prospective

Introduction and problem identification

While the overweight and obesity emergency that Mexico faces could have been avoided by properly implemented policies on agricultural, educational as well as commercial matters, with a health concerned focus related to diet, a sectorial effort to achieve universal access to drinking water in the country is an essential part of a national strategy that may deal with that emergency at the time it may be addressed on reaching the right to food.

Analysis, results and implications for policy and/or research

Food poverty rates in Mexico and their degree of inequity have remained fairly constant since 1992, in proportion. Specifically, indigenous people, women and elders are the most vulnerable groups identified at official reports. One factor that feeds on inequity is the high level of inhabitantsÂ´ dispersion: one fifth of whole population lives in communities from 1 to 2,500 inhabitants, and another 15% lives in communities from 2,500 to 15,000 inhabitants. Most of these communities are located in rough and mountainous land. This problem, coupled with an increasingly generalized situation of overweight and obesity -70% of adults are overweight or obese- have led the authorities to address the issue of chronic non-communicable diseases as a public health priority; to be more precise, a food health one. Just in 2008, type B diabetes, cancers, and cardiovascular diseases whose sources are overweight and obesity cost Mexico -in medical care- 0.3 per cent of the national GDP.

Therefore, to achieve universal access to drinking water service has become one of the lines of action of great relevance to reach food security in Mexico. An analysis of the evolution of drinking water coverage in the country over the past two decades, and a micro-watersheds account system (estimating costs at present value to reduce the historic backwardness) allowed a prospective study for calculating the time it would take for the universal coverage of the service to be achieved.

Considering the current coverage and the population growth, it is calculated that investments of nearly 0.1 of current government annual incomes are required in order to close the gap to reach universal access to drinking water as well as to achieve universal coverage of sanitation services in twenty years from now. These investments should be directed towards the extension of networks in urban and rural areas, rainwater harvesting and the implementation of low-cost technologies for the collection and treatment of wastewater in rural areas. But also, reaching universal access to both water services will require the implementation of the following structural initiatives:
I) Giving a more relevant responsibility to state governments as regards drinking water and sanitation;
II) Promoting the systematic certification of management and technical staff of drinking water and sanitation utilities;

III) Promoting tariffs that obey technical criteria and are not used for political purposes, and
IV) Strengthening the capacities and attributions of the federal authority and its state (regional) commissions to promote, supervise, and regulate drinking water and sanitation services.

Creating Shared Value – Testing a Model of Corporate Value Creation through a Water Lens to Address Water and Agriculture

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Keywords: creating shared value, water partnerships, water stewardship, water, food

Introduction and problem identification

Within the business and academic community, the notion of 'Creating shared value' (CSV) has been recently put forward as a new paradigm in corporate behavior and strategy. While this idea is theoretically an advancement on corporate social responsibility (CSR), it is largely an un-tested view.

Of particular interest is whether or not shared value creation could satisfy social needs and values of resources (water and food) in ways that allow business to leverage/manage near and long term value.

Analysis, results and implications for policy and/or research

In this paper we look into the framework of CSV and position current corporate debates and actions with regard to water and agriculture. Specifically we suggest that since the concept of CSV is an attempt to reshape the perceptions of the private sector, it may be insufficient to deal with the social and environmental values apportioned to water and food security. We argue that a stewardship lens would be more sufficient given the risks inherent in sharing water resources in many parts of the world and the limited utility of resource efficiency in the face of challenging management of water for agriculture, economic development, environment and society.

Constraints and Missed Opportunities: A Review of IFAD's Investments in Participatory Irrigation Management

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Keywords: participatory irrigation management, WUA, IFAD, impact assessment, Asia

Introduction and problem identification

IFAD's investments in agricultural water management promote the formation of Water User Associations (WUAs) and the devolution of management authority and associated costs for irrigations systems, to these beneficiary-led groups. In this way, IFAD's institutional investments in irrigation conform to a broader policy strategy termed Irrigation Management Transfer (IMT) or Participatory Irrigation Management (PIM) which has been adopted in more than 60 countries around the world (FAO, 2007).Through the systematic review of 24 IFAD-funded PIM interventions we investigate the actual potential and effectiveness of PIM in terms of strengthening livelihood systems of the rural poor, improving food security and promoting equitable access to water resources. We provide an in-depth analysis of WUA performance and highlight alternative points of entry to improve irrigation management for water and food security.

Analysis, results and implications for policy and/or research

This study examines the experience of 24 IFAD-funded PIM interventions. In doing so, it makes several important contributions. First, we develop and apply a methodology for classifying PIM interventions based on their impact on the performance of irrigated agriculture. We show how the outcomes of IFAD's PIM interventions are highly variable across technical, social, economic and agricultural indicators. We also argue that the impacts of PIM cannot be easily isolated and often reflect complex interactions and overlap between different project interventions, such as systems rehabilitation, marketing, extension and micro-finance. Our study then identifies conditions that shape the effectiveness of WUA. We find that the source of their success often has little to do with design (which is pretty generic). Rather, in these community irrigation schemes, WUAs are transformed by their relationships with, and vis-a-vis other actors involved in organizing water management, particularly traditional water operators, village level CBOs and the irrigation agency.

We also find the likelihood of WUA success increases when farming systems benefit from greater policy and institutional changes, such as those funded by IFAD, relating to land reform, market access, and other support services which help farmers increase their crop productivity and consequently their ability to absorb the costs and responsibilities of management. Finally, our analysis of IFAD's project budgets suggests WUA performance is best where software (institutional development and training) investments are about 35-40% of total project expenditure. This could be an optimum average (good balance) for IFAD's future investments. Third, through field observations from five project sites in Sri Lanka, Cambodia, Philippines, Nepal and Bangladesh, this study sheds light on how IFAD's PIM investments have played out on the ground.

In particular, we draw on these case studies to investigate the relationship between donor policy and the actual field practices of WUAs. We first show how the WUA model is at odds with farmers' actual management practices. We then illustrate how WUAs alone fail to respond to the some of the core management challenges faced by water users with particular reference to issues of inequitable water distribution. Finally we show how WUAs ignore many other institutions involved in managing water use in agriculture - traditional actors, informal O&M mechanisms and broader social institutions. Our results confirm arguments made by Srivastava and Brewer, namely that in farming systems characterized by individual pumps, diversified livelihoods and marginally profitable irrigated agriculture, it may not be worthwhile for farmers to invest heavily in management associations (1994:15). In such contexts, it is necessary to look at a much broader set of possibilities for irrigation management organization and draw on the strengths and inter-connections of existing governance systems to manage irrigation. In this way our field observations contribute to a broader critique of IFAD's focus on a single institutional solution - as an inadequate response to the complexity and multi-dimensionality of water management problems in the sector. Finally, we illustrate how an appreciation of WUAs actual functioning and roles may provide new entry points for irrigation reform initiatives and show how farmers' have the ability to create alternative paths to enhance their development needs, beyond single-policy solutions. We argue that future intervention could produce big impacts, in terms of livelihoods, equity and food security by supporting farmers' adaptations in the context of unequal distribution and water scarcity. Our work indicates that farmers respond to the problem of unequal water distribution by altering their cropping patterns, crop selection, or using tube wells for groundwater pumping rather than engaging in systems maintenance. Efforts to improve irrigation management practices for food and water security could focus on facilitating farmers' ability to define these alternative paths.

Multiple Use Water Services for Food Security and Health: Lessons Learnt by the MUS Group

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Keywords: food security, health, participatory governance, blue water, multiple uses

Introduction and problem identification

In spite of the global emphasis on integrated water resource management, the mandates of public water services sub-sectors remain focused on one use, and often one source. Many international donor and financing agencies, national governments and NGOs continue to measure their performance in terms of improvements in the single dimension of wellbeing related to their single-use mandates, so either health, or food security, or crops for income, or economic growth. This is far from the realities on the ground, in particular in peri-urban and rural settings where people depend in many ways upon multiple water sources for multiple uses. Whether planned or not, people gain resilience to rainfall variability by using and re-using multiple conjunctive sources for multiple uses through cost-effective multi-purpose infrastructure. The water sub-sectors miss the opportunities of these age-old practices because of persistent sector-based upward accountability.

Analysis, results and implications for policy and/or research

Since the early 2000s, the new approach of Multiple Use Water Services (MUS) has emerged to overcome these institutional barriers. Shifting accountability downward, MUS takes people's multiple water needs as the starting point of planning and providing water services. Various organizations have piloted MUS. The global MUS Group synthesized lessons learnt on 'how to do MUS' in guidelines. Economic analysis led by Winrock International corroborated that MUS is a more cost-effective way of achieving food security, health, nutrition, women's empowerment and income than conventional single use water services. In innovating MUS, each sub-sector has its own entry point to meet the sub-sector's conventional mandate and more. Four MUS modalities have emerged by now: domestic-plus, irrigation-plus, self-supply and community-based MUS. Scaling pathways of these modalities leverage the ongoing investments of the sub-sectors. This raises two questions, as asked by Rockefeller Foundation. How robust are the MUS modalities by now? What are promising scaling pathways? This presentation provides the answers. The WASH sector applies MUS by adopting a 'domestic-plus' approach. This robust modality implies the increase of service levels to deliver more water near to or at homesteads for domestic and productive uses. Three to five liters per person per day should be safe for drinking. Scaling of domestic-plus has started in few projects that formally aim to improve health, sanitation, and food security. With the income earned, the ability to pay for the water supplies will increase. In the irrigation sector, FAO has developed a robust 'irrigation-plus' approach in the Mapping Services and Systems for Multiple Uses (MASSMUS) methodology. Instead of the conventional priority for crops in fields, MASSMUS considers add-ons to infrastructure, multiple uses of recharged groundwater, and municipal water needs. MASSMUS has been applied in large-scale irrigation schemes in China, India and Vietnam.

Barriers to both the domestic- and irrigation-plus approaches are the extra costs of participatory planning and multi-purpose infrastructure than under the conventional mandates. Reaching the poorest also remains a concern. The expected improvements in sustainability can only be assessed after larger-scale implementation.

A third MUS modality is self-supply. When people privately invest in wells, household tanks, lifting devices such as the rope pumps or motor pumps, or point of use treatment, each technology or their combination meets their multiple needs. Scaling of this robust MUS modality takes place by stimulating the recent support to self-supply by both the irrigation sector and WASH sector. Technology development and dissemination for the poorest and women are particularly important.

Lastly, community-based MUS puts communities in the driver's seat of participatory planning of construction and rehabilitation of water storage, conveyance and conservation, typically for multiple uses from multiple sources. Remarkably, this modality has already reached massive scales outside the water sector. For example, India's Mahatma Gandhi National Rural Employment Guarantee Scheme channels untied funding through local government to over 50 million households for 100 days guaranteed labor per year. Communities and local government decide on the allocation of these public resources. Water and drought proofing works for multiple uses appeared most popular. In other community-driven development programs, people also prefer water projects. While scale has already been reached, it is still a question how robust and inclusive community-based MUS is, and how water professionals' more integrated technical and institutional support can strengthen it. At the spatial scales of irrigation-plus and community-based MUS, water services and water resources management cannot be separated. MUS realizes the potential benefits of provisioning ecosystem services by adding infrastructure to the equation. Ecosystems' resilience and multi-functionality are recognized by combining multiple sources. Similarly, MUS is 'local-level, service- and livelihood-oriented IWRM', as reported in the last three World Water Forums. Communities' bottom-up integrated management, which his often informal, and their formal representation in local government complement IWRM's current top-down basin institutions and legal frameworks. In water allocation, MUS moves beyond a-political monolithic sectors. By focusing on people, each with multiple water needs, MUS gives voice to the poor to negotiate their equitable share in water resources. In this way, MUS is the most effective way of using water to contribute to all MDGs and to the human right to drinking water and the human right to food security, livelihood, and participation.

Water Management in a Globalized World: The Case of Soybean, Corn and Wheat Production in Argentina

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Keywords: virtual water, water footprint, soybean, Argentina, food security

Introduction and problem identification

The water footprint (WF) and virtual water trade (VWT) are used to describe the relationship between water management, international trade, sector policies and resource use as part of human consumption. The global VW flows related to international trade amount to 1,625km^3/year, equivalent to 40% of total global water consumption. 80% of total VW flow is for agricultural products trade, and 20% for industrial products trade (UNESCO, 2009). Argentina is a main VW exporter (Chapagain and Hoekstra, 2004) especially through soybean, corn and wheat (Aldaya et al., 2010), exporting about 50.6km^3 and importing 5.6km^3/year. In Argentina the agricultural frontier expansion has grown steadily, but now structural and technological innovations are being developed to allow more intensive agriculture. This is closely related to water use and consumption, and its environmental impact (Viglizzo et al., 2010). Argentina is a green water-abundant nation, so land and water management is the key issue.

Analysis, results and implications for policy and/or research

Food security is strengthened by optimizing major food items productions, which includes agricultural water use analysis in an international trade context. This could lead to a better water governance. Use of water resources is spatially disconnected from consumers. Revealing the link between consumption and water use can provide a basis for the formulation of new policies and strategies in water governance. The WF is a multidimensional indicator that shows amount and type of water used. It shows the resource appropriation through products and is the basis of analysis of possible uses, like production of food for humanity. Thus, WF involves final consumers, retailers, suppliers and food industry and traders in the study and acquisition of commitments related to an adequate and responsible water management. Nations development depends on freshwater both for production processes and to satisfy basic needs, including food supply. Use and consumption of water should be done in a sustainable manner. This can be achieved through the application of management tools such as the use of indicators in market and state policies. In recent years several studies have highlighted the importance of virtual water trade in redistributing water resources and achieving water and food security at a global level Blue water is the freshwater accumulated in surface and groundwater systems (e.g. rivers, lakes and aquifers) and green water comes from precipitation and is stored in the soil (Falkenmark, 2003). This distinction is important since they generally have different characteristics in terms of opportunity cost and environmental and hydrological impact, as well as different policies to manage each of them. Further research highlights the strategic importance of green water in international grain trade (Aldaya et al., 2010). This document includes trade analysis in soybean, corn and wheat from Argentina. The estimation of indicators has been performed using global data from FAO, during 2000-2004. The present study aims to improve previous estimations with more accurate local data and estimations.

First, it replicated the work of Aldaya et al. (2010) considering the same provinces (their production accounts for more than 90% of the country) and time period, using global data of FAO (CLIMWAT and CROPWAT) and agricultural data from the Ministry of Agriculture, Livestock and Fisheries. Then it was performed including all the provinces that produce soybean, corn and wheat, and taking into account weather stations representative of cultivated areas. The analysis outcomes are shown in the following table, in comparison with the study of Aldaya (Original). VW (m^3/ton) VW export (km^3) soybean corn wheat soybean corn wheat
Original 1321 595 725 9.86 6.41 6.82
Replication 1775 966 770 11.72 10.34 7.17
Provinces 1889 1185 1071 12.47 12.69 9.98

The original and replication analysis show different volumes, especially in the corn case. This may be due to differences on the data used. In some cases the reference data lead to slight variations, such as planting date or length of crop stages, it is possible that maize has emphasized this effect because it is very sensitive to water stress and environmental conditions, which may change greatly from month to month, and affect the plant differently at each stage of development. When considering all provinces, the results show a clear increase, showing a higher water demand, especially in the case of corn and wheat. The VW export also increases considerably. In this scenario, it is necessary to adjust the sowing periods to each latitude, because Argentina is a vast country that covers planting areas in latitudes from 24° north to 38° in the southernmost part. Thus, deep analysis about the water consumption in less productive provinces and planting and harvest periods are needed. Finally, it is remarkable that the blue VWT values are negligible, reinforcing the result of Aldaya et al. (2010), which highlights the importance of green water in Argentine products. For the time being and almost in the entire world, WF analysis has focused on hydrological aspects. There is a growing need to integrate nature conservation, social equity and economic growth into the process of decision making. The WF combined with other socio-economic and environmental methods (e.g. land footprint, carbon footprint, economic analysis) can be a useful tool providing a transparent and multidisciplinary framework for informing and optimizing water policy decisions and the needs of economic sectors and healthy ecosystems. The green and blue water consumption estimation nationwide and the determination of the VW trade of crops estimated at different spatial and temporal scales provides additional data as an input for the policy decisions. Furthermore, the results put Argentina as a relevant player in the international VWT and in the global water and food security puzzle.

Workshop: Rainfed Production Under Growing Rain Variability: Closing the Yield Gap

Rainwater Management Transforms Africa Towards Food Security and Resilience

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Keywords: rainwater, africa, platforms, strategies, institutions

Introduction and problem identification

Water scarcity and land resources degradation are two major drivers affecting the livelihoods of most African communities, and exposing them to recurrent food insecurity and poverty. As most of the African continent is drought-prone, the capacity of the rural communities to respond to climatic and market shocks is low, and effects of climate change may exacerbate water scarcity, there is an urgent need to develop a strategy to adapt to these changes. One of the most important strategies to reverse the downward spiral towards poverty is managing the surface and rainwater using improved land and water management practices. Moreover, high and growing population density and increased encroaching of communities to forest lands, wetlands and water towers has been increasing the sediment load, depleting the nutrient status of production systems and affecting downstream investments, including irrigation schemes, hydropower dams, roads and other infrastructure in the continent.

Analysis, results and implications for policy and/or research

Rainwater management (RWM) is an integrated development strategy that enables actors to systematically map, capture, store and efficiently use runoff and surface water emerging from farms and watershed in a sustainable way for both agricultural and domestic purposes. Integrated rainwater management aims to decrease unproductive water losses (runoff, evaporation, conveyance losses, deep percolation) from a system, as well as increasing the water use efficiency of respective enterprises, and increasing returns per unit of investment (Amede et al. 2011). Unlike conventional approaches, it focuses more on the institutions and policies than on the technologies; it capitalizes on rainwater harvesting principles but also advocates for water storage and water productivity at various scales; in the soils, farms, landscapes, reservoirs and other facilities. It is also an effective strategy to manage the consequences of climate change (e.g. floods and drought) by combining water management with land and vegetation management at landscape scales. It could satisfy water demands during dry spells and create opportunities for multiple use, captures and stores water in the rhizosphere, encompassing in situ water management strategies. This is particularly critical for SSA, where about 70% of the land falls within arid, semi-arid zones. We will display rainwater managment strategies emerged from cross landscape learning of three sub-basins on the following areas:

1) Present selected appropriate technological suits for Rainwater management from the Nile basin and Identify key research gaps;
2) Share experinces on national innovation platforms in improving managment and policy on RWM; particulaly in identifying critical policy and institutional gaps for consolidated action;
3) Share local communication strategies for capturing, distilling and communicating key lessons, facilitating information flows, and linkages among sector actors and enable learning across the various scales.

Household Relations and Rainwater Harvesting: Matching Innovations to the Context and Capacities of Resource-Poor Farmers in Sub-Saharan Africa

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Keywords: rainwater harvesting, gender, sustainable livelihoods, household, Burkina Faso

Introduction and problem identification

In most areas of sub-Saharan Africa rainfall constrains the production of rainfed agriculture and so water management techniques such as rainwater harvesting (RWH) hold underexploited potential to increase water use efficiency and crop productivity. However, despite the widely claimed potential of RWH, current evidence indicates that on the whole predicted improvements in agricultural production and reductions in levels of poverty across sub-Saharan Africa as a result of RWH use have not been achieved. Current RWH literature overlooks the socio-economic context within which these technologies must fit and fundamental factors that contribute to the success or failure of a scheme, such as livelihood strategies, farming practice and institutional dimensions at the household level, are addressed inadequately. RWH techniques need to be developed and modified to properly match the context within which they are placed.

Analysis, results and implications for policy and/or research

The main aim of this research is to improve understanding of the use of rainwater harvesting for increasing crop productivity in rainfed agriculture and uncover some of the reasons for the lack of productivity increases experienced. The conditions under which rainwater harvesting contributes to increased productivity and/or reduced risk at the household level are identified and the institutional issues that influence the adoption and sustained use of rainwater harvesting in Burkina Faso are explored. By determining if the technology fits farmers' livelihood strategies, resources and constraints, and identifying the key technical and environmental factors that influence the adoption and use of RWH technologies by farmers, potential improvements in the implementation of the technology to gain maximum benefit are highlighted. This article draws on data collected during the first phase of two extended periods of fieldwork in Burkina Faso. Data collection methods include focus groups, in-depth household level interviews and participant observation conducted in three communities located in central and south-western Burkina Faso. Analysis of the data centres around an in-depth household level livelihoods study, informed by the sustainable rural livelihoods analytical framework (Scoones, 1998), which defines sustainable rural livelihoods in relation to five key indicators: resources, strategies, contextual environment (including policy, climate, demography), institutional and organisational structures and processes, and outcomes). This approach is multi-dimensional, complex and involves key concepts of risk and uncertainty. Preliminary findings indicate that RWH can provide a meaningful contribution to increasing water productivity and minimising water and soil losses, enabling farmers to adapt to increasingly stochastic rainfall. However, results show that gender and age relations at both the household and community level are an important consideration in assessing the contribution that RWH technologies can make.

Gender and age both affect access to inputs, such as land and labour, defined by both formal and informal institutions, which has a significant impact on farming outputs in Burkina Faso; this has important implications for the distribution of social costs and benefits of rainwater harvesting. The findings imply that in order to improve RWH and other soil and water management innovations in the future, approaches need to be considered in the context of household characteristics and household level approaches to livelihood strategies and risk reduction. The results presented in this paper provide the basis for a second phase of fieldwork and will assist in the future formulation of a draft diagnostic socio-technical framework for agricultural RWH that will provide guidance on how critical contextual issues for any specific intervention site can be identified and their relative importance with respect to RWH adoption and use assessed. Broader recognition and incorporation of these factors into implementation frameworks, might usefully ensure that the technology is only advocated where conditions are appropriate at the household level.

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Improved Food Security through Rainwater Harvesting-Driven Irrigation

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Keywords: food security, rainwater harvest, drip irrigation, poverty reduction, nutrition

Introduction and problem identification

Food security is achieved by a household having access at all times to enough food to enable them have an active and healthy life. In order for a family to attain food security, it has to work towards achieving the following; it has to ensure that it has a safe and nutritionally adequate food supply at the national and household level; a reasonable degree of food supply stability from one year to another and finally each household should have physical, social and economic access to enough food to meet its needs (Ngigi et al 2003).Uganda receives a bi-annual rainfall pattern one from March to May and the other from October to December.

Analysis, results and implications for policy and/or research

Uganda Rain Water Association carried out a study visit to some districts in Uganda i.e Sembabule, Karamoja region, Ntungamo, Isingiro and Apac to document Rainwater harvesting practices for production and environment conservation. On the tour it was discovered that small holder farmers in semi arid regions had to depend on changeable unreliable and low rainfall for their livelihoods.

Survival food crops are generally grown under rain-fed conditions. Consequently there was a growing concern in complementing this risky rain-fed food production with all year round cultivation of other income generating foods like fruits and vegetables than depending only on rain fed agriculture. As a result, URWA decided to plan an intervention strategy for irrigation in order to ensure an economic return if there is production all year round. URWA intends to build the capacity of farmer groups and masons in construction of Rainwater harvesting systems to enable them make use of the technologies and to benefit from irrigation. This will help to reduce poverty, and increase food security. URWA hopes that with the development of low cost irrigation techniques, there will be the enhancement of water use efficiency, the sustainability of water resource utilization, the increase of agricultural production and farm income hence, the empowerment of community members.

Irrigation systems are convenient since people don't have to spend time watering by hand or moving the hose around the yard. An irrigation system protects peoples' landscape investment, and is environmentally friendly. To learn more about irrigation, URWA organized a field visit for staff to an agency (AGROMAX U) already practicing irrigation to learn about irrigation practices and emphasize rainwater harvesting for production in local communities. The visit was aimed at drawing lessons from their practices on irrigation on small scale and large scale and forge ways of how the knowledge acquired could be used by URWA to accelerate rainwater harvesting for production and environment conservation. In the future, URWA plans to train the artisans in the communities and staff members for future implementation and use this technology to boost agriculture in Uganda. Community members will be taken to for an exposure visit to other communities promoting rainwater harvesting to learn from their experiences and promote the utilization of rainwater for agricultural productivity. URWA through its initiative of Domestic Rainwater Harvest (DRWH) can be helpful in improving the amount of water farmers can have access to especially during the dry spells.

By storing rainwater in rainwater jars, tanks or even underground tanks which normally hold a large capacity, this rain water that is collected can be used for small scale irrigation in the gardens where storage capacity is available. There are a number of challenges that have come with improving rain fed agriculture; many farmers have invested before and have not got a return for their money, this makes them hesitant to invest their capital since losses in yield quantities are quiet common when the farmers only depend on the rain. Sometimes it may rain in such big quantities and is manifested as storms that destroy the crops while in other cases there may be long spells of dry weather which end up also destroying the crop. When farmers are able to manage their water by being provided with means to bridge persistent intra-seasonal dry spells they will be more interested in learning about rain water harvest and including irrigation as part of their investment to improve their agricultural yields. When crops have access to enough water, more money spent on fertility of the soil, crop husbandry and timing of operations will reap good results through improved soil and water productivity. Small scale irrigation has not been widely embraced in Uganda, less than 1 percent of ordinary farmers use irrigation, Commercial farmers use it more since they are growing crops on a large scale and they make up 5 percent and grow crops like rice sugar and flowers. The rest of the farmers depend on rain to grow their crops. There are very few projects in the whole country that have been able to adopt irrigation in order to ensure food security. Irrigation as a whole is not a priority area when it comes to increasing farmers' access to water in Uganda.This can change.Irrigation could work together with the harvested rainwater in households to ensure that they are able to grow crops on a small scale and improve their livelihoods throughout the year. Irrigation is used to meet soil moisture deficit during the dry season. This in addition to growing drought-resistant crops will go a long way in increasing the amount of food a family can access. Forestation is another solution to the long dry spells that Uganda is facing, if farmers are encouraged to grow a tree for each tree they cut, it will help in keeping the soil compact hence avoiding soil erosion.

Securing the Sustainable Rainfed Yield Production in Arid Conditions

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Keywords: rainwater harvesting, food production, microcatchment, trees, rain variability

Introduction and problem identification

The availability of water resources is one of the main factors governing the development of arid regions. Unfortunately, the majority of dry regions do not contain easy-access to water sources, especially higher quality water. This makes intensive irrigated agricultural development impossible and, accordingly, causes food shortages. Rainwater agriculture can be implemented as a sustainable solution for the food crisis in arid and semi-arid environments, as well as a means of preventing desertification. Various types of these techniques have been applied for thousands of years in Mediterranean agriculture and, to a lesser extent, in semi-arid tropical regions. Renewed interest in these techniques has resulted from the need to utilize more fully the available land and water resources.

Analysis, results and implications for policy and/or research

Implementation of successful rainwater harvesting depends on three main components:
1) water collecting;
2) water storing;
3) stored water use.

All three components are being studied at the Mashash experimental runoff harvesting and desert agro-forestry farm of the Ben-Gurion University of Negev (Israel). The aim of the study is the optimization of scarce rainwater resources through managing and providing stable and secure agricultural production in small water harvesting systems - microcatchments. Microcatchment is a technique for collecting, storing and conserving local surface runoff in order to grow trees/shrubs. Microcatchments have relatively small runoff generation areas (from dozens to hundreds sq. m), are cheap, simple and have a good potential for food production under arid climatic conditions.

Microcatchment collection area is usually a small depression located nearby the runoff generating area in which one or a few trees/shrubs may be planted. Due to the short overland flow path, runoff generation is efficient and even short low intensity storms may generate runoff. The drawback is however that due to the small size of the generating area small volumes of water are conveyed to the storage plots. The increase of runoff amount during runoff generation in microcatchments was studied. The runoff generation area of a microcatchment with the area of 120 m^2 was treated, and runoff was collected in a tipping-bucket system. Soil treatments included soil compressing, salt spraying, and natural crust preservation, all treatments in three replicates. None of these approaches provided a runoff coefficient higher than 10% (the best result for the long-term crusted area) with an average runoff coefficient among the replicates of 5-7%. Runoff generation depends not only on the total rainfall amount but also on rainfall intensity.

In conditions of high rainfall variability, when a great number of rain events may be of low intensity showers, most of the water does not reach the water collection area, infiltrates to a shallow depth and is lost to evaporation after the rain. So the agricultural activity at microcatchments becomes too challenging to provide a stable agricultural yield. The second part of the study was an efficiency analysis of the water storage at microcatchments. Usually, various types of natural or human-dug shallow pits are used for water collection and storage at microcatchments. We studied the influence of the microcatchment runoff collecting area's depth on the efficiency of water conservation in the soil profile. Pits of different depths were flooded, followed by monitoring of the soil water content dynamics. The results show that the pit depth has a significant effect on soil water losses through evaporation. No pit depth influence on the water losses from the pit bottom was observed. The differences in water losses from the pits with different depths were mainly caused by the water losses from 'outside' of the pits. The shallow pits lost as much as six times more water than the deep pits. In order to increase the efficiency of water collection and conservation, we built an experimental system that included the following characterisitics:

1) the runoff generation area was mulched with polyethelene sheets and
2) the water collection area was built in two variants,
2.1) as a shallow trench of 20 cm deep and 1m wide with sealed trench walls and Narcissus flowers planted at the trench bottom and an olive tree next to the trench, and
2.2) a deep trench of 1m deep and 1m wide with olive trees planted inside. In both cases, we got at least a 10-fold runoff amount increase when even very low intensity rain created runoff over the polyethelene mulching. In the 2.1 case, water infiltrated only through the pit bottom to the deeper layer, and evaporation was better prevented. The main idea of planting flowers was to show the possibility of growing additional plants along with trees or shrubs in microcatchments. Flowers may easily be replaced by other plants suitable for the specific region. Since flower roots take water from a very shallow depth and don't compete with the tree root system, such an approach could be considered beneficial. In addition, flowers naturally destroy the crust at the pit bottom during the flower bursting, create natural organic mulching and enrich the soil with organic material inside the trench after the flowers die. Monitoring five years after the system's implementation showed the succes of the system, both in runoff accumulation and in plant growth. In the 2.2 case, water infiltrated through the bottom and the walls, but evaporation was minimal because of the system depth. The microcathment has supplied enough runoff for excellent tree growth. The study shows that microcatchments may provide stable yields, when managed efficiently, water wise.

Integrated Rainwater Water Harvesting Scheme: A Strategy to Turn Challenges into Opportunities in the Upland Areas of the Philippines

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Keywords: food basket, rainfed, rainwater harvesting, seasonal aridity, uplands

Introduction and problem identification

In a tropical country setting such as in the Philippines, there is the persisting problem of rainfall being "too much or too little"on a seasonal basis. With climate change, the dry season of March-April- May will become drier that may intensify the so-called "seasonal aridity". On the other hand, the wet season of Jun-Aug and Sep-Nov will become wetter that may result to uncontrolled surface run-off, soil erosion and flooding of low lying areas. The situation is further aggravated by continuous degradation of our once-healthy and bio-diverse watersheds. Indeed, there are a lot of challenges in the uplands. Now, that the upland areas are considered as potential food baskets, necessary interventions are very crucial to maintain their productivity and protect their important resources. Turning current and future environmental challenges into opportunities is a key toward increased agricultural productivity and environmental sustainability.

Analysis, results and implications for policy and/or research

The Philippines receives an average annual rainfall of 2,400 mm which is adequate to meet the annual water demand for crop production. However, rainfall is not evenly distributed throughout the year in most parts of the country. With climate change, aside from risks brought by extreme events, there will be uncertainties in rainfall occurrence such that our reference for planning purposes should be according to the projected changes. The rainfed upland areas with marginal soil and water resources will be the hardest hit which may result to further increase in yield disparity between rainfed and irrigated crop production system. This scenario calls for an integrated approach that will collect, store, and manage rainwater through rainwater harvesting, water use optimization through the formulation of appropriate cropping pattern and calendar, on-farm water management through a more controlled water application in the point of use, and watershed management. An integrated approach on rainwater harvesting is important because rainwater harvesting is more than providing irrigation to upland crops. The project facilitates multiple uses of stored rainwater as it a) provides water for supplemental irrigation, domestic purposes, and livestock production in critical and less accessible upland areas; b) serves as strategic small-scale upland structure for flood prevention and control in high rainfall areas; c) enhances and facilitates recharging of groundwater and spring sources for domestic and other uses; and d) provides value-adding activities and environmental impacts such as recreation, and development of habitat for wildlife and biodiversity, respectively.

With structural height of 5-15 meters and average storage capacity of 0.30 million cubic meters, rainwater harvesting (i.e. also known as small water impounding projects or SWIP) in the Philippines are being implemented by the Department of Agriculture through its regional field units and the Bureau of Soils and Water Management (BSWM).

As of December 2009, 436 units have been implemented providing supplemental irrigation to about 26,400 hectares and benefiting 17,600 farmers in the upland areas. The peak of its implementation was achieved in 1997-1998, when SWIP was considered as one of the major interventions to mitigate the impacts of a severe El Niño that hit the country during the period. Previous studies on SWIP conducted by several researchers (e.g. Monsalud et.al., 2003) identified the benefits at various levels that can be derived from SWIP. At the farm level, these include a) increased cropping intensity and yield per unit area; b) facilitated the growing of crops (e.g. vegetables, onion, garlic, tomato) other than rice; c) integration of fish production and livestock raising; and d) utilization of water in the reservoir for other purposes (e.g. domestic and recreational purposes).

At the community level, benefits generated include a) local food security through availability of fish and farm produce; b) increased labor demand; and c) facilitated the construction of better roads and other community facilities. Rainwater harvesting has been introduced and promoted long time ago and it is slowly gaining momentum as the formulation of a national policy on rainwater harvesting begins to move.

There is already an on-going deliberation of a bill in Congress that intends to promote soil and water conservation technologies and approaches for sustainable land management in the Philippines. In order to ensure project sustainability, we are proposing the following future directions of rainwater harvesting development a) establishment of cluster of smaller scale rainwater harvesting facilities in high impact areas such as watersheds; b) pursue more R and D efforts, particularly on water management, water quality protection, and cropping pattern and calendar adjustment to address the changing rainfall pattern; c) integration of other viable farming enterprises for increased farm productivity and income; d) strengthen community participation in the project implementation; and
e) engage in watershed protection and management to prolong the life of rainwater harvesting facilities. While "too much" rainfall is viewed as agent of soil erosion and flooding, on a positive note, this could be transformed into a more productive resource for upland agriculture through a well-planned rainwater harvesting scheme.

Evolution of Agricultural Water Management in Smallholder Crop-Livestock Systems of the Volta Basin

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Keywords: agricultural water management, crop-livestock systems, evolution of technologies, research and development proje, Volta Basin

Introduction and problem identification

Agricultural water management (AWM) technologies have been extensively studied and promoted in the Volta Basin during the last four decades. However, economic and physical water scarcity still limits agricultural production of most smallholder crop-livestock farms of the basin. The objective of this paper is to synthesize existing knowledge, interventions, lessons, and identify possible gaps in knowledge regarding rainwater management in the Volta basin. The questions addressed include (i) who did what, how, where, with which results and why, (ii) what are the lessons learned for longer term development efforts and interventions and (iii) what are the knowledge gaps, with focus on the Volta Basin.

Analysis, results and implications for policy and/or research

Key resource informants were interviewed and more than 250 peer-reviewed research papers and grey literature were studied, from 1970 up till now. In response to demographic pressure, environmental degradation, priorities of development actors and needs of smallholder farmers, AWM technologies and development interventions have evolved with time, along with the concepts related to them. First linked to erosion control in the 1960, AWM technologies were promoted for cash crop production in large scale state projects relying principally on technology transfer. Following the repeated droughts of the 1970s and the related food shortages, the focus moved to staple crop production and promotion of soil and water conservation technologies through large scale projects. Interventions were dominated by top-down approaches, with largely external expertise with "silver bullet" solutions in 2 or 3-years projects, lacking consideration for farmers' preferences, traditions and indigenous knowledge. When the second wave of droughts struck the basin in the 1980s, the smallholders were once again severely affected by loss of yields and income. Learning from these failures, researchers and developers started to think in terms of participatory approach and gave increasing importance to indigenous knowledge. Traditional technologies were improved and new technologies were tailored for smallholder needs in the various agroecological zones of the basin. Researchers started to investigate farmers' perceptions, adoption drivers and local institutions.

Paradigms on soil and land resources developed from "sustainable land management" to "land husbandry" which explicitly include the socio-economic context. To address all these complex facets research-for-development projects became multidisciplinary and multi-stakeholder oriented. Between 1970 and 2009, 195 bilateral and multilateral AWM projects were implemented in Burkina Faso, corresponding to an investment of 641 million of US$. In Ghana, only 46 projects of this kind were implemented, for a total of 258 million of US$.

While these projects yielded numerous technical solutions, their actual impact on livelihoods is controversial. On the one hand, impressive outcomes are reported: in Burkina Faso, an estimated 200 000 to 300 000 ha were rehabilitated, yielding an extra 80 000 tons of food annually, i.e. enough to feed 500 000 people. On the other hand, the general consensus among researchers and policy makers is that the investments were ineffective and that the environment in fragile areas of the Basin continues to degrade, with destruction of vegetation cover, depletion of soil fertility and intense erosion. Given the quantity of AWM projects implemented and the amount of investments made in the Volta over the past 40 years, the question of the return of aid investments on water availability, food security and livelihoods would be of particular interest. The study of the evolution of AWM in the Volta Basin yielded key recommendations for research-for-development interventions and new concepts for research on water management. When promoting AWM technologies, projects should carefully study the available information on factors triggering adoption, and play on these factors to ensure sustainable uptake of the technology. Local capacities and agendas should be better accounted for when promoting AWM technologies. Participatory management of the infrastructures should be carefully planned, through integration of maintenance costs in project budget, capacity building of actors towards assumption of more responsibility, and ways to deal with turnovers within management committees. Farmers' capacity building is definitely a key asset for enlightened risk management and continuous adaptation to a changing world. Scope for improvement lies in the coordination, collaboration and communication among various institutions and organisms active in the AWM sector. Future research and development projects should concentrate on how to leverage the factors limiting adoption and enhancing system productivity while sustaining healthy ecosystem services.

There is a need for a system perspective, to improve water-crop-livestock interactions, to develop off-season cultivation options and market access, and to balance gender benefits repartition. There is a need for a landscape perspective, to understand ecological landscape processes and trade-offs between ecosystem services derived from and affected by AWM technologies adoption to scale. There is a need for an institutional perspective, to facilitate management of AWM technologies structures and to raise awareness. Finally, there is a need for a long-term perspective, to foresee the best strategies for adaptation to climate change and manage risk to accelerate sustainable development opportunities of the Volta Basin.

Water Requirements for Future Global Food Production, and Potentials of On-Farm Green – Blue Water Management to Increase Crop Production

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Keywords: green water, climate change, food production, water harvesting, water scarcity

Introduction and problem identification

Climate change, population growth and changing diets will put joint pressure on the world's freshwater resources via increased water demand for the production of crop and livestock products. It is an open question whether enough water – blue and green – can be made available to meet the growing food demand, and what the global potential of different blue and green water management options is to alleviate possible water-for-food shortcomings. Models able to simulate crop growth as coupled to terrestrial water cycling can help quantify future water limitations to global agriculture under conditions of changing and more variable climate, and help identify possibilities of increased crop water use efficiency to meet the impending water-for-food challenges.

Analysis, results and implications for policy and/or research

This global-scale model study quantifies how much water is required to produce a balanced diet (3,000 kcal cap - 1 d - 1, assumed to consist of 80% vegetal and 20% animal products). By comparing the requirements with available blue and green water on present agricultural land per country, water scarcity can be determined in more detail compared to previous scarcity indicators. It will be shown how thus defined green – blue water scarcity will change in the future (by 2070-2099) under 17 climate models, rising atmospheric CO_2 concentration, and population growth. Simulations show that while water availability per person will probably diminish in many regions, calorie-specific water requirements often decrease, e.g. due to the effect of rising CO_2 on crop water productivity. They also show that under present nutrient/water management water scarcity will aggravate in many countries, and that a number of countries are at risk of losing their capacity to be food self-sufficient (in terms of the specified diet). But improved on-farm water management can significantly relax this situation: methods to increase crop water use efficiency, such as reductions in unproductive soil evaporation and harvesting of run-off water for use during dry-spells, can increase crop production by up to ca. 20% globally (depending on the extent of implementation in the field). However, adverse effects of climate change cannot be fully buffered by such management, and even if maximum efficiency increases were achieved on present cropland, green-blue water resources will not be sufficient to meet the requirements for producing the specified diet for more than 9 billion people.

Appropriate Soil Water Conservation Practices can Mitigate Abiotic Stress and Promote Pulses in Rice Fallows in India

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Keywords: rice fallow, soil moisture conservation, pulses

Introduction and problem identification

In India, rice fallow ecosystem (11.7 mha) is one of the major rice based systems in rainfed areas. Continuous growing of rice and subsequent fallow resulted mono-cropping effect like imbalance in soil fertility, declining soil organic matter, nutrient sickness in rooting depth, hard pan formation etc.

Rice fallows basically imply to those low land rainy season sown rice areas which remain uncropped during winter due to various reasons such as lack of irrigation, cultivation of long duration varieties of rice, early withdraw of monsoonal rains leading to soil moisture stress at planting time of winter crops, water logging and excessive moisture in November/December. Most of rice fallow areas are found in North-east, Central and Peninsular India. Excessive water or water logging is common in low lands of North-East India and coastal peninsula in October/November, while early withdrawn of rains and soil moisture stress at central India.

Analysis, results and implications for policy and/or research

Productivity and profitability from second crops in rice fallow can be improved with suitable crop management technique even by utilizing residual soil moistureResource conservation technologies (RCT) like zero tillage, residue incorporation, mulching, seed priming, foliar nutrition etc are some of the key practices suitable for pulses in rice fallows. The RCT which deals with soil water conservation, organic matter build-up and improvement in soil structure and microbial population could be an appropriate approach to address the problems. Two basic principles of RCTs viz. no-tillage and retention of crop residue on soil surface are already followed under paira (utera) system of production. Seeds of pulses are broadcast in standing rice field without any tillage. Further, 20-25% crop residue as stubbles are retained in the field. Under other system where pulse is sown after harvest of rice with land preparation, zero till seeding is advocated as it facilitates advance planting by a week, saves energy and labour. If crop residues are retained on the soil surface in combination with suitable planting techniques, it alleviates terminal drought condition in pulses by taking care of soil-water balance and brings overall improvement in resource management. The performance of pulses in rice fallows has been evaluated at Indian Institute of Pulses Research, Kanpur, India through a series of multilocational trials under National Fund Project. Zero tillage with crop residue management is found to reduce soil water evaporation, soil sealing and crusting. Crop residues in combination with zero tillage also increase soil hydraulic conductivity and infiltration by modifying mainly soil structure, proportion of macropores, and aggregate stability. Hydraulic conductivity under straw-retained direct- drilled treatments is 4.1 times greater than that of straw-burnt conventional tillage treatments. The improvement in soil properties due to management practices ultimately has reflected in yield.

Dibbling sowing in zero tillage followed by spreading of mulch had 28% higher chickpea yield (1660 kg/ha) and 72% relative water content over conventional tillage. Sowing with no- till drill in zero tillage + mulching (1589 kg/ha) followed the next best. Higher yield under zero tillage with mulch was primarily due to maintenance of 15% more soil water at flowering. The study revealed that development and promotion of moisture conservation technologies would facilitate growing of pulse crops in hostile environment of rice fallows and will meet the growing demand of pulses in the country

Conservation Agriculture as a Move Towards Improved Household Food Security: Perspectives from Participatory GIS in Insiza district, Zimbabwe

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Keywords: conservation agriculture, participatory GIS, Insiza, food security, yields

Introduction and problem identification

The Insiza district in Zimbabwe is located within the confines of the Limpopo River Basin. This part of the basin is characterised by erratic and low to below average rainfall patterns (450mm per annum).

This has consequently led to recurrent droughts in the area. Furthermore, it has also among other factors contributed to reduced rain fed agriculture productivity; which is the main livelihood strategy and source of food production for the communities. Reduced agriculture productivity has in turn rendered about 63% of the rural households in the district food insecure. Therefore, this prompted the district authorities and Non-Governmental Oganisations to implement agriculture water management technologies aimed at addressing food insecurity in the district. Conservation Agriculture (CA) is one such intervention technology which has been locally adapted to suit the conditions in the district and it has been practiced since 2004.

Analysis, results and implications for policy and/or research

CA is guided by its principles and practices that ensure soil moisture conservation, minimum soil disturbance and minimum resource utilisation. The technology is based on in-field water harvesting using basins which trap water and increase infiltration thereby increasing soil moisture availability even during dry spells. It also includes the application of specified quantities of inputs (manure, seed, fertiliser), use of mulch, setting the recommended basin size and spacing. In addition, the technology can also be practised by those households without draught power as it only requires the use of a hand held hoe to prepare the basins. However, some of its challenges are related the labour and time demands of the technology. Thus this research was aimed at identifying successful cases on agriculture water management technologies in Insiza district so that lessons could be drawn from such cases for replication in other parts of the basin faced with the challenges related to poor rainfall patterns. Data collection was done through Participatory Geographic Information System (PGIS). This approach ensured maximum community participation as it entailed mapping, focussed group discussions and interviews. The approach also allowed for the integration of experiences and knowledge from the stakeholders into GIS. The PGIS was done at two levels in which the first level involved the district stakeholders. At this level 16 participants took part in the PGIS exercise, which was a representation of all the district stakeholders responsible for water and agriculture related development initiatives in the district. The second level was the community meetings which were done in three out of 12 wards that are prone to droughts and vulnerable to food insecurity as identified by the district stakeholders. In total 36 households from the three wards participated in the discussions.

Findings show that C.A has led to a significant improvement of agricultural yields. On average, the communities indicated that they harvest 1.7 to 2 t ha-1of maize from CA compared to conventional farming in which they get average yields of 0.7 t ha-1. CA is being practiced on the plots sizes of between 0.25 and 0.6 ha. The main crops grown under C.A include: maize, beans, groundnuts and sorghum. These increased harvests have enabled the farmers to get enough grain for household consumption that lasts them until the next planting season. Some even have surplus grain for selling and they use the money to meet other household needs like paying school fees and medical costs. As such the technology has also been adopted by other households after realizing the significant increase in yields. Furthermore, the adoption and part of the success of C.A was attributed to the technical (trainings) and material (seed inputs) support given by extension officers and implementing NGOs. Therefore, CA has increased the rain fed crop production in Insiza district, especially during the years when below average rainfall is received and hence improved household food security. This could imply that those areas that are faced with poor rainfall patterns which lead to agricultural droughts and prolonged dry spells in the wet season can resort to such intervention measures to improve rain fed cropping and hence avert food insecurity. This could be particularly so given that predictions indicate the increased frequency of droughts and dry spells in the region.

Exploring Ecosystem Services Contribution to Social-Ecological Resilience in Ethiopian Agricultural Landscapes

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Keywords: ecosystem services, adaptability, poverty, livelihood trajectory, response diversity

Introduction and problem identification

Rural people's livelihoods depend directly upon ecosystem resources and services in many agricultural landscapes in sub-Saharan Africa, in that way they are strongly coupled Socio-Ecological Systems (SES). Reduced supply of ecosystem services constrain several attributes of SES resilience, hence are clear indicators of a system development trajectory towards vulnerable state. In this paper, we apply concepts from SES theory to explore interactions among ecosystem services, livelihoods and resilience of SES. Our approach was to i) examine trends in the stock of bundle of ecosystem services in three study landscapes namely Fogera, Jeldu and Diga within the Blue Nile Basin of Ethiopia, ii) describe the trajectories in livelihood strategies, poverty status and present evidence of success and failure in these SES, and iii) explore linkages between stocks of ecosystem services, livelihood conditions and resilience of the SES.

Analysis, results and implications for policy and/or research

Using historical data enriched by local perceptions, we found that over time, the supply of provisioning services has increased at the expense of other ecosystems services in all three landscapes. The livelihood trajectories in each landscape showed progressive transformations towards intensification and exploitation of increasing land areas and landscape niches. In Fogera, for instance, livelihoods transformed from mainly livestock based (semi-pastoral) systems in the past to crop dominated systems today. Crop production is now contributing more than 90% of annual household income. Simplifications of landscapes and their individual component inter-linkages, exploitation of increasing land areas and increased evidence of degradation are characteristic of these livelihood transformations. There are signs of adaptation whereby plantation forest, use of improved seed varieties, fertilizer, irrigation developments and other activities compensate for loss of ecosystem services, but thus far are insufficient to reverse the trend in SES trajectory towards degradation. Concomitant with the decline in most ecosystem services in the landscapes several social and biophysical factors also declined indicating the general failure and increasing vulnerability of the SESs in the sites. These signs of failure include: the continued shrinking of land holdings, declining productivity, increasing landlessness, reduced diversity of livelihood sources and assets coupled with poor human capital and the economy. Unfortunately, the growth in crop outputs achieved and the extensive consumption and degradation of other ecosystem services has not resulted in increasing household incomes, human capital development nor changes that can boost the adaptive capacity of the entire SESs. Instead household incomes in general remain very low, except those engaged in commercial crop irrigation on very restricted land areas. At this point in time, observed socio-economic and biophysical problems in the landscapes are re-enforcing each other through feedback processes to lead the SES into a poverty trap.

Overall, the decline and degradation in stock of a range of ecosystem services has had strong negative impacts on resilience as evidenced by reduction in future options for positive transformation, response diversity and adaptability of the SESs. This is particularly true when set in the context of increased likelihoods of further shocks and disturbances, which will further decrease resilience. We discuss that increasing landlessness and outmigration indicates the nearing of a tipping point in these systems, which may induce new options for adaptation or further failure. We suggest that in strongly coupled SESs, such as the study areas, the stock of ecosystem services supplied by a landscape is a useful indicator for assessing trends in resilience of SESs.

Utilizing Runoff Water to Increase Household Food Security

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Keywords: utilizing, increase, household, runoff water, food security

Introduction and problem identification

In Rakai District of Southern Uganda over 90% of the people are dependent on subsistence agriculture. Most farming is done on sloping land between hilltops and valley swamps with average farm size between 2 and 3 acres. Population pressure results in encroachment on watersheds. The area's two rainy seasons have become less predictable and weaker over the past 10 years.

Subsistence farmers face problems of water availability and depleted soils, and need to make better use of natural precipitation. They do not have knowledge or skills, and schools do not teach such practical agriculture. Despite HIV/AIDS, population growth is putting pressure on land and water resources. For more than five years, Voluntary Action for Development has taught mulching, contour cultivation and water management as part of an integrated organic agriculture program which increases food security and diet diversity, a village-based program is used with residential trainings organized by VAD.

Analysis, results and implications for policy and/or research

Results There is increased household food security due to utilization of runoff water harvested in water storage pits. A total of 450 households can now feed their families 3 times a day out of this initiative. There is observable improved nutrition among the families because with runoff water farmers are in position to grow a variety of fruits, vegetables and other food crops which are a source of nutrients. Runoff water has enhanced water and soil conservation and farmers are in position to practice agriculture throughout the year. Women no longer have to walk distances find water to feed their domestic animals. Runoff water has saved women time to find water for their animals. Implications for policy/ research Run off rain water harvesting has a wide range of potential applications in developing countries and Uganda in particular. This involves creating irrigation alternatives for farmers, to providing potable water to rural and urban domestic purposes. The approach is flexible and effective technology that deserves wider support and expands use. Run off rain water harvesting has few environmental impacts ranging from water and conservation and with proper aid and government intervention can be made affordable to a wide range of community. The approach can also be adapted to a wide range of climates since in Africa, the average rainfall is greater than 1000mm per year and saves over 90% of water over traditional surface irrigation systems and produces high plants yield than any other forms of irrigation. One of the challenges is that there is less attention from government and less funding from International NGOs and finance organizations. More efforts to gather successful case studies, performance quantities an assessment is needed to change these funding priorities.

Developing Rainwater Management Strategies through Integration of Technologies, Institutions and Policies for Blue Nile Basin, Ethiopia

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Keywords: rainwater management, Blue Nile Basin, integration, innovation platforms, ecosystem services

Introduction and problem identification

About 80 million extremely poor and food-insecure people live in the water scarce and highly degraded highlands of Blue Nile basin of Ethiopia. Crop-livestock based agriculture is predominantly subsistence, low-yielding and rainfed (>95%). Rainfall, runoff and sediment losses are erratic and dry spells significantly reduce crop yields and sometimes lead to total system failure. Historically, sustainable productivity-enhancing innovations did not happen until recently and the entire agricultural, economic and institutional system lost its resilience leading to periodic famines and perpetual food insecurity. Agricultural production is dominated in the highlands by low input-low output rainfed mixed crop-livestock production. To meet the needs of growing populations and to restore landscapes to more productive conditions with sufficient ecosystem services for all stakeholders, there is a need to reverse land degradation,manage rainwater and improve productivity of crop-livestock system.

Analysis, results and implications for policy and/or research

A consortium of researchers and local partners under the CGIAR Challenge Program on Water and Food is implementing an innovative Nile Basin Development Challenge Program with a goal to improve rural livelihoods and their resilience through a landscape approach to rainwater management. The project is based on the premise that improved water management can be an important part of increasing land and water productivity, producing more food at a lower cost, generating employment and fostering equitable economic growth. In these rainfed farming systems of Ethiopian highlands, dramatically increased water productivity and crop production can be achieved with small amounts of water, if timed to mitigate yield losses from dry spells and other needed inputs are available. Livestock management such as feeding strategies has a role in increasing water productivity and integration of livestock typically results in higher water and economic productivity when compared to similar systems without livestock. However, further analysis showed that the existing model of both extensification and intensification of agriculture and allied activities are increasing pressure on water and other natural resources, enhancing climatic vulnerability through reduced ecosystem services and threatening to undermine long-term productivity.

Approaches to improving livelihoods and resilience need to take into account complex linkages between different components of agricultural and livelihood systems- technological innovations, institutional coherence and inclusive policies. As past development interventions are more disappointing and research also has taken a limited view by focussing excessively on the cropped fields during the main rainy season only; the present research adopted a landscape approach where water (and related) needs of crops, livestock, trees and other ecosystem services both during the rainy and non-rainy season to

enhance productivity and improved livelihoods were considered. To operationalize these concepts the project has selected three representative study sites in the Woredas of Fogera (north-east of Abbay basin, east of Lake Tana), Diga (southwest of Abbay basin) and Jeldu (south of Abbay basin). The three woredas represented a range of agro-ecologies with varied annual rainfall, were at different levels of degradation of the landscape and ecosystem services but all faced serious seasonal water scarcity. For detailed and continuous hydrological monitoring and assessment of the impacts of the large-scale interventions one river catchment was selected in each of the watershed - Mizewa watershed in Fogera (27km^2), Dapo watershed in Diga (18km^2) and Meja watershed in Jeldu (96km^2). Through comprehensive analysis of the bio-physical, social, economic and institutional settings at each location the project devised a set of specific strategy, practices and interventions for each site. A 'bright spot' anchoring community was also identified for ease in communication and validation of innovative ideas and interventions. To ensure continued and broad-based stakeholder participation 'Learning Alliances and Innovation Platforms (LA&IP)' have been setup at the watershed, woreda, regional and national levels. These LA&IP have memberships (about 10 to 12 persons) from a range of community, research, public and private development, market, finance, non-governmental organisations, donors and policy making institutions. The project has been able to demonstrate a paradigm-shift in its approach "instead of developing a few small watersheds through some interventions and showcase this as a success; rather develop, demonstrate and change the entire process and policy of landscape development through inclusive and informed interactions at all levels". Some of the early successes of actual demonstration and stakeholder participation in the process of integration of technologies, institutions and policies include:

(i) participatory approach towards hydrological and meteorological monitoring for improved rainwater management
(ii) estimation of the impact of the conservation practices on increase in base flow of the rivers/ local water sources during non-rainy season and its gainful use for productive agriculture, livestock and homestead and domestic uses,
(iii) mapping of the past degradation of ecosystem services and putting in the interventions benefitting especially the landless, marginal and women stakeholders,
(iv) vibrant and effective Learning Alliances and Innovation Platforms at all levels ensuring inclusive development and ownership by the institutions and alignment of the short-and long term policies and investments with the needs and aspirations of the community
(v) capacity building of the community and its leadership,local and regional researchers (including students), development practitioners and policy planners, and
(vi) innovative documentation and dissemination of the most significant change stories.

Building Farmers' Resilience to Food Insecurity in Southern Zambia under Rainfall Variability

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Keywords: food security, livelihood, climatic shock, agricultural system, adaptive capacity

Introduction and problem identification

A vicious cycle of poverty and environmental degradation are major causes of global environmental problems. This is especially the case in the semi-arid tropics (SAT) including Sub-Saharan Africa, where a majority of the world's poor are concentrated. Within the SAT, communities' livelihoods depend critically on fragile and poorly endowed natural resources, and poverty and environmental degradation are widespread. To surmount these environmental challenges, human society and ecosystems must be resilient to environmental shocks, i.e., to recover quickly from shock, increase adaptive capacity and re-organize themselves. In other words, resilience of social-ecological system (SES) is considered an important component for achieving sustainability. The objective of this research is to identify ways in which the resilience to environmental variability of subsistence farmers in the SAT can be strengthened. For an empirical approach to resilience, we focus on the mechanism and the speed

Analysis, results and implications for policy and/or research

We conducted an integrated study for analyzing farmers' coping strategy against climatic shocks in selected areas in Southern Zambia. We collected various intensive household level data including on-farm precipitation, agricultural production, off farm production, consumption, and anthropometric measures as a proxy for nutritional status for three cropping seasons from 2007/2008 to 2009/2010.

The rainfall pattern varied across rainy seasons and farmers were facing not only annual variation but also seasonal variation of precipitation. The December 2007 heavy rain (473 mm/week) caused significant damages to agricultural production and infrastructure such as roads and bridges in the region. Farmers responded quickly by replanting maize, and shifting to other crops. The field experiment suggested that maize yield was strongly influenced by topography and temperature. Thus cultivation under different topographic contexts partly mitigated climatic shocks. Resilience at the household level was quantitatively measured and factors affecting resilience were identified. A sharp decline in food consumption before harvest was observed after heavy rain in December 2007.

After March 2008, food consumption gradually recovered, however the speed of recovery was very slow. Heavy rainfall in 2007 resulted in a sharp increase in maize prices in February 2009 affecting the ability of households to purchase food. It took more than one year for most households to recover food consumption to the level before December 2007 heavy rainfall. The recovery speed was high in lowland due to personal gift, public food aid and non-agricultural income. Cattle holdings helped household recovery in upper terrace. Some new activities for getting cash income, such as livestock sales, fishery and wage labor emerged to offset a shortfall of income. Flexibility in employing diverse strategies to successfully cope with climatic shocks is a suggestive of household resilience.

Resilience in SAT context can be defined as the short-run recovery of food consumption, food production and livelihoods. In the long-run, resilience is the adaptive capacity of household, community and region to absorb shocks, adapt to change and to learn, innovate and transform. Rural households and communities in Africa are facing not only risks from natural disasters but also risks from social and economic changes, such as international price hikes of cash crops. Various assets including agricultural technology, livestock and land holdings and cash income opportunities/abilities are considered as crucial for the recovery of households and communities. Diversified access to resource use help households to recover from shock quickly including information via mobile phone use. The availability and the access to ecological services that supply wild food during the lean period are also important for consumption smoothing. Strengthening social safety net in different levels is necessary to increase adaptive capacity. Especially female headed households had less resilience compared to male headed households due to poor access to food and agricultural technologies. Development of infrastructure that enable households to access market for crop sales and food purchase, as well as for stabilizing food prices in the region is also important. Comprehensive approaches and long-run observations are necessary to understand complex responses and feed backs due to environmental and socio-economic factors affecting rural households. For enhancing adaptive capacity of individuals and households, long-term strategies are required to improve basic services such as education, medical services, public road and transport. In the long-run, not only is increasing specific resilience against climatic change and/or disaster risks but also increasing general resilience of the society required to prepare for uncertainty.

Water Resource Development in Shiwalik Hills of North, Western Himalayan Region

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Keywords: water conservation, rainwater harvesting, ground water recharge, LDPE lined farm ponds, catchment treatment

Introduction and problem identification

Impact of climate change on agriculture is being witnessed all over the world. Himalayan region is also experiencing severe impacts of climate change in terms of increased temperature, reduction in annual rainfall, drying of perennial springs, drought, etc. Weather patterns are becoming more unpredictable and extreme. This phenomenon is causing concern over the long term reduction in total water supply, affecting lives and livelihoods of the Himalayan people. Despite mountains being the global storehouse of fresh water, there is severe shortage of water, both potable, as well as for irrigation. Even though water is available in the valleys, the constraints of terrain forces large proportion of the agricultural fields to be dependent upon rains alone. Further, water requirement of crops is also likely to go up with projected warming. Thus, there is an urgent need of water resource development for mitigation and adaptation to impacts of climate change in the region.

Analysis, results and implications for policy and/or research

Shiwaliks, the most important ecosystem of the foothills of the Himalayas, have been identified as one of the eight most degraded rainfed ecosystems of the country. They are characterized by undulating barren hill slopes, undulating agriculture fields, gravely coarse textured soils with poor moisture retention capacity and erratic rainfall pattern. Though an annual rainfall of 1100 mm received in the area is enough to cultivate two good crops, its erratic and uneven distribution both spatially and temporally cause paucity of water during non-monsoon months. These intermittent and prolonged droughts lead to yield reduction and even crop failure. Monsoon rains are concentrating during August/September in place of June to September earlier i.e. before 1990, resulting in high rates of surface runoff that cause severe land degradation. Furthermore, winters in the sub-temperate mid hills region are becoming warmer over time. The increase in temperature coupled with decreased rainfall during the winter and spring period is making current production systems in the region highly unsustainable. Taking into account the amount of rainfall received in the region, good potential exists for water resource development. With development of water resource, through rainwater harvesting and by tapping surface and sub-surface flow, it is possible to stabilize crop production and at the same time divert biotic pressure from the hills, recharge ground water and ensure economic and ecological development of the region. Keeping this in view a project entitled "Augmentation of water resources through water harvesting in hilly areas" funded by Ministry of Water Resources, Government of India, New Delhi, is being implemented in Solan district of Himachal Pradesh. Under the project, various measures for catchment treatment and water harvesting such as contour trenches, earthen loose boulder structures, percolation ponds, gabion structures, low density polyethylene (LDPE)

lined ponds, afforestation, silvi-pasture development, etc. are being taken up to mitigate the adverse effects of heavy runoff especially in the rainy season and to promote the ground water recharge. Runoff water from the fields, catchments, roads, roof tops and water from streams, springs, which due to unpredictability and meager flow rates do not per se serve for irrigation can be harvested in various water harvesting structures. Soil moisture and water levels in different water bodies is being monitored regularly. Higher soil moisture contents around various catchment treatment measures have been observed as compared to the adjoining untreated areas. Various water harvesting techniques are expected to improve base flow, increase irrigation potential and augment groundwater. The main challenge is low cost and affordable technology which farmers can adopt easily. In this context, water harvesting through the construction of low cost LDPE lined ponds is an ideal proposition for the resource poor hill farmers having small and fragmented land holdings and poor irrigation facilities. This technology is highly suitable and useful for the rainfed areas of hills having narrow terraces (5-6 m width). Construction of these ponds doesn't require elaborate management skills and resources. Contrary to reinforced cement concrete tanks, poly-lined ponds are resistant to mild earth quake tremors. Simple village masons can easily construct these ponds. Ponds of 50-200 m^3 can be easily constructed on individual farmer basis which are sufficient for vegetable cultivation in about one kanal area (400 m^2). A 100 m^3 capacity farm pond once filled can provide five irrigations of 5cm each (through traditional systems) to one kanal area. The irrigation potential may be much higher if micro-irrigation techniques are used. As the water available to meet the human, animal and crop needs is decreasing day by day, efforts must be directed towards conserving and utilizing maximum amount of rainwater and recharging ground water by adopting low cost, successful and environment friendly techniques, following precision farming techniques like micro-irrigation, encouraging afforestation and reducing indiscriminate mining and quarrying activities. Watershed approach needs to be followed on a community basis for proper water management and sustainable development.

Collegiate Participation of the Community for Integrated Water Resources Management in a Percolation Pond – A Case Study from Vadipatti Town, India

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Keywords: percolation pond management, water productivity, crop diversity, collegiate participation, integrated farming

Introduction and problem identification

India is a tropical country with more than 75% of its rainfall occurring during the monsoon season.So in this spatially and temporally varied rainfall conditions, rainfed production can only be done with effective and integrated water resources management.The assessment of this integrated farming is done through an intensive study of a percolation pond in Vadipatti town.The percolation pond after construction is orphaned by the government and other agencies and is left unmanaged.The farmers and villagers are also less concerned about the pond, as they consider the government as the sole proprietor.So for effective management and income generation from the pond, an integrated management is approached.It promotes of Biodiversity and intensive vegetative cover, to control soil erosion.It helps in the all-round development of agriculture, fisheries, duck rearing, and other sideline occupations practiced.Participation from the villagers are incorporated through the Participatory management.

Analysis, results and implications for policy and/or research

The analysis was done in Vadipatti Panchayat Town, in Madurai District. The integration of fish farming with livestock production and farming of agricultural crops, including vegetable farming is the concept of an 'integrated farming', which helps in the all-round development of agriculture, animal husbandry, fisheries and other sideline occupations. The percolation pond was constructed by the government at a cost of 4 Lakhs with a total surface area of the pond 900 m^2 and volume of 2700 m^3. The pond is filled with the rainwater for an average of 120 days (North-East Monsoon -60 days, Water retained for another 60 more days after the monsoon). It is observed that an average evaporation of 5 mm/day takes place. 500 m^3 of water is lost by evaporation, So the total available water will be 2700-500 = 2200 m^3 of water. The Pond water is managed by the Community people by who take care of the Fish cum Duck Integrated Farming System, Agricultural Farming system approach, and the Apiculture. Fish species like Catla, Rohu, Mrigal, Silver carp, Grass carp and Common carp are cultivated here. A proven poultry farmer does Semi-intensive raising, in which the egg laying ducks are fed at the same rate as on land and kept at a relatively high density per unit of pond area. Therefore, higher amounts of manure and uneaten duck feed (estimated to be 10%) usually fall into the fish pond and consequently higher fish yields can be obtained. The duck house is built on the pond dyke and the floating resting and feeding places are constructed on the pond surface. Ducks are the "volunteer aerators"while swimming and chasing each other in the pond. Very little or no supplementary feeding and fertilization is needed for the fishes in the pond. As the dropping of ducks, distributed all over the pond surface, has high nutrient value and which act as manure and fish feed. Spilled over duck feed are also good food for fish. Fish pond provides an excellent environment for duck. No additional

land is required for housing ducks. Duck can collect considerable part of their nutrient requirements from the pond by means of eating tadpoles, some miscellaneous fish, insects, snails etc. From the economic analysis, a net profit of 50,000 was obtained from this duck-fish integrated farming. The cost of production for fish was Rs 3.33/kg. The fish were sold at a fixed government price of Rs 20/kg. The eggs were also sold at Rs 2.5/egg. The ducks were sold at Rs100/duck. In the agricultural farming system approach, the farming is done in the berm, bund, bund slopes and in the spaces beyond the bund. Tomato, Brinjal, and banana cultivation is done in the berm. In the Bund tops, Jasmine and marigold flowers were cultivated. In the bund slopes Aleovera plants were cultivated and beyond the bund coconut trees are planted. A net profit of Rs 1,20,000 was collected from the integrated farming. Experiments on integrated livestock-fish farming will opened up a new horizon of high animal protein production at very low cost.The PRA tools used helped to gain a rapport with the people there and helped to get the information from them.The collegial participation brings in benefits for both the community and the environment preserving the food-water synergy.

Effects of Climate Variability on Maize Production in Kenya

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Keywords: climate variability, drought, rainfed maize, yield, Kenya

Introduction and problem identification

Kenya is a drought-prone country located in East Africa, with 80 percent of the territory covered by arid and semi-arid land where annual rainfall varies between 200-500 mm. Only about one-third of the total land area of Kenya is agriculturally productive, including the central highlands, coastal plains and the lake region, where rain-fed cultivation dominates. The other two-thirds have low, unreliable and poorly distributed rainfall. Periodical droughts are part of the climate system that affects Kenya.

A recent survey covering the humid, temperate, semi-arid, and arid agroecological zones of the country found that more than 80 percent of all households interviewed had experienced drought over the last 5 years, regardless of agroecological zone. Erratic rainfall affected 18-45 percent of households, depending on the district. Like elsewhere in sub-Saharan Africa, food shortages in Kenya are most often associated with drought.

Analysis, results and implications for policy and/or research

We quantitatively assessed the impacts of climate variability on the yield and production of maize, the main staple in Kenya. Agro-ecological zones is used as the basis of analysis because climatic and agronomic conditions within the same zone are similar and moreover, available data do not support a more detailed country-wide analysis (e.g. at district level). We focus on analysis of drought, the dry form of climate variability events, because drought is a very real threat and historically had caused major crop losses and food shortages in Kenya. Although certain global climate models predict increasing rainfall trends for East Africa, the risks of future droughts should not be underestimated given rising temperatures in the context of climate change and increasing climate variability suggested by many climate studies on East Africa. Drought analysis in this study find that dry events seem to have become more frequent and more persistent over recent years, although whether they are due to natural causes or as a result of anthropogenic climatic changes is still a question. We found through the crop water production modeling that water stress caused by insufficient rainfall plays a significant role in rainfed maize production. This finding most likely holds true for other crops as well. Zone I suffers little from drought and has the least yield loss in general. However, all the other zones appear to be vulnerable to drought, even for Zone II where a 40 percent yield loss in dry year is not uncommon. Zones V, VI, VII have rather low relative yields, implying a good harvest in those zones is unlikely without irrigating the crop. Irrigation analysis suggests great payoff of irrigation development, nevertheless the marginal return of irrigation declines as the amount of irrigation water increases. This suggests the "optimalâ€ level of irrigation development depends on the marginal cost of irrigation and careful cost-benefit analysis is necessary for any irrigation investment decision-making. In addition, uncertainties and risks arising from non-technical areas, such as price volatility of both crops and agricultural input, also have important impacts in such decisions. While geography and climate largely explain Kenya's exposure to drought, the root cause of the country's vulnerability is its dependence on rainfall for economic and social development.

Poor rural households are particularly susceptible to the financial consequences of weather-related natural disasters. Good and proactive policy can mitigate the negative effects of droughts. For example, a severe drought affected much of Kenya in 1984. Food production for the 1984/85 agricultural year declined dramatically from the 1981/82 to the 1983/84 average, down by 35 percent for maize and 40 percent for wheat. However, the appropriate policy response to drought warnings in Kenya helped the country to avoid famine.

Workshop: Health and Food Security

Waste-Water Reuse Management in Jordan: Applications and Solutions

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Keywords: reclaimed water, reuse, health, sustainable, standard

Introduction and problem identification

Jordan is about 90,000km^2 in area and the climate is arid to semi arid. The annual rainfall ranges from 50 mm in desert region, to about 600mm in the western mountains adjacent to Jordan Valley.

The long average total rainfall in Jordan is estimated at approximately 8.3 billion m^3/yr, of which about 85 percent is lost to evaporation. According to Jordan's Water Strategy issued in (2009), the country's annual per capita water availability is less than 150 m^3/yr.Available water supply is less than the demand, and with continuing population growth, per capita availability is projected to keep declining in the coming years and the solution to use reclaimed water according to standard.

Analysis, results and implications for policy and/or research

The Water Authority of Jordan (WAJ) is responsible for the management of water and wastewater system in the country, and also responsible for managing the supply of treated effluent for reuse purposes. Development of wastewater collection and treatment systems started mostly during 1980s. Most treatment plants in early years used waste stabilization ponds (natural treatment system). As the population grew rapidly during 1990s as a result of high natural population growth, influxes of refugees and returnees to the country, many of the treatment plants became overloaded and upgrade of the treatment plants became an urgent issue for the government.During the 2000s, treatment plants have been upgraded employing mechanical treatment processes for more efficient treatment and higher effluent quality occurred. One of these treatment plants is As-samra located in approximately 40km north-west of Amman and working with an activated sludge system that replaced the lagoon treatment system which was constructed in 1985.It is considered as the largest treatment plant in the country with a treatment capacity of 267,000 m^3/d operating under (BOT) contract. The new plant came online in 2008 to provide better effluent quality. As of 2010, the treatment plant received approximately 230,000 m^3/d and treated effluent is discharged to the Zarqa River, which flows into the King Talal Reservoir where it is mixed with surface water. The mixed water is being used for irrigation in the Jordan Valley for various food crops. Currently Over 64% of the Jordanian population is connected to sewerage system and raw wastewater is discharged to 25 wastewater treatment plants in operation, of which 21 plants have mechanical treatment processes, and 4 plants are utilizing natural treatment processes. Approximately 117 million cubic meter (MCM) flows to the existing treatment plants and about 110 MCM was produced in 2010.The effluent from smaller treatment plants have been used locally predominantly for fodder crop irrigation. The use of treated municipal wastewater is regulated through the water reuse standard JS893:2006.The current standard was issued in 2006, replacing the previous standards from 1995 and 2002.The standards allow irrigation of agricultural crops that will not be eaten raw. The use of reclaimed water for other purposes such as cooling and fire fighting are permitted on a case by case basis, when confirmed with appropriate studies.

Recently, Water reuse is planned concurrently with the construction of wastewater treatment plants. WAJ has been contracting with farmers to provide them with reclaimed water for agricultural irrigation; larger scale sites of this kind include, among others, As-Samra, Madaba, Ramtha, Akeder, and Mafraq. As of 2009, a total of about 760 ha are irrigated with reclaimed water under contracts with WAJ. It is worth noting that fodder crop irrigation is the dominant application for all other water reuse schemes in Jordan, with a few exception of irrigating trees such as date palm and olive. This is partly due to the high dependency on imported livestock feed. It is also due to the hesitance of farmers to use reclaimed water for food crops that may be exported to neighboring countries. In an effort to integrate reclaimed water resources in national water planning, the government of Jordan, with support from the US Agency for International Development (USAID), has been for the past ten years implementing several projects for direct water reuse activities. Wadi Mousa Water Reuse Pilot Project is one of these projects that seek to demonstrate that reclaimed water reuse can be reliable, commercially viable, socially acceptable, environmentally sustainable and safe. A demonstration pilot program for the use of reclaimed water for irrigation was first established in Wadi Mousa in 2002 as a 6.9 ha demonstration site at the time of the Wadi Mousa WWTP upgrade, and it was later expanded to approximately 37 ha to include the use of reclaimed water by a local community.Effluent from the treatment plant is transferred to the irrigation water storage pond within the WWTP boundary, and reclaimed water is distributed through the irrigation water pump station and the irrigation water distribution system. Progress in wastewater reuse in Jordan has been significant.Initiatives are underway to further enhance the framework of laws and standards for improved integration of treatment requirements for the wastewater with likely reuse of the treated effluent in order to minimize the treatment costs, ensure public health and preserve the environment.

Addressing Water-Related Health Risks in Agroecosystems

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Keywords: water management, health, disease, zoonoses, vector

Introduction and problem identification

Worldwide, diseases associated with agriculture have important health impacts, particularly on poor people and those who are directly exposed to the risks such as farmers and households in agricultural areas. Many of these health risks are related to agricultural water use, such as water-related diseases, misuse of agricultural chemicals and antibiotics leading to contaminated water, and food-borne illnesses caused by consumption of crops and animal products which are rendered unsafe by water containing contaminants.

Analysis, results and implications for policy and/or research

Irrigation and water storage systems often provide breeding grounds for, and exposure to, vectors of water-related diseases. These include parasitic infections such as malaria, schistosomiasis, and emerging diseases such as cryptosporidiosis, giardiasis, and buruli ulcer. Water storage systems bring people, livestock and wildlife into close contact, especially where water is a scarce resource. This results in a greater effective contact among animals and humans, and ultimately facilitates disease transmission between animals and humans. The avian influenza pandemic provides an example of the role of irrigation in disease emergence. Numerous strains of low pathogenicity avian influenza virus circulate in wild birds that form the natural reservoir. The key evolutionary step towards virulence was adaptation to domestic ducks, which then through close contact transmit the infection to chickens; this is linked to rice farming combined with free grazing duck farming in wetlands.

Further risks can derive from toxic algal blooms, associated with agrochemical water pollution. Hence, with many of these diseases influenced by the management of agricultural production systems, these could be positively influenced by a holistic agroecological approaches. The health sector has developed interdisciplinary approaches such as One Health, striving to attain optimal health for people, animals, and our environment, and EcoHealth, a participatory methodology to understanding and promoting health and wellbeing in the context of social and ecological interactions. These two approaches have much in common and are increasingly aligned; both emphasize multi-disciplinarity and the importance of agriculture and ecosystem-based interventions.

This makes them highly suitable for addressing water-related diseases, complementary to the efforts by the health sector. Agricultural practices creating health risks, such as those related to water management, obviously require farm-level interventions, and food-borne diseases require management along the field-to-fork, or boat-to-throat risk pathway. This includes management of water used at different stages, be it as production input, in processing, or in meal preparation. Most zoonoses need veterinary and agroecological interventions in addition to medical ones, as they cannot be controlled while diseases remain in the animal reservoir. For zoonoses transmitted through water (e.g. leptospirosis) or with aquatic hosts (e.g. schistosomiasis) interventions may also need to be directed at the aquatic ecosystems.

Improved and innovative agricultural and water management practices can help reduce crop contamination, farmer exposure, vector breeding, and vector resistance. The reduction of health risks from using contaminated water, or being exposed to water-associated disease vectors, has to be carefully balanced with the need to support the livelihoods of farmers and provide affordable food to poor consumers. Further along the value chain, consumers can be protected while costs for the public health sector will decrease. The role of agroecosystems is particularly important in the case of malaria, that can no longer be handled using existing means only: mosquitoes have become resistant to insecticides used in agriculture, while the parasite itself is increasingly resistant to anti-malarial drugs. Here the health sector has actively sought collaboration with professionals in the areas of water management and plant disease control, leading to vast experience of relevant agroecological interventions that can help mitigate negative health impacts of water management.

Safe Wastewater Reuse: A Call for Sanitation Safety Plans

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Keywords: wastewater, health risks, water safety plans, sanitation safety plans, WHO

Introduction and problem identification

The publication of the third edition of the WHO Guidelines for Drinking-water Quality (WHO, 2004) introduced the concept of integrated, preventive risk management through water safety plans (WSPs) as a means to put in to operation the principles, standards, norms and best practice proposed by the Guidelines. The WHO suggests applying the same concept to support the implementation and operationalization of their Guidelines for the Safe Use of Wastewater, Excreta and Greywater in Agriculture and Aquaculture (WHO, 2006) which follow the same principles of HACCP and health-based targets. Such Sanitation Safety Plans (SSP) could be of similar value to the WSP in providing a hands-on manual to the application of the WHO (2006) Guidelines in different settings and situations for the safe use of wastewater and excreta in agriculture. The first SSPs will be developed in the framework of a 3 year funded project considering economic, institutional, technical, environmental & health aspects.

Analysis, results and implications for policy and/or research

A new Swiss funded project is supporting the development of SSPs. The presentation will describe the project conceptual framework and options for SSP development in order to stimulate discussion and much appreciated feedback. Pilot SSPs will be linked to agricultural wastewater and excreta reuse cases thus addressing the critical interface between sanitation and food safety. The project management team involves two international organizations, two research institutes (sanitation, epidemiology and public health), and an international capacity building centre for water management services. The implementation in the field will involve partner institutions from research to policy and concerned communities in Africa, Asia and Latin America.

Integrated Food Security Project in Bolivia's Andes

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Keywords: Bolivia, integrated, food, security, health

Introduction and problem identification

Bolivia is one of the poorest and most food insecure countries in Latin America. The Western part of Bolivia, dominated by the Andes Mountains, is the home of thousands of indigenous communities which have traditionally been forgotten by governments in addressing their needs. These indigenous populations live in high areas where water resources are scarce and agricultural productivity constrained. Rain water fed crops are common and access to irrigation is very limited. As a result, they exhibit significant deficiencies in all dimensions of food security: access, availability and use, as well as vulnerability to climate change, landslides, and other natural disasters. Extreme poverty affects Bolivia and of every 10 Bolivians, six are under the poverty line, and four under extreme poverty.

Analysis, results and implications for policy and/or research

Watersheds are severely degraded, limiting their productive capacity. Few plant species grow at high altitudes in the Andes, and the climate limitations from droughts and other natural disasters, limit agricultural production. Quinoa is one of the few productive plant species that grows under these severe conditions and is the only cash crop in the region. Chronic malnutrition is prevalent, maternal mortality high, and early nutritional deficiencies common, all having a significant impact on development. Many communities lack clean water and poor sanitation, resulting in higher rates of gastrointestinal diseases and increased risk of malnutrition. To address the above, the United States Agency for International Development contracted Abt Associates Inc.(www.abtassoc.com), to implement a five-year project with the objective to increase food security in targeted communities in areas of extreme poverty in Bolivia, while reducing chronic malnutrition among vulnerable segments, utilizing an integrated community driven approach. The specific objectives of the activity include: improving food availability through modern sustainable agricultural production technologies; increasing food access through improved commercialization and market linkages; reducing maternal and child malnutrition through improved food use and improved social services such as health and education; addressing the lack of rural infrastructure that supports food security in areas such as access to potable water, basic sanitation; reducing threats to biodiversity and building resilience to climate change impacts through adaptation measures and strategic development of the quinoa value chain. At the heart of the IFS strategy is the concept of integrality. Recognizing that poverty is a multifaceted issue, approaches to alleviating poverty must also use multiple tools and actions. The Project is implementing a full set of economic, productive, health, nutrition, water and sanitation, irrigation and environmental activities at the community level. Each beneficiary community is thus engaged in an integrated set of cross-cutting food security focused activities that address Income Generation and Livelihoods, Health and /Nutrition, Water Infrastructure, Biodiversity and Climate Change Adaptation, Best Practices for Integrated Food Security Programming, and Behavior Change Communications. The IFS Project views and applies the concept of sustainability in the same way it does integrality, as both an overarching strategic approach and a practical implementation tool.

Additionally, the IFS project designs activities so that they can be replicated in other communities, thus incorporating a third strategic concept, replicability. The IFS Project proceeds from the basic premise that:
(a) good agricultural practices include stewardship of fragile lands, adequate soil and water management of land used for pasture or crop production, and appropriate use of agrochemicals as well as reliance on integrated pest, disease and weed management practices;
(b) a bias toward intensification of land use rather than expansion of the agricultural frontier;
(c) use of cleaner technologies such as ecological cook stoves;
(d) activity design based on watersheds and landscape analyses; and,
(e) reduce negative impacts on biodiversity, and in general foster better natural resources management.

This two-and-half year old project (with a 5-year term) has so far achieved impressive results in a number of communities in some of the poorest parts of Bolivia's Andean region. One example is the implementation of about 2,000 ecological cook stoves "Cocinas Malenas" in more than 100 communities reducing rates of respiratory infections due to smoke inhalation in the home; reducing the loss of natural vegetation by promoting more efficient fuel consumption; increasing acreage of natural vegetation through the planting of communal forests under improved NRM practices; and, improving health, hygiene and nutritional best practices amongst participating communities. Another example of a successful integrated approach is the irrigation, water and sanitation project system launched in the community of Tunazani in touristic Torotoro in the Department of Potosi in southern Bolivia. This program delivers irrigation systems to over 50 families and more than 200 beneficiaries in a highly food insecure location, complemented by clean water, improved sanitation, and ecological stoves. The IFS Project is scheduled to run through 2014 in the most disadvantaged areas of Bolivia in partnership with local authorities and the communities to improve the quality of life of thousands of women, children and the elderly.

A Systems Analysis of Irrigation Water Quality in Environmental Assessments Related to Foodborne Outbreaks

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Keywords: irrigation water quality, foodborne outbreak, systems analysis, environmental assessment, Water Safety Plan

Introduction and problem identification

Much food safety research has focused on risks in harvesting, packaging, processing and handling fresh produce, emphasizing the elimination of microbial contamination at these points. This reflects the concept of the Hazard Analysis Critical Control Points (HACCP) approach, which seeks to assure food safety from harvest to consumption. This approach does not always include pre-harvest factors that may also affect food safety, such as the quality of irrigation water. Nonetheless, irrigation water has been implicated as a possible source of pathogens in produce linked to major disease outbreaks in the US and Europe. Many sources of irrigation water are subject to input of pathogenic loads from point and non-point sources as a result of land uses throughout the watershed. Research on the potential effects of irrigation water quality on food safety therefore requires a systems perspective at the watershed scale accounting for all factors that may influence irrigation water quality.

Analysis, results and implications for policy and/or research

Two nationwide disease outbreaks linked to fresh produce in the US are used to illustrate the concept of a watershed scale systems-based environmental assessment to investigate potential impacts of irrigation water quality on food safety. In the first example, fresh bagged spinach from a single farm in California was implicated as the source of a 2006 E. coli O157:H7 outbreak that caused over 200 illnesses and 5 deaths. The environmental investigation to determine how and why the spinach became contaminated included a component focused on irrigation water. This component included a watershed scale assessment of the farm's surroundings to identify factors related to irrigation water that may have contributed to contamination of the spinach. Groundwater used as irrigation water and its potential contamination by surface water recharge were identified as the most likely water-related contributing factors involved in this outbreak based on the available information. Because of the seasonal climate in this region of California, winter rains are stored in reservoirs and then released during the dry summer season to recharge aquifers used as sources of agriculture water. Analysis of water samples from a river flowing through the farm found a bacterial strain matching the outbreak strain found in patients and bagged spinach. Analysis of the hydrogeologic conditions at the farm showed that pathogens in surface water could potentially have reached wells on the farm and contaminated irrigation water. Those conditions included a groundwater table that dropped below the level of the river during the growing season, allowing surface water to recharge groundwater on the farm. High rates of irrigation well pumping and layers of coarse-grained soils would also have contributed to creating the conditions under which contamination from the river could have reached the irrigation wells. In the second example of a systems-based environmental assessment, iceberg lettuce served in chain restaurants was identified as the vehicle of transmission for a different E. coli O157:H7 outbreak in 2006. Samples from an initial environmental investigation revealed a genetic match between the outbreak strain and environmental samples from a single farm in a different region of California, leading to an in-depth systems-based analysis of the irrigation water systems on that farm.

The farm was located adjacent to two large dairy farms, and the assessment found that the farm's irrigation systems and the dairies' wastewater effluent conveyance systems were combined into a complex piping network. Three sources of irrigation water were used on the farm: groundwater pumped from onsite wells, surface water delivered through canals by a local water management agency, and effluent from wastewater lagoons on the dairy farms. The wastewater effluent was blended with water from the other sources and used only to irrigate animal feed crops. However, water management on the farm, including control of the wastewater blending process, appeared to create potential for cross-contamination.

Backflow prevention between piping networks used to convey blended wastewater and water from the other two sources was insufficient. In addition, the hydraulics in the combined piping networks were such that either high or low pressure situations could create potential for cross-contamination.

The irrigation network on the farm had evolved over time to attempt to meet various needs, without an overall analysis of how that evolution created possibilities for contamination of irrigation water.

One implication of the results of these assessments is that the scope of produce-related outbreak investigations and potential prevention measures needs to be conceptually broadened to include factors beyond those actually found on the farms identified as sources of produce involved in outbreaks. A systems-based, watershed scale analysis is necessary to comprehensively identify factors potentially contributing to irrigation water contamination. A dimension of time also needs to be added: environmental variables such as water quality are dynamic, with seasonal or other variations influencing the quality of irrigation water. Irrigation systems themselves also evolve over time to meet varying needs, and those incremental changes may lead to unintended vulnerabilities.

A preventive approach such as that contained within the Water Safety Plan process for drinking water may also be useful in managing irrigation water quality. Such an approach would include a systematic identification of risks to irrigation water quality. For example, seasonal variation in the quality of surface waters used for irrigation would need to be taken into account, as well as the multiple pathways of contamination potentially contributing to surface water quality. Factors such as well construction and protection and groundwater/surface water interactions would need to be analyzed for groundwater sources.

The Impact of Schistosomiasis on Swamp Rice Cultivation in Ndiagu-Igbudu Community, Ebonyi State Nigeria

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Keywords: schistosomiasis, infected, volunteer, water snail, swamp rice

Introduction and problem identification

Ndiagu-Igudu Community is a popular swamp rice cultivating community in Ebonyi State, Southeast Nigeria. Most families in the community are rice farmers and the children are not left out for they assist their parents on the farm. The sources of water in the study area include rain, spring and river.

The community has just a river which plays a very important role in the socio-economic well-being of the people, as it serves as the major source of water for irrigating farmlands, fishing, swimming and washing. Schistosomiasis is a tropical water-borne disease which is confined to fresh water lakes and rivers. It is caused by a microscopic, parasitic fluke worm called Schistosoma. The disease poses a major public health problem to those engaged in water related activities. The aim of this work is to elucidate the impact of schistosomiasis, a neglected tropical disease, on swamp rice cultivation in the study area, and make appropriate recommendation for the control of the disease.

Analysis, results and implications for policy and/or research

Urine and stool samples were collected from 202 rice farmers in the study area and screened for the presence of Schistosoma species using Sedimentation, and Direct Wet Mount Microscopic Examination techniques respectively. With the aid of a sweep net, water snails were collected from the study area and identified using reference charts for water snails' taxonomy. Of the 202 volunteers screened, 124 (61.4%) were infected with Schistosoma haematobium and Schistosoma. mansoni, while Malacological Studies revealed that the collected water snails belong to the species: Bulinus globosus, Bulinus senegalensis, Bulinus truncatus and Biomphalaria pfeiffer. The 124 infected volunteers were interviewed with the aid of structured questionnaire on the impact of schistosomiasis on them and their farming activities. The respondents reported that they had severe debilitation, weight loss, haematuria and inability to do reasonable work on their farms. The study revealed a loss of between 12-34 labour days per infected person. Due to the debilitating effect of the illness, most of the farmers spent more money on hiring labourers to work in their rice farms.

Statistical analysis revealed a high negative correlation (rs = -0.8 at 95% Confidence Interval) between labour days lost due to infection, with net farm income. This implies that schistosomiasis is strongly associated with the declining productivity of infected rice farmers. Therefore, urgent Schistosomiasis Control Measures like community-based health enlightenment campaign programme, routine diagnosis and chemotherapy, molluscidal operations, as well as environmental sanitation and hygiene activities, are strongly recommended for the mitigation of schistosomiasis and its impact.

Arsenic Exposure in the Bengal Delta: From Water to Rice to Humans

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Keywords: groundwater, arsenic exposure, grain shape and size, rice consumer, system of rice intensification

Introduction and problem identification

Arsenic (As) related health problem is most severe in South Asia, notably in the Bengal Delta Plain where people are mostly dependent on groundwater for domestic purposes. This kind of As related problem is not only from groundwater but also from rice which is the staple food for rural people(1). People are cultivating their lands with groundwater that contains high level of As(2). Continuous flooding of the irrigated land is the general practice of rice cultivation as a result soil becomes anoxic with time during cultivation which increases the bioavailability of As in the soils and consequently the accumulation of As in rice grains(3,4,5). Both inorganic and methylated forms of As are present on rice(6). Therefore rice is considered as one of the potential pathway of dietary As exposure in many parts of the world notably in West Bengal and Bangladesh. Consumption of As-enriched rice is an important contributor to the high incidence of skin lesions that still exist in study region.

Analysis, results and implications for policy and/or research

The rice samples (n=157) that we have collected from the household were in brown color and grain shape and size were short bold (SB), medium slender (MS) and long slender (LS) respectively. The important findings of this work were that As concentration of rice grain decreased with increasing grain size of the rice and the median value of As concentration in rice grain were SB: 0.32 mg kg-1, MS: 0.16 mg kg-1 and LS: 0.10 mg kg-1 respectively. Most of the rural people prefer SB type of rice due to its low cost and they believe that it takes longer time for digestion resulting in that they feel less hungry. It was estimated that if a participant with body weight (bw) of 47.5 kg (median value, n=157) daily consumes 0.40 kg (median value, n=157) of SB, MS and LS rice then total daily intake of As from rice will be 2.7 μg day-1 kg-1 bw for SB, 1.3 μg day-1 kg-1 bw for MS and 0.8 μg day-1 kg-1 bw for LS type of rice. From this it is clear that those participants who are consuming SB type of rice have a higher risk than those consuming other types of rice. This study shows that consumption of brown rice, particularly of SB type, in rural Bengal may be a potential alternative pathway of As exposure. Therefore, only remediation of As from drinking water is not enough to mitigate the As hazard. In addition to species selection the rice cultivation itself might be modified to decrease arsenic content in rice. Since the 1980s the so called System of Rice Intensification (SRI) has gained ground, notably in north-eastern China and in the Indian peninsula. In SRI the rice field is allowed to dry up between irrigations. As mentioned, constant flooding causes anoxic conditions, increasing the bioavailability of the arsenic. The production is often higher than for conventional practice with flooded fields. A test was done in Bangladesh in which it was found that the SRI promoted clearly more oxidized conditions in the subsoil decreasing As(III) which is the main specie taken up by plants.

No significant decrease in arsenic content in rice grains was found which might be due to that the field used for the test cultivation was a virgin one with initially low contents of arsenic. To abandon the use of high arsenic groundwater is one of the mitigation policies to reduce the health hazards.

The economical constraint in the rural villages is also an important burden to reduce As exposure. The reduction of poverty may also help to mitigate this problem by increasing the living standard (consumption of long grain rice, proper nutrition etc.) of the rural populations. Thus As mitigation in West Bengal and Bangladesh demands a spectrum of actions from changing irrigation practices, rice species selection, and better nutrition to a general reduction of the level of poverty.

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Assessment of Potential Health Risks of Waste Stabilization Ponds (wsps) Effluents for Irrigating Vegetables: A Case Arusha Municipality wsp, Tanzania

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Keywords: potential health risks, medium to high health risks, education to farmers and consu, irrigation methods, tracing out from the field

Introduction and problem identification

For more than three decades, Waste Stabilization Ponds (WSPs) effluent have been used by people of Lemara (peri-urban) in Arusha Municipality, Tanzania to irrigate their farms in order to get better crop yields as source of their food and income(source of their livehood). Despite of highly acceptance of wastewater reuse by the people in Lemara, there has been no effort to assess the health impact associated with wastewater reuse practices in this area. The area has approximately 57 acres of vegetables and fruits which are irrigated using WSPs effluents. The application of WSPs effluent on the field is done using buckets and conveyance drains around the farms. Farmers often prefer treated wastewater because of its high nutrient contents. This reduces or even eliminates the need for expensive chemical fertilizers. However the use of vegetables and fruits from these fields can have significant potential health risks to human being especially when eaten uncooked.

Analysis, results and implications for policy and/or research

Main Objective of the study was to assess the potential health risks associated with re-using the Lemara WSPs effluents in Arusha Municipality for crop irrigation. Specifically the study was meant to determine the performance of WSPs in terms of FC, Helminth eggs, BOD5, to assess the levels of FC and Helminth eggs on crops irrigated by WSPs effluents from the field to the market place and to assess the potential health risks associated with the re-use of WSP effluents. The study was conducted at Arusha WSPs which occupy an area of about less than 8 ha and receive an average flow rate of 5,430 m^3/d and 4,350m^3/day of municipal wastewater during rain and dry season respectively. The overall retention time of the ponds doesn't exceed 29 days. The system consists of one anaerobic pond, two facultative ponds and two maturation ponds where for each point grab samples were collected at four different sampling points. BOD5 was analysed using APHA, feacal coliform was analysed by membrane filtration method while helminth eggs by modified Bailenger method. Results have indicated that WSPs in Arusha have the removal of 63% of BOD5 in anaerobic, 49.9% in facultative and 33.6% maturation ponds. The overall removal of BOD5 in WSP was found to be 87.7% resulting into an effluent quality of 79.3mg/l. This indicates that the WSP system does not meet WHO standards of 30 mg/l. The removal efficiency for FC was 99.53% with the effluent containing high amount of faecal coliforms (105) which again doesn't meet WHO guidelines. As it was expected, maturation ponds have higher removal (90.9%) of FC as compared to anaerobic pond (83.6%) and facultative ponds (68.57%). Treatment of wastewater along the pond system shows high reduction in the helminthes eggs of more than 99%. Tracing out the presence of FC and helminth eggs for crops irrigated by WSPs effluents, from the field to the market place have shown to have FC of 2.5x10^4/100ml and helminth eggs 17.6 eggs/100g/l) in vegetables, which poses many question on the irrigation practice and a need of handling these vegetables before consuming.

It was observed that for all seasons, helminth eggs and FC found to be above acceptable levels (< 1000 FC/ 100 ml and intestinal nematode ova of <1 / ova). From the basic risk assessment, it has been shown that the health risks associated with reusing the effluent from the WSPs is of medium risk in terms of helminthes eggs and high risk in terms of FC which suggests the fecal contamination and can result into cholera, typhoid etc which are very serious cases. It can be concluded that the presence of very high FC (4.40-9.45 x 105 No/100ml) in the effluent of maturation pond is an indication of poor performance of ponds and as such high health risk category was identified during the assessment.

While water treatment or the use of clean water sources are undoubtedly 'better' options, they are unaffordable, wastewater re-use is the best option and therefore to minimize the risks from wastewater re-use is a priority. Education for farmers and consumers is the key. This is because from the interview conducted it appears that farming communities are unaware of the dangers from wastewater, but there are few who can afford boots and gloves hence they provide high levels of protection against infections, and regular self-treatment for intestinal worms can have a major impact on their general health. Education to consumers about proper washing of vegetables hardly sounds groundbreaking, but can have a profound effect on the levels of disease. The type of crop that can be grown is another way of reducing risks, for instance growing maize, wheat, sorghum, and other fodder crops instead of fruits and vegetables. Other simple method for farmers is to change in irrigation methods, which can have very different levels of risk. Using flooded furrows to irrigate leafy vegetables, for example, can greatly reduce the risk of contamination compared to overhead use of watering cans.

Vegetables Gardens in Rural Schools in Colombia a Way to Enhance Nutrition – A Challenging Learn Experience

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Keywords: rural schools, nutrition, vegetable garden, pupils, compost

Introduction and problem identification

Rural schools have been the center of the projects of the Health and Environment Institute from El Bosque University, Bogota, Colombia, as it is thought that these have the potential to serve as demonstration centers for the community to know alternatives for a better life, while students can serve as mediators of transmitting knowledge at home what they learn in school. Apulo municipality has 13 rural schools that have on average 10 to 20 students in first through fifth grade, ages 6 to 16 years, one teacher teaches the subjects in each grade to all children in the same classroom, the school has a person responsible for preparing lunch. All schools receive and prepare the same food; due to the socioeconomic conditions of many families, the food received by children in school becomes the main meal of the day. That is why the opportunity to offer fresh food produced in the school has an important value for the student's nutrition, can be a major strengthening in their food.

Analysis, results and implications for policy and/or research

Apulo municipality is located in the departament of Cundinamarca has an average temperature of 28 Celsius degrees, an altitude of 400 m.a.s.l., and a population of 8,162 inhabitants of which 59% live in rural areas. The project objective was to implement school gardens in the rural schools of Apulo municipality, the children chose the best place to start assembling the garden, also chose the name.

The size of the vegetable garden was determined by the space and the number of students. All had sufficient space for the seedlings and to plant at least 4 different species of food, among which are the cilantro, cabbage, beans, green beans, carrots, radishes and corn. For the implementation of vegetable gardens a guide has been developed especially designed for children including the different recreational activities: from the preparation of the seedbed and the seeding through the transplant, the watering, plant care and finally harvesting. The gardens were totally organic. The project gave to each school the following basic tools: shovel, rake, watering can, seeds, seedbeds, and a notebook that served as a diary where students painted all activities and development of plants. As part of the educational materials were also developed posters with information on composting, the vegetable garden development, beneficial insects, pests and diseases. The activity of the vegetable garden had a fixed weekly time allocated for each teacher. This project implemented school vegetable gardens in the 13 schools between the years 2008 to 2010 also were included the composting of all the biodegradable waste produced inside the school, transforming in to an organic fertilizer for the vegetable garden. Seeing the success of this project, the urban school wanted to be part of this and was included at the end of the project.

The most important results were:
1. Rural children learn to plant, tend and harvest food.
2. The product of the vegetable garden was used to strengthen food for the children, with healthy and fresh products.
3. When production from the garden was large the products were sold in the community and the money was used to buy more seeds.
4. The teachers used the vegetable garden to teach the various subjects like Science, Math, Writing and Art outside the classroom 5. Some mothers were really engaged with the results, and they have decided to set up an own vegetable garden at home.

Conclusions
1.The school gardens are an opportunity for rural children learn in schools, performing activities that are related to their lifestyle
2.Much of the success of this project depends on the motivation of the teacher to do it
3.The project is easy to replicate in other schools especially in rural areas as well as in the parents' homes The project received financial support from Bayer CropScience and the NGO, "Lazos de Calandaima" Foundation, involving the Municipality Mayor, the school principal, all the teachers, the kitchen staff and students.

Health and Food Security Challenges in High Arsenic Aquifer Areas of India – A Case Study from Proterozoic Hard Rock Terrain

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Keywords: groundwater, arsenic, Bengal basin, Chhattisgarh, India

Introduction and problem identification

The availability and access to blue water is a fundamental modulator that governs the links between food security and health. Large part of extra peninsular India, particularly the Indo-Gangetic alluvial plain is affected by geogenic Arsenic contamination and is covered under arsenic advisory zone.

Apart from the worst effected Bengal basin, identification of new arsenic contaminated groundwater areas within the country is progressing fast. Identification of high arsenic aquifer in Proterozoic rocks of Chhattisgarh is one of them. Bengal basin is one of the major producers of food grain in India.

Effect of irrigation by Arsenic contaminated water has been established in the food chain in India. This would be a serious health concern not only for Bengal basin but also for the area out of arsenic advisory zone.

Analysis, results and implications for policy and/or research

The high Arsenic ground water occurrence in eastern part of Chowki block, Rajnandgaon district, Chhattisgarh is confined to the early Proterozoic meta volcanics and granites, along the N-S trending Kotri-Dongargarh rift zone. The geographical extent of this high Arsenic ground water occurrence is found in isolated clusters distributed over an area of 330km^2, nearly in a 10km radius zone. The most severely affected villages are situated on rhyolite and granite, close to shear zone. The relatively younger metabasics, basic and pyroclastic aquifers are less contaminated. This is an important findings since 28% of the area is covered with basic rock closely associated with rhyolite, the dominant rock type of the area. The intrusion of rhyolitic- granitic magma is followed by the hydrothermal phase which is responsible for Arsenic enriched sulfide mineralization and Arsenic enrichment in the host rock. The emplacement of basic rocks took place after the hydrothermal phase. Therefore the basic rocks are less contaminated. The Arsenic in basic rocks is due to assimilation and remobilization reaction only. The area is predominantly mono-cropped. Kharif is the cropping season and mainly rain fed, supported by surface canal irrigation and occasional ground water irrigation. Second crop area is very scanty and is invariably based on ground water irrigation.

The area is having limited ground water potential, which is restricted to the upper 150 m weathered and fractured zone. Present annual ground water draft for irrigation is 8.6 MCM only. Overall ground water development of the area is 24%. Bore wells and hand pumps are more affected with Arsenic than dug wells in general, more particularly applicable to the area where Arsenic contamination is less. During the ground water exploration in the area some arsenic free or limited Arsenic contaminated (< 0.040 ppm) fractures were tapped through specially designed wells by Central Ground Water Board,

which can be used as alternative source. Geochemical control on occurrence of high Arsenic ground water has been established. The ground water with electrical conductivity >800 micro sim./cm are found invariably containing lower Arsenic value, below 0.050 ppm. Long term analysis of ground water level at Ambagarh Chowki have shown significant decline in pre and post monsoon water level in last decade, where as in previous decade the level were either stable or rising in trend. This clearly indicates enhancement of draft during recent past, which is gradually exposing more and more of aquifer thickness to oxidizing environment, resultant in release of Arsenic to ground water. The deepest static water level is at present around 18 m and maximum drawdown recorded in the area is 38 m. Hence, present zone of fluctuation is around 60 m below ground level(bgl) which is the zone of hand pump operation in the area. Artificial recharge to groundwater in the area is found suitable in dilution of Arsenic contamination. Since the soil and weathered rocks are enriched with Arsenic hence method of artificial recharge which can bypass the soil and weathered zone must be applied for the area. The Vadose zone available in the area for recharge to dilute the Arsenic contamination has been worked out 41 MCM. The lithological and geochemical control as interpreted would enable providing safe and alternative drinking and irrigation water in the area. The present finding is significant and encouraging for investigations in other high Arsenic aquifers. In Bengal basin Arsenic contaminated groundwater is found to be restricted to the top aquifer system, which is confind down to 100m bgl. With increasing awareness and efforts drinking water extraction from aquifer are now largely concentrated from the deeper Arsenic free zones. However, irrigation water is still drawn predominantly from shallow zones of within 100m depth which is largely affected by high Arsenic contamination. Irrigation through the high Arsenic groundwater is reaching to the food chain in the area, which is a serious health concern.

Therefore, identification of litho-geochemical control in high Arsenic groundwater area is significant for health and food security.

Agricultural Practices that Promote Mosquito Breeding in Rural Farming Communities of Southeast Nigeria: Implication for Food Security

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Keywords: malaria, mosquito, food, productivity, health

Introduction and problem identification

Agricultural practices such as the use of irrigation during rice cultivation, the use of ponds for fish farming and the storage of water in tanks for livestock provide suitable breeding grounds for anthropophylic mosquitoes. The most common anthropophylic mosquitoes in Nigeria which cause much of the morbidity and mortality associated with malaria belong to the genus Anopheles gambiae complex. Farmers are therefore at high risk of malaria - a disease which seriously impacts on agricultural productivity and food security. Unfortunately, information relating to agricultural practices and farmers' behavioural factors that could assist malaria programmers plan and implement interventions to reduce risk of infections among farmers and enhance productivity is scanty. Farmers' knowledge about malaria and agricultural practices which favour the breeding of mosquitoes in Izzi, Ikwo and Ezza rural farming communities in Ebonyi State, Southeast Nigeria were therefore assessed.

Analysis, results and implications for policy and/or research

This descriptive cross-sectional study involved the collection of data through the use of ten Focus Group Discussions (FGDs) and the interview of 350 randomly selected farmers using semi-structured, open-ended questionnaires. The communities were purposively chosen because they are centres of intensive traditional agricultural activities and some of their agricultural practices have potentials for promoting the breeding of the female Anopheles mosquitoes. These sets of information were supplemented with observations of agricultural practices made in 100 randomly selected farms. The FGD data were recorded on audio-tapes, transcribed and subjected to content analysis while the quantitative data were analyzed using descriptive and inferential statistics. Most respondents in the communities had low level of knowledge of malaria causation as only 10.5% stated that mosquito bite could transmit the disease. Less than half (42.7%) correctly mentioned the signs and symptoms of malaria as high body temperature, body pains, headache, body weakness and cold/fever. The reported main methods for preventing mosquito bites in the farming communities included removal of heaps of cassava tuber peelings (62.3%), bush burning/clearing (54.6%) and clearing of ditches (33.7%). The dumping of cassava tuber peelings which allows the collection of pools of water in the farms, storage of peeled cassava tubers soaked in water in uncovered plastic containers, digging of trenches, irrigation of farms and the presence of fish ponds were the observed major agricultural practices that favoured mosquito breeding on the farms. A significant association was observed between respondents' knowledge about malaria and agricultural practices which promote mosquito breeding.Farmers' knowledge of malaria causation and signs and symptoms was low, while agricultural practices which favour mosquito breeding in the farming communities were common.

There is an urgent need to engage farmers in meaningful dialogue on malaria reduction initiatives including the modification of agricultural practices which favour mosquito breeding. Multiple intervention strategies are needed to tackle the factors related to malaria prevalence and mosquito abundance in the communities. Generally, use of small and large dams for agricultural purposes is known to favour the breeding of mosquitoes in sub-Saharan Africa. Public enlightenment is another feasible intervention that can be adopted. The radio and traditional media such as the use of town criers which are common sources of information in most communities in rural communities of southeast Nigeria, including the study area have crucial roles to play in this regard. Training is the third complementary intervention that needs to be conducted. It should be designed and implemented with a view to enabling farmers to acquire basic knowledge and skills relating to mosquito control, adoption of use of insecticide treated nets (ITN) and environmentally friendly food processing practices.

Onchocerciasis in Rural Farming Communities in Nigeria: A Threat to Food Security

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Keywords: onchocerciasis, health, food, community, rural

Introduction and problem identification

Onchocerciasis, a neglected tropical disease is increasingly being recognized as a major disease of public health importance in endemic parts of the world, with sub-Saharan Africa, especially West Africa, being the most hyper endemic foci in the world. The disease has been widely reported in Nigeria, where about 7 million people are infected and another 40 million were at risk of infection.

Onchocerciasis is basically a rural disease affecting communities sited along fast-flowing rivers, which enable the breeding of the vector, Simulium, resulting in infection with Onchocerca volvulus among the inhabitants of the area. The symptoms of the disease are particularly irritating and disabling, often associated with long-term exposure to infection, and this affects the social and economic activities of the inhabitants concerned.The study was carried out in some Onchocerciasis endemic communities in three states located in the south-eastern part of Nigeria, namely: Ebonyi, Imo, and Anambra.

Analysis, results and implications for policy and/or research

The data were collected with the help of Local Government Onchocerciasis control officers and community health workers in the areas. This was done to ensure maximum cooperation of the study subjects. The sampling was carried out in company of volunteer village health workers (VVHW), that were distributing mectizan during Onchocerciasis control programme carried out in the area. On physical examination.macula-papular rashes of forearm extending to the shoulder with a fixed painless oedema of the arm were shown also on the leg.Craw - craws combined with leopard skin of the knee were noted. The symptomatic manifestations of the disease were: Leopard skin with the highest prevalence of 45.5%, ocular lesion, 24%; nodules, 15% and lizard skin, 10.5%. More males (30%) than females (23.5%) had onchocerciasis but the difference was not statistically significant ($P > 0.05$). However, age had a significant effect on the prevalence of onchocarciasis ($P < 0.001$). Socio-economic studies using structured questionnaires and interviews were carried out. The results indicated that onchocerciasis was associated with a variety of adverse social and economic effects on the people. All the respondents agreed that black fly is a problem in their communities and (80%) of the respondents attributed body itching/ swelling to black fly bite. Majority of the respondents (60%), lost14working days in a year due to illness caused by black fly bites. Those who lost between 7 and 14 days in a year due to black fly bites constituted (37.8%). While in the sick bed, (51.1%) respondents had at least one person detailed to stay with them and the majority of them used up to $100 in treating the ailment. The results emphasize the need to break man/fly contact considering the fact that most of the affected people are subsistence farmers with low incomes. 40.5% of subjects, mainly farmers and artisans, which presented with pruritus or itching complained of insomnia, general fatigue and lack of concentration at work, with a net effect of low productivity.

Some children of infected parents reportedly dropped out of school. 14% of females with ocular lesions had given up jobs such as sewing, weaving and hair plaiting because of visual impairment thus leading to loss of personal and household economic productivity. 95.5% of subjects with lizard skin and 50% of those with leopard skin presented with varying levels of body disfigurement, had high level of low self-esteem, marital problems and social stigma.Itching was observed as the most troublesome symptomatic effect that was not age specific. The study subjects described itching as painful with a compelling, irresistible and self destructive behaviour. 47.67% of the study subjects who presented with itching complained that the disease prevented them from sleeping at night as individuals spent the whole night scratching. 25% of the subjects said they were in distress and felt frustrated. 15.5% of the subjects reported that unrelenting scratching reduced their strength and resulted in lack of concentration at work while 14.5% admitted that their education suffered due to distractions in class caused by constant itching. The greatest burden of onchocerciasis in the study areas are impaired visual acuity and blindness, and dermatitis which reduces life expectancy, decreases agricultural productivity, forces children out of school and results in the emigration of the work force. The subjects, in this study, who presented with ocular lesion, reported giving up jobs such as sewing, weaving and hair plaiting because of visual impairment. The farmers abandoned their farm work. Visual impairment incapacitates a large segment of the community and makes them an economic burden by preventing them from reaching their maximum productive capacity.. The disease had adversely affected the social and economic life of the study population. Onchocerciasis is associated with significant levels of stigma which cuts across the entire aspects of life in the communities studied. While some people pity those infected by the diseases, others despise them.. Infected individuals are burdened with low marriage rate, falling birth rate, and drop in productivity, economic stagnation or decline, and social disintegration. The disease adversely affects the productive population, including farmers, artisans, traders etc as well as school children.

Community Managed Water Saving and Eco-Friendly Farming Towards Health Safety and Food Security – A Replicable Model in Bangladesh

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Keywords: groundwaterdecling, safe water crisis, hiking food prices, water saving usage, organic farming

Introduction and problem identification

Poor people at Amarak peri-urban area of Chapainawabgonj municipality, locates in the semi-arid area of Bangladesh, suffer from severe water and food crisis due to rapid declining trends of groundwater table. Extraction of groundwater using mechanical deep-wells for irrigation accelerates the declining trends which result water pumps non-working. Women have to fetch water from irrigation pumps and can carry little drinking water while they face various social problems and sexual violence. Excessive use of synthetic pesticide and chemical fertilizers in farming cause surface water contamination. Poor people collect this water for domestic use from drains. Irrigation, use of pesticides and chemical fertilizers cause higher food costs which poor people cannot afford. Intake of Insufficient and ill-quality foods and water lead poor people into various health risks. SPACE has introduced innovative water and food facilities among poor people that lead them into new hope.

Analysis, results and implications for policy and/or research

Semi-arid zone of Bangladesh covering around 40% lands of the country is located in Northwestern part where drought is a natural phenomenon for eight-nine months in a year. Average temperature is 40°C-42°C during extremely dry season. Annual rainfall is 1200mm-1500mm which is lower than national average. Effects of Climate Change cause irregular rainfall that again aggravate droughts.

These areas may be divided into three categories:
i) Low-dry areas covered by mostly plain lands, dry season starts earlier and shallow-wells do not work;
ii) Dry areas covered by contour lands and Deep-Set pumps do not work;
iii) extremely dry areas covered by higher lands, dry season comes earlier and existing water pumps do not work.

839 migrated poor people along with 163 children of <5 years and 6 physically challenged people, at 177 families live in Amarak since the 12 years losing all assets due to river attrition. Being skilled farmers, all people are involved in small-scale farming on leasing lands. Drought and irregular raining due to effects of Climate Change has led them in uncertain farming and earning. Additionally, they cannot bear cost of irrigation, buying fertilizers and pesticides due to their poverty. Nevertheless, they have to pass days without wages and foods that cause their continual starving. Nonetheless, water shortage during dry season makes poor people use contaminated irrigation water mixed with sprayed pesticides and synthetic fertilizers which expose them into various water borne and malnutrition related diseases, that again expose them into different socio-economic vulnerabilities.

Children, Women and physically challenged people are at the center of these unwanted circumstances. Excessive use of chemical fertilizers and synthetic pesticides badly contributes in hiking food price, degrading soil quality and water holding capacity.

Due to lack of relevant studies, there is no accurate data on the bad impacts of utilizing chemical fertilizers and synthetic pesticides. Field experience reveals that food cost has inclined more than 80% compared to 7-8 years correlated with price hike of fertilizers, pesticides and cost of irrigation. It has also been experience that one hector farmland needed 100 kg chemical fertilizers and 250 gm synthetic pesticides and 1500BDT for irrigation purpose before 10 years. Compared to previous figure, the same area of lands need 300 kg chemical fertilizers, 1000 gm pesticides and 3500BDT since the last 3-5 years, which is almost triple than those of previous years. This situation is not only stressful for farmers in terms of cost but also difficult for the poor people to afford foods, which results in starving, consuming insufficient and lower caloric and contaminated foods by poor people, which lead them into various malnutritions related diseases. Having strong feelings, SPACE, a WASH specialized NGO, facilitated peri-urban people with innovative initiatives including installation of 14 urine diversion dry toilets for water conserving and reuse of treated human urine and feces organic fertilizers in the farm, 14 vermin compost units for converting kitchen wastes into organic fertilizers and water saving washing mechanism for utensil cleaning along reuse of waste water in small farming. SPACE also facilitated in social preparation to the people through awareness and hygiene promotion activities, training for safe handling and application of treated human and kitchen wastes in agriculture. SPACE also imparted human value-based WASH education to target people for water saving utilization and use of rainwater for drinking and other domestic purposes during rainy seasons. Field findings reveal 100% families use, clean and manage urine and feces for recycling, 100% families manage and recycle kitchen wastes by vermin-composting, 97% families practice water saving wash using ash and small water and reuse waste water in agricultural fields after recycling. 100% families save water using dry toilets. Field reports further reveal that 100% families produce various vegetables and fruits using recycled wastes, safely and hygienically handled those for applying in firming. As results, they got more yields utilizing organic fertilizers produced human and kitchen wastes; production cost reduced more than half and they can produce vegetables year-round using treated human urine, feces and household wastes as organic fertilizers. They also use domestic waste water in kitchen gardens after natural treatment. During monsoon, 100% families collect, preserve and use rainwater for drinking and domestic usage. Field reports further indicate that 87% women are involved in small farming and produce food crops; 96% families have chemical free fresh adequate foods round the year. 100% of them know ways in securing health and foods utilizing their own resources. Remaining people of the same and neighboring areas come to see and show interests in accepting the mechani.

Exploring Possible Alternate Safe Sources of Water for Irrigation in Arsenic Affected Areas in the Middle Ganga Plain, India

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Keywords: ground water arsenic, irrigation, food chain, safe source of water, Middle Ganga Plain

Introduction and problem identification

Bihar state, located in the Middle Ganga Plain (MGP), has remained the focal point of research and operational responsive actions for nearly a decade, ever since the reportage of elevated arsenic concentration in groundwater in the year 2002. Large alluvial tracts along the Ganga River and patches in northern plains are affected by arsenic load of >50 ppb (the regulating limit) in groundwater. The contamination zone covers a geographical area of 9,104km^2 falling mostly in the rural parts of 15 districts (out of total 38). More than 10 million people (~10% of state populace) reside in the risk zone with the dependency on the shallow contaminated aquifer for their entire drinking need. If 10 ppb limit (WHO 1993) is considered, this number can be many folds. Besides, the entire irrigation of these intensively cultivated tracts is also dependent on the same contaminated aquifer. It is apprehended that the arsenic may enter the food chain through food grains and dairy products.

Analysis, results and implications for policy and/or research

The arsenic contamination zones in MGP remain confined to the palaeo-/abandoned channels and their adjoining belts. Ironically, these patches are highly fertile and richly cultivated through multi-cropping systems for paddy, vegetables and pulses. The common groundwater abstraction structures are shallow tube wells (STWs), tapping aquifers between 15-40 m, which possess arsenic groundwater. Water lifting is cheaper, since the water level remain shallow round the year; between ~2.0 m and ~8.0 m with annual fluctuation in the range of 1.5-4.5 m. The present work investigates and assesses alternate safe and sustainable sources of water for irrigation after due consideration for safe drinking water. A strategic model for alternate safe sources of water including the groundwater and surface water for irrigation has been suggested. The contaminated area is underlain by a multi-tier aquifer system within the Quaternary alluvial deposits down to the depth of ~600 m below ground level (bgl). Within the depth of 300 m bgl, there exists a two-tier aquifer system, separated by middle clay of 5 to 25 m thickness. The downward extension of the upper aquifer varies between ~50 m and ~90 m bgl. This aquifer bears groundwater arsenic either in its entire thickness or in parts at its upper levels. The middle clay behaves as an aquitard and its vertical permeability lies in the range of 0.047-0.0072 m/day. The piezometric level of the deeper aquifer stands at <1.0 m to 2.0 m above the hydraulic head of the shallow aquifer, indicating separate flow regimes of the two aquifer systems.

The deeper aquifer is of high potential with the transmissivity and storativity values ranging between 3000-7000 m^2/day and 0.001-0.004 respectively. The contaminated area in the state possesses a net annual replenishable/dynamic groundwater resource of 2.80 billion cubic meters (bcm). The current draft for irrigation is 1.04 bcm. On an average, 64.6% of the area is put to cultivation with the

cropping intensity at ~134%. Considering the annual crop water requirement as 0.45 m, the volume of water required to meet the irrigation for the gross area cultivated can be estimated as 3.55 bcm. Drinking water need in the area is ~0.26 bcm @ 70 litres per capita per day. Thus, a volume of 3.81 bcm water is required from sources other than the contaminated upper aquifer. Arsenic free groundwater from the deeper aquifer can be exploited for irrigation purpose. Hydraulically and environmentally safe yield from the aquifer, worked out on the basis of storativity concept (area X change in piezometric level X storativity) stands at 0.07 bcm. An additional flux component of 0.54 bcm, worked out on the TIL concept (where, T-transmissivity, I- hydraulic gradient and L- piezometric level contour length) is also available. These resources, even taken together (0.61 bcm) cannot meet the irrigation requirement. Exploitation of additional volume from the deeper aquifer may lead to decline of the piezometric level below the head of shallow aquifer, thereby inducing downward percolation from the contaminated aquifer. The dug wells (DWs), which were under regular use prior to 1970s, have been replaced by STWs. The DWs remain free from arsenic contamination. The sandier areas (scroll bars, point bar plat forms etc), lying close to the contaminated patches display low groundwater arsenic load (often < 0.003 ppb) in the STWs. The geographical area of a meander scar of Ganga varies between 75-100km^2. A study reveals only 25-30% of this area as arsenic contaminated. Thus, about 70% of the dynamic groundwater resource (~1.96 bcm) is contamination free. However, a greater volume of the resource can be exploited for irrigation through installing STWs in safe zones and using DWs in a larger scale in the entire area. The consequent lowering of water table will enhance the scope of additional development from the deeper aquifer. Artificially recharge avenues may be created for the deeper aquifer to augment its head, so that the development potential of the aquifer is increased. The annual rainfall in the area varies from 991 mm to 1280 mm, with 85% as monsoon contribution (June-September). 75% of the annual precipitation (9.0-11.7 bcm) goes as surface run-off and evapo-transpiration. There exists scope to retain 5-10% of the run-off for irrigation through the construction of artificial structures and the use of natural depressions in the flood plains. Controlled development from the deeper aquifer coupled with extraction of groundwater from the safe zones of shallow aquifer can meet the irrigation demand in the arsenic contaminated areas. The system can be supplemented by surface water irrigation through rain-water harvesting and strengthening the deeper aquifer system through recharging it.

Determination of the Presence of Eggs and Larvae Ascaris Lumbricoides from the Biosolid in Composting Process in the City of El Alto, Bolivia

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Keywords: Ecosan, sumaj huasi, Bolivia

Introduction and problem identification

Currently many countries are developing organic fertilizer from human waste, such as from urine. (Pradhan et al. 2007) and (Phuc et al. 2006, Tajima 2007) Composted human waste contains micro nutrients that can be used as an organic fertilizers in agriculture. These nutrients can also be used in application on forestry with less risk to public health. However, the problem is to obtain a safe use of these organic fertilizers as it is important to demonstrate the absence of pathogens in the final product. The absence of pathogens is important and ideal, the risk of for people to be exposed to pathogens due to composting is quite low. Therefore it is important to demonstrate with indicators the safety of the final product. The "Ascaris lumbricoides", can be used as an indicator of the deactivation of all pathogens, as they are very enviornment resistance.

The method used to determine the presence of viable Ascaris Lumbriciodes eggs in compost samples is taken at different processing times (3, 6, 9, 12 and 20 months). This is based primarily on the visualization and quantification of eggs and cysts, in each stage of development from the embryo, with no evidence of developing embryos, and embryos developed to larvae. The viability count was carried out or moving hatched larvae inside the eggs.To view the viability, recounted the number of larvae hatched or moving inside the eggs.

Linkages Between Water Supply and Sanitation (WSS) and Food Security in Four Villages in East Hararghe Zone, Ethiopia

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Keywords: food security, household, linkage, sanitation, water supply

Introduction and problem identification

The aim of this study is to assess the linkages between WSS and food security at a micro level by taking a sample of four water scarcity and food insecurity villages in East Hararghe Zone of Oromiya Region in Ethiopia. Food security has a strong relationship with agricultural performance. Access to safe drinking water reduces exposure to a variety of diseases that obstruct the intake and utilization of food, as well as expenses related to health.

Analysis, results and implications for policy and/or research

This study uses an analytical framework that identifies the multiple attributes related to both WSS and food security and offers assumptions as to the nature of their interconnections. Access to sufficient and safe water on a sustainable basis will help in the various dimensions of food security that is, reducing vulnerability to shocks; increasing food availability and access; and enhancing the utilization components by improving health and sanitation. It was found out that the majority of respondents in all four villages believe that their inability to produce sufficient grain and rear livestock deters them from becoming food secure. All respondents underline the significance of water supply for crop production. Introduce schemes for household consumption, sanitation, livestock watering and irrigation.

Participatory Governance a Highway to Food Security

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Keywords: Irrigation, migration, malaria, participatory governance, food security

Introduction and problem identification

The episodes like recurring malarial deaths and disease relapse now have become the order of the day of the farmers in the endemic kattamaduvu in Dharmapuri district, Tamil Nadu. The major reasons studied were irrigation development accompanied with mismanagement and migration. Kattamaduvu with the distinct geographical structure like meandering rivers and its consequent pools, open wells, improper shutters in tank, incomplete removal of tank silts, inadequate drainage facility and its resultant perturbed flux, furnished suitable grounds for malaria proliferation. With irrigation water mismanagement and the unrewarding cultivation, the farmers particularly marginal and landless migrated in search of their livelihood to the nearby industrial centres where the asylums have become death beds.

Analysis, results and implications for policy and/or research

The present study emerged with the central questions; what were factors responsible for the farmers to lose their lives while they went in search of their livelihood? How did malaria affect food security in the endemic places? And what could be the best bets in controlling malaria to enhance food security? The objectives were to identity the predominant risk factors of malaria with the view to analyse its impact on food security and to evaluate the participatory governance in endemic places. Using purposive sampling method, 200 farmers were selected (80 landless, 60 marginal, 55 small and 5 medium). At the outset a focused group discussions helped in identifying the endemic population.

Then using Semi- Structured Interview method, Cause and Effect, Time Trend and Observation methods the data were collected. The results were then analysed with simple percentile analysis and PRA methods. The study came up with the conclusion that malaria showed a great problem in a stone quarry area Hosur Bande approximately 75km, from Dharmapuri district. Investigation was carried out from April 1998 in this area. A total of 560 blood smears were collected in 1998. All were found positive; 93 P. vivax, 455 P. falciparum and 12 mixed infection. An. culicifacies was the main vector (mrcindia.org). People of kattamadoo has the history of migrating to Hosur Bande to work in quarry. This is true to all in kattamadoo small farm and landless households who migrated to the nearest places like Bangalore and Hosur to take up construction and quarrying works. The farmers who migrated, fell prey to malaria and they gave away their lives. Apart from the above the other major risks identified in katamaduvu due to mismanaged irrigation water and its consequent migration were; Non-compliance with drug regimen, lacking follow up, absenteeism from work and school, wage cut, unattended family responsibilities, bereavement and its consequent psychological stress, mental illness, orphans, widowhood and its social and economic and psychological set backs all these ultimately affected the family earning capacity which aggravated poverty and affected food security. The best bets controlling malaria and enhancing food security in Kattamaduvu were the following.

Social:
a. Poverty: The lower the caste group was the higher the migration pattern observed among them. The poor and the lower caste households did not have proper sanitation facilities. In many villages, the state administration provided electricity, sanitation facilities, and water pumps in the upper-caste areas, but neglected to do the same in the neighboring, segregated Dalit (lower caste) area.
b. Community participation: Identification of malaria cases by health staff and community members was difficult and highly variable due to the absence of distinct symptoms and multiple differential diagnosis possibilities (Chaturvedi H et al, 1989). This combined with variations in cultural perceptions and interpretations of symptoms resulted in health deterioration and discouraged early presentation for all fever episodes. In kattamaduvu, as was the case in many traditional societies of India, causal events were given a religious dimension, such as breaking of taboos, and sorcery. These had all been identified as underpinning health, illness and misfortune. These customary beliefs were intrinsically interwoven with Hinduism.

Engineering:
Lacking prioritisation of irrigation interventions i.e from the most demand driven to the least was witnessed here. Particularly taking up interventions from hydraulic unit level, on the basis of social, economic, geographic and spatial imbalances was a great challenge.

Medical:
In all the health centres, the HSC's could not function effectively as the number of health workers was very small who had to be engaged in other massive programmes like polio immunization and family planning. The laboratory was ill equipped and the inadequate fund provided by the government for malaria control was also a reason for the failure of the wide reach of the health workers. With increasing negligence by the government and poor public response even efficient services at times have taken the back seat.

Legal:
The goal of conducting health campaigns, processions and sensitizing programmes to make participatory ideology in policies a mandatory to all health and irrigation management practices gone void of attention.

Economic:
Empowerment could not make way to strengthen the community especially the downtrodden, women and children, health specialists and health workers as there was least importance given to the inclusive development in empowerment interventions.

Political:
Political Associations of health and irrigation bureaucrats. The mission of malaria control with the vision to curtail the fatalities and increase food security could be possible by implementing participatory malaria control, empowerment of poor and women, efficient diagnosis.

Technological Measures for Improving Agricultural Product Quality and Reducing Healthy Risk at Wastewater Irrigation Land

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Keywords: food quality, wastewater irrigation, healthy risk, heavy metals, natural treatment system

Introduction and problem identification

The field investigation and experiments were conducted for ages to make the available measures for effective wastewater application in agricultural irrigation with a guarantee for food quality. The case study was performed at West Gansu where a large metallurgical enterprise stands. Here, the annual precipitation is less than 100mm, however, the evaporation exceeds 2150mm/y. As the region is close to gobi-desert, the industrial and domestic wastewater of 40,000 m^3/day was directly discharged into the deep desert after the secondary treatment. The households living along the wastewater discharge channels used to pump wastewater to irrigate winter wheat, summer corn and vegetables, so some food products were contaminated by heavy metals, which caused the healthy problems, especially the incidences of chronic diseases of digestive system and itai-itai disease were higher than other regions. The valid measures were studied for effective wastewater irrigation to guarantee food quality.

Analysis, results and implications for policy and/or research

The study area is located at an oasis of dry West China, where groundwater is the main water resource for living, agriculture and industry. However, the water table sharply declined from 5m into 70-90m below surface because of over-drawing in past 3 decades, so water shortage has become the key issue for economic development. Since 1990's, the local metallurgical enterprise has gained the water supply from a reservoir through long-distance transfer, and wastewater was discharged into desert after the secondary treatment. Thus, the disposed wastewater was used to compensate for irrigation water scarcity. However, the unreasonable wastewater irrigation resulted in the apparent accumulation of heavy metal residues at top soils within 20cm deep, even beyond the agricultural soil quality standards at some lands. The main heavy metals residues analyzed were Pb, Cd, Cu and Zn that are very influential to plant growth and could be stored in tissues. Furthermore, food products proved to have the high contents of Cu in wheat grains ranged as 11.64-19.37mg/kg, exceeding the Chinese food standard by 18.21% when overage contents of Fe, Pb, Zn, Cd as 14.82, 0.117, 36.23 and 0.076mg/kg, respectively. The contents of heavy metals in corn were little less than in wheat, but all the contaminants could be detected in corn. The qualities of oil plants and vegetables were impacted by heavy metals with the evident selectivity. For instance, radish was very sensitive to Cd in the heavy metal contaminated land instead of absorbing other metals when Cd and Pb are easily accumulated in cabbage. Overall, vegetables can adsorb and store the heavy metals according to the metal activities following the order as Cd > Zn > Cu > Pb in this sandy soil. The analysis indicated that the heavy metals could obviously be found in the vegetables irrigated by the wastewater. At most cases, the individual content was below the acceptable level, but the total accumulative quantity still had a healthy risk for local people if eating for ages, which might be the reason for local people to be suffered from digestive diseases in past. To sufficiently and technically use wastewater, the research project turned to strengthen wastewater treatment for irrigation purpose.

The oxidation pond and land treatment system were chosen for implementation since the wide waste lands are distributed in study region. Both the industrial and domestic wastewaters were collected and discharged into the three oxidation ponds that were connected together in series where the wastewater retained for totally 3 months before the further treatment in the land treatment system. It was evident that the quality of wastewater achieved the irrigation water standard already after retaining and flowing through 3 serial ponds. In comparison with the influent into the first pond, the effluent from the third pond only had the limited concentrations of heavy metals by removing 86-94% when suspended solids (SS) was removed by 97.4%. The SS sediments contained high concentrations of heavy metals about 540-680mg/kg. At the land treatment field, the pretreatment wastewater infiltrated vertically until reaching groundwater table with a hydraulic load of 26m/y, which had the formal depressing cone recovered, and gradually formed a water dune. The groundwater quality was good enough, even almost matched with the drinking water standards except for F-coli number of 5-8 cells/ml. Households were strongly suggested that vegetable could only be irrigated with the groundwater treated through land treatment system. To guarantee the crop quality, the research also determined the safe irrigation periods for the application of recycled water. At the early growing period, crops could be irrigated by the lagoon-treated wastewater, but could only be irrigated with land-treated water during both blossom and seed filling time. The recent analysis of Pb, Cd, Cu and Zn in samples of wheat and corn indicated that the contents were much lower than the safe limits according to Chinese Food Standards for Heavy Metals. As the vegetables generally grew in green houses in study areas, vegetable could always be irrigated with the wastewater treated at the land treatment system, but the lagoon-treated wastewater were absolutely forbidden for direct application in greenhouse. Following the new wastewater application measures, the contents of heavy metals in vegetables reduced sharply by 71-84% when only trace quantity were analyzed, even Cd and Pb were undetectable in some samples. Because households keenly accepted the knowledge and new irrigation methods, the statistics of local public heath & hygienic office proved that chronic diseases of digestive system reduced by 62%, meantime, the new patient of itai-itai disease was never found since using the wastewater retreated with oxidation ponds and land treatment system following the application utilization regulations recommended.

Workshop: Safeguarding Global Food Security and Life Supporting Ecosystems

Black Soldier Fly Larvae – A Sustainable Protein Source?

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Keywords: ***Hermetia illucens***, sanitation, sustainable, fishmeal, aquaculture

Introduction and problem identification

Wild caught fish and fish trimmings are used to produce fishmeal, which has been used in farming and food production for centuries. Used as a protein supplement in aquaculture, swine, and poultry farming, demand for this important protein source has increased in line with the world population and is now starting to outstrip supply. With the limit to how much fish can be captured in the wild already reached, this is not a sustainable solution to the world's protein shortage. Alternative sources are needed which do not jeopardise wild fish stocks any further.

Analysis, results and implications for policy and/or research

There has been an increase in research into replacements for fishmeal, focusing on lowering costs, improving sustainability and maintaining the nutritional quality of the feed. Some protein sources researched include plant protein concentrate, animal by-product meal, and insect larvae protein. The partial or full replacement of fishmeal with these alternatives has varied levels of success. One of the most promising alternatives is the use of insect larvae as a substitute, more specifically the larvae of *Hermetia illucens*, the black soldier fly. Our research has examined the potential of Black Soldier Fly larvae (BSFL) to turn waste into protein and other valuable products to help address this issue. Black soldier fly larvae are detritivorous insects used regularly in household composting and as a food supplement for exotic pets. Research shows the larvae can consume large quantities of organic materials, including household waste and animal manure. They are efficient enough to provide a manure management system in chicken and swine farming situations; reducing the manure significantly, reducing egg laying of the fly *Musca domestica*, and reducing odours produced by the manure. The final larval stage of the black soldier fly is known as the prepupal stage and has high protein and fat contents, 42-45% and 31-35% respectively. Research has found that the prepupae can be converted into biodiesel, processed into high protein animal feeds and have the nitrogen extracted from the chitin. There is already evidence that the prepupae are a suitable replacement of fishmeal for fish and other animal diets. Our studies have focused on whether human faecal waste, of which there is an ample supply globally, can act as a substrate for larval development. We have shown for the first time that BSFL are capable of developing successfully on fresh human faeces in a lab environment. Initial studies showed that there are no significant differences in larval and prepupal weights ($p=0.93$) when the larvae feed on vegetarian or omnivore human faeces, and that the larvae reduced the faecal weight significantly compared to a control ($p=0.0029$). Further experiments tested the effects of different feeding regimes on larval and prepupal weight; these will be important in developing practical applications of this approach linked to improving sanitation provision. In these experiments we varied the feeding ratio (1000 or 100mg faeces/larvae/day), the absolute number of larvae, and the frequency of feeding (either all at start or every two days). The results showed that larvae fed smaller amounts more frequently developed faster but were significantly smaller than larvae fed on one large amount. Some differences in prepupal weight were found for the different feeding ratios.

The greatest mean prepupal yield was obtained overall from a ratio of 1000mg faeces/larvae/day, feeding frequency of once at the start and was 0.315g. This is higher than prepupal weights found in four other studies of BSFL fed on different feeding materials.

These experiments strongly support the use of BSFL as a means of generating valuable protein from human excreta, thereby leading to both environmental and sanitation benefits. Future research and development aims to determine the viability of BSFL as a means of treating human waste from pit latrines, resulting in improved sanitation in rural and peri-urban communities in developing countries. The advantages of using BSFL as a sanitation method go beyond a safe means of treating dangerous human waste. With the growing world population, and increasing demand on aquaculture farming, BSFL could provide a sustainable, environmentally friendly, and commercialisable alternative to fishmeal and its negative impact on marine ecosystems. I would like to acknowledge the Bill and Melinda Gates Foundation as the source of funding for this research, and thank Belen Torondel and Seth Irish for their advice and support.

An Ecosystem Approach to Water and Food Security

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Keywords: agro-ecosystem, ecosystem services, water management, food security, IWRM

Introduction and problem identification

With a growing global population and the increasing impacts of climate change, sustainable use of ecosystems and water for food security is a great challenge. Recognizing the multiple functions of agroecosystems and the many services they provide is essential to fostering an integrated ecosystem approach to natural resources management, agricultural production, and food security. The services provided by agroecosystems can be optimized through appropriate land use planning that takes into account the limits of each ecosystem's carrying capacity, while multiple users need to be brought together in common management arrangements to sustainably reconcile the needs of food production and ecosystems services. Thus food production can be made more sustainable; more productive by producing more food, services, and benefits per unit of land and water; more resilient to climate change and other shocks; and more compatible with sustaining other ecosystems with their functions and services.

Analysis, results and implications for policy and/or research

Inter-sector collaboration at ministerial level is essential to ensure good ecosystems care while providing the necessary food and services to communities. There is scope for actions at all levels and scale: local, national and river basin level. Managing for multiple ecosystem services at landscape level, through Integrated Water Resource Management (IWRM) that considers all sources of rain, surface and groundwater, can be a powerful and sustainable response to freshwater scarcity. Thus, more resilient ecosystems can support a wider range of ecosystem services, including water management functions that are crucial for stable food security, and become more diverse and more productive, also in the longer term. Managing agriculture as agroecosystems embedded in a diverse landscape will not only produce food, but also deliver a whole range of other ecosystem services necessary for long-term food security. This can be achieved by diversifying the landscape; introducing multipurpose trees to tighten water, nutrient and carbon cycles; managing surface water and groundwater to bridge dry spells in crop systems; careful nutrient management; innovative field practices and adapted cultivars; providing healthy aquatic ecosystems with clean and oxygenated water for aquaculture and fisheries; and supporting livestock management strategies that improve animal health and survival, supplemented by broad feeding strategies and sustainable grazing management practices.

Ensuring Global Food Security, Healthy Ecosystems and Green Growth with the System of Rice Intensification (SRI)

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Keywords: system of rice intensification, climate-smart agriculture, water use efficiency, pro-poor green growth, food security

Introduction and problem identification

Sustainable ecosystems and their role in assuring water availability are vital for food security. Countries around the world do experience rapid economic development, paralleled by population growth and poverty, an intensification of agriculture, and depleting resources. The effects of climate change do add to these challenges and intensify the multiple pressures to ecosystems and natural resources, including water and biodiversity. Especially poor farmers depending largely on rice production do face increasing difficulties to sustain food security and a living.

Analysis, results and implications for policy and/or research

The Mekong Delta of Vietnam is only one example for the mutually interfering challenges to global food security and life supporting ecosystems: The intensive use of agrochemicals and antibiotics in agri- and aquaculture cause heavy water pollution in the regions' ample aquatic ecosystem, the Mekong River. Prevailing rice production techniques rely on huge inputs of water. In spite of increased production output in the last decades, further output growth is nowadays diminishing and constrained by factors such as decreasing soil fertility, limited land area and climate change impacts.

On top of this, many small-scale rice farmers face reduced profit margins due to the constantly rising input prices. Given this set of factors, previous development efforts focusing on one single objective seem to have reached their limits. In contrast, combined solutions may set future standards by teaming economic growth with poverty orientation, climate change mitigation and adaptation, through sustainable production. With so-called Green Growth, we may be able to achieve more with less inputs and resources and thereby sustain robust ecosystems and food security. Again, an integral part of Green Growth is climate-smart agriculture. Proven by numerous examples, climate-smart agriculture sustainably increases productivity, resilience, climate change adaptation and mitigation, and adds to achievement of food security. One such climate-smart option is the System of Rice Intensification (SRI), which successfully addresses the above challenges and is being practiced in more than 35 countries already. SRI is not a technology in a conventional way, but rather a flexible set of practices aiming to provide the best environment for the rice plant to utilize its potential, and to improve the productive efficiency of land, labor, nutrients, capital, and water. Thus, it constitutes a low-cost strategy for rapidly increasing yields of smallholder (rice) farmers while reducing their need for inputs. Besides water savings of up to 40%, SRI leads to a cost reduction of around 23% per ha, including up to 90% less seed and reduced reliance on chemical fertilizer and pesticides. Yield increases of circa 50% do result in increased incomes up to 70%.

With regard to adaptation and mitigation of climate change impacts, SRI practices reduce methane gas emissions and nitrogen fertilizer use, and result in more resilient plants. SRI has shown positive social effects through active participation and responsibilities from the SRI farmers. Lastly, SRI contributes to maintaining biodiversity in terms of soil biota as well as seeds.

This presentation will embed the example of SRI into the broader context of climate-smart agriculture, constitutive for Green Growth, global food security, and robust ecosystems, including water. The presentation illustrates SRI-experiences and research from several countries while highlighting its water-saving features.

Intensification of Livestock Production Systems: Driver of a Regime Shift in Water-Related Ecosystem Services in Uruguay?

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Keywords: livestock intensification, water-related ecosystem servic, regime shift, soybeans, Uruguay

Introduction and problem identification

Globally agriculture and livestock production systems are undergoing an intensification process where extensive grazing production systems are transformed into cultivated pastures or feed crops. Conversion to intensive animal feed production affects livestock water requirements and thus, actual consumptive water use associated with livestock production (Deutsch et al., 2010).

This study captures the shift from extensive to intensive livestock production systems for dairy, meat and wool production in our case study of Uruguay in terms of water use and explores how quantitative water numbers can be translated to local, regional, and global impacts on water resources and water-related ecosystem services.

Analysis, results and implications for policy and/or research

This study builds on former work by Deutsch et al. (2010) where a composite matrix was developed to analyze the effects of livestock-related freshwater uses, with hydrological alterations impacting water-related ecosystem services. The matrix is intended to enable quantitative numbers of consumptive water use to be related to and illustrated through local ecosystem services associated with production of feed, fodder and grazing or directly affected by their production. Further, this study is a collaborative effort between the Stockholm Resilience Centre, Potsdam Institute for Climate Impact Research (PIK) and International Livestock Research Institute. This collaboration has resulted in a model quantifying global livestock water requirements related to feed (Heinke et al. in press). This model is coupled to the original matrix and applied to the case study in Uruguay and then further refined to link quantitative data with ecosystem dynamics related to the shift from extensive to intensive livestock production system in terms of water-related ecosystem services (WRES). Uruguay was chosen as our first case study since the intensification process is on-going and has taken place recently, only since 2000. Traditionally, Uruguay has had an extensive pastoral system and has been a net exporter of meat and wool products. However, the consumptive water use and changes in ecosystem services associated with the recent intensification of livestock production are not mainly driven by locally-produced livestock production, but indirectly initially driven by the production of soybeans for export, to be used as animal feed for livestock production in other countries, mainly in China. However, the process of agricultural intensification is now permeating throughout the entire livestock sector, particularly in the dairy industry. Our study has inventoried the changes in management practices associated with intensification in the country that are linked to changes in WRES, whether positive or negative. Present changes in management that we have observed, through our analysis and synthesis of studies performed by our local contacts, are mainly through changes in soils, land use and land cover.

The main changes are:
1) conversion of grasslands and pastures to croplands for feed crop production,
2) improvement of natural grasslands with seeds and fertilizers,
3) removal of pastures in crop rotational schemes,
4) increased continuous cropping with soybeans and other crops,
5) increased use of conservation tillage,
6) increased use of inputs such as fertilizers, innoculants and pesticides,
7) increased field sizes with resulting decreases in edges in crop fields,
8) increasing use of irrigation. Additionally, we are in the field now in February and March and have not yet analyzed our data on two additional metrics, but this will be completed by June:
9) reduction of riparian forest areas,
10) percentage of wetlands in agricultural landscapes.

These management changes can affect multiple ecosystem services. We already see the following results specifically in relation to WRES from the above management changes in Uruguay:
1) lowest soil moisture content associated with continuous cropping systems,
2) reduced soil organic matter resulting from continuous cropping,
3) increased erosion control from use of conservation tillage,
4) positive effects on soil moisture and infiltration resulting from increased macro fauna diversity associated with improvement of pastures,
5) decreased water quality due to increased leakage of nutrients and other pollutants. Again, we are in the field and still quantifying the following linkages:
6) local changes in water levels due to increasing irrigation
7) disappearance of riparian habitat associated with loss of riparian forests
8) whether the removal of wetlands (drainage and ploughing of wet meadows, bogs and marshes) in the agricultural landscape has passed critical threshold levels for several WRES: flood flow, the hydrological regime of streams becomes less stable (higher peaks flows and lower base flows between rains), higher loading rates of suspended solid-per-unit-area than watershed with more than 10 percent of wetland cover.

Impact of Fertilizer Subsidy on Paddy Production, Livelihood and Water Quality of Kala Oya Basin in Sri Lanka

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Keywords: fertilizer subsidy, paddy production, water pollution, nitrate-N, Kala Oya Basin

Introduction and problem identification

Paddy is the single most important crop in Sri Lanka and occupies 34% of the agricultural area of the country. Around 20% of the total population, 32% of the total labour force and 50% of the agricultural labour force of the country are involved in the paddy sector. In order to safeguard the livelihood of the poor rural paddy farmers and to cater the food requirement of the country the government implemented an agricultural development programme named Kethata Aruna (promoting paddy sector) in 2005. Under this programme, the government subsides over 90% of the full cost of recommended amounts of paddy fertilizer, namely; Triple Super Phosphate (TSP), Muriate of Potash (MOP) and Urea. Therefore, an increased use of fertilizer in paddy sector is expected as a result of this subsidy.

Analysis, results and implications for policy and/or research

Use of high amounts of inorganic fertilizer may lead to eutrophication and enhancement of the growth of aquatic weeds thus reducing the quality of water and also interfering with the irrigated infrastructure. Some have attributed this water quality deterioration to the presence of increasing incidence of Chronic Kidney Disease (CKD) prevalent in the dry zone of the country. With this background, this study was carried out to determine whether; a) the subsidy has triggered the paddy farmers to use fertilizer in high quantities compared to the past, b) the subsidy has increased paddy productivity and income, and c) the subsidy has contributed to deterioration of the quality of water in a selected basin.

In addition, an attempt was made to review the present policy and propose an appropriate policy options in view of the findings of the study. This study was conducted in Kala Oya Basin, which is one of the major paddy cultivating areas of Sri Lanka. It is approximately 2870km^2 in size and lies in the dry and intermediate zones of the Northwestern part of the country. KOB has a good hydrological network with a several major reservoirs and about 600 minor irrigation tanks. It also receives water from River Mahaweli via trans-basin diversion. Irrigated agriculture uses more than 99% of the abstracted water in the basin. Statistical data obtained from respective government institutes for the period of 1979 to 2009 were used to graphically and statistically analyze the trends in fertilizer usage in paddy sector against fluctuations of fertilizer price. The impact of fertilizer usage on national paddy production was also assessed. Water quality variation in terms of nitrate-Nitrogen load, electrical conductivity (EC) and pH was investigated for the period from 2001 to 2010 at selected points in the KOB to capture the impact of the subsidy on water quality. To determine the social impacts of the subsidy scheme, a farmer survey was carried out representing 9.1% of the total farmer population of two major paddy farming villages in the basin. Focused group discussion and interviews were conducted to gather relevant information to supplement the findings of the questionnaire survey.

The results indicate that 88% of the variation of the national paddy production is explained by combined effect of total fertilizer, sown extent and the technological improvement. An increase of 1% input of total fertilizer results 0.109% increase in the total national paddy production. Though the Kethata Aruna fertilizer subsidy scheme has resulted higher fertilizer use in paddy sector, it has controlled the imbalance fertilizer usage in the past, particularly the overuse of Urea compared to TSP and MOP. The pH and the EC of basin water have increased from upstream to the downstream. Increase in the EC indicates the deterioration of water quality towards the lower basin, possibly due to accumulation of leached inorganic fertilizers used in the basin. There is a substantial impact of fertilizer subsidy on the livelihood of the rural community. Within the study basin, the average paddy production has increased by 0.54 t/ha as a result of fertilizer subsidy. This has helped to increase the average income of a farmer by Rs. 16,200/ha. In addition, the direct saving due to fertilizer subsidy has saved Rs. 20,690/ha. Therefore, the overall benefit to a farmer is about Rs. 36,890/ha. This may be the reason that the government is continuing with the subsidy policy for the seventh consecutive year. This could be also be one of the factors for decreasing the poverty from more than 20% about few years ago to a less than 7% in year 2011. However, delaying of fertilizer delivery to farmers, inefficient subsidy procedure, illegal trading and leakages among subsectors and the high transaction cost on the government are the major drawbacks of the existing fertilizer subsidy policy. The overall conclusion of the study suggest that it is appropriate to continue the fertilizer subsidy scheme at a higher price, while aiming for a long term target to shift towards more organic fertilizers use for environmental protection and economical sustainability. Strategies to bring private sector to participate in the subsidy programme, strengthening the extension service to make farmers aware of proper application of fertilizer and to avoid adverse impact of water pollution are also suggested.

Resilience Assessment and Modeling of Ecosystem Services in the Volta Basin: Towards Plausible Interventions that Enhance Livelihoods

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Keywords: Volta Basin, ecosystem services, livelihoods, resilience, strategic interventions

Introduction and problem identification

Humans have changed ecosystems extensively to meet rapidly growing demands for food, freshwater, fiber, and fuel but have also caused enormous environmental damage. Despite their importance, ecosystems are constantly undergoing rapid degradation and depletion of the vital services and resources they offer. Sustainable ecosystem services management may alter this trend by supporting interventions that gradually reverse detrimental anthropogenic effects while offering feasible strategies and opportunities for community livelihoods in the Volta Basin of West Africa.

Analysis, results and implications for policy and/or research

The perceptions of communities in the Volta Basin on ecosystem services and the contribution of these services to livelihoods serve as credible indicators for environmental tipping points that need monitoring, modeling and careful evaluation. For example, recent survey data from unstructured questionnaires of randomly sampled Volta Basin communities indicated that 80% of the respondents conduct landscape burning as a management practice, 30% reported incidences of using pesticides in streams for fishing, 75% complained of erosion problems while 60% in riverine communities admitted to clearing of riparian vegetation for agricultural production. Some of the listed practices may have short-term gains but ultimately have long-term detrimental impacts which could serve as a recipe for undesirable transformations and regime shifts. System trade-off analysis will be conducted with the InVEST model to identify strategic interventions that address current problems. Although local farmers in these landscapes house the social and ecological memory of the remnant vegetation, long-term data, traditional knowledge and understanding) which can contribute to their adaptive capacity, they lack the skills and knowledge to sustainably manage their environment. They need to be educated and engaged on coping with transformations in a manner which reverses practices that negatively impact ecosystem services and their livelihoods.

To address the detrimental impact of land use changes and other anthropogenic activities on ecosystem services, this study uses a conceptual framework with ecosystem services as the nexus between environmental habitats and livelihoods. It is hypothesized that water and land management interventions (community engagement, education campaigns and soil/water conservation measures) enhance complementarities for ecosystem services and their supply at multiple scales.

An interdisciplinary approach is used to characterize the bundles of ecosystem services, while geospatial (ArcGIS Spatial Analyst/Arc-Hydro) as well as biophysical tools (the InVEST framework) are used to model, quantify and value ecosystem services in the Basin. Finally, the study is currently assessing trade-offs and synergies associated with using the prior mentioned interventions to enhance ecosystem resilience. Though the analysis of results is on-going, final results from this study could be used as a decision support tool for policy makers and researchers for plausible land management interventions that minimize resource degradation and could have relevance in other global river basins.

Interactions Between Bundles of Ecosystem Services and Livelihood Strategies in Semi-Arid West Africa

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Keywords: ecosystem services, landscape types, livelihood strategies, interactions, dryland

Introduction and problem identification

To improve the welfare of millions of resource-poor rural farmers, a key is to understand interactions between different ecosystem services (ES), including rain fed crop production, and interactions between these ES and farmers' livelihood strategies. The West African Sahelian/Soudanian zone presents an interesting case in this context. The region has a highly challenging hydro-climate, rainfed agriculture is a major livelihood strategy, and multidimensional poverty is widespread. At the same time, a trend of increased biomass productivity has been observed over the past 20 years in this region, both in remote sensing studies(1, 2) and in local case studies(3, 4). However, knowledge on what the observed vegetation change means in terms of ES generation, and how this translates to livelihood impacts, is still lacking. This knowledge is important to identify pathways towards high productive and multi-functional agro-ecosystems in regions where people are highly dependent on local ES.

Analysis, results and implications for policy and/or research

This paper presents a spatial analysis of ES in village landscapes, accounting for intra- and inter-annual variability in ES contribution to consumption and income. It further identifies bundles of ES, and synergies and trade-offs among services that are important for the livelihood outcome of the landscape. The analysis is based on fieldwork in six villages in the Sudano-Sahelian zone in northern Burkina Faso. Three of the studied villages are located in an area where vegetation increase over the past 20 years is at the same time more pronounced, and less related to rainfall increase, according to recent remote sensing studies, whereas the other three villages are located in an area where vegetation increase is less pronounced and more related to rainfall. Participatory resource mapping and transect walks are used to map landscape characteristics and document from where in the landscape different resources are harvested. Satellite imagery analysis is used to further determine the spatial distribution of different landscapes types. Yield of Sorghum bicolor is evaluated on a set of fields in each village. Seasonal calendars in focus groups are used to capture seasonal and inter-annual variability in importance of ES. Based on this data, the paper identifies a set of landscape types and key ES related to each landscape type. It discusses ES appearing together in bundles in the landscape types, and key interactions among these services to identify synergies and trade-offs.

Management practices influencing the generation of ES and interactions among services are also discussed, as they are important shaping the landscapes and patterns of ES. The dominating landscape types identified are 1) agricultural land with scattered trees on sandy-clayey-stony soil, 2) shrub dominated land on more stony land, 3) (temporarily) water filled depressions.

Key ES associated with type 1 are yield of sorghum, millet and groundnuts, shea nuts, baobab leaves, fodder and erosion control. Key ES associated with type 2 are fuel wood, erosion control and pasture. Key ES associated with type 3 are vegetables, rice, sorghum, and drinking water for animals. Generation of ES does not only show spatial patterns, but also temporal variation. When evaluating food security this temporal variation must be taken into account as other ES from the landscape often are crucial when cereals from the last harvest runs out and in case of crop failure. Seasonal calendars drawn in focus groups with women show that leaves and fruits from several trees are collected some months before cereal harvest, when workload is high and last years harvest is finished. This makes them important services not only for consumption in general but particularly for being available during a critical period. Differences in distribution of landscape types and generation of associated ES between the area with more pronounced vegetation change and the area with less pronounced vegetation change will be analyzed up to August. Preliminary results from the yield evaluation of Sorghum bicolor show that yields are low and highly variable between fields, but slightly higher yields for the area with more pronounced vegetation change is observed. Two of the soil and water conservation (SWC) methods used in the region, half-moons and za planting pits, are more common in this area as compared to the area with less vegetation change, indicating that these management practices may contribute to an increased productivity in the area. Stone bunds or vegetation strips to decrease water runoff are the most common SWC techniques, and approximately equally applied in the two areas. Identification of key ES related to landscape types allows for analysis of the change in ES over time, based on earlier aerial photographs and satellite images, and interviews on changes in resource use. Relating the change in ES to change in patterns of livelihood strategies in the villages over time, as well as to regional and global drivers of change will give an understanding of the system and its feedbacks. This systems understanding will be a tool to analyze how livelihood strategies and generation of ES might change under different scenarios taking local, regional and global drivers of change into account. Global drivers of change include potentially changed rainfall pattern due to climate change, market prices of cash resources from the landscapes, and articulation of ecosystem services at a global scale, potentially manifested in payment for ecosystem services schemes. These drivers will be included in a conceptual model of interactions between ES and livelihood strategies.

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Economic Valuation of a Multiple Use Wetland Water System in the Gangetic Floodplain of West Bengal, India

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Keywords: economic valuation, direct uses, ecological benefits, multiple use water system, wetland

Introduction and problem identification

In the Gangetic floodplain of West Bengal, multiple use wetlands play a significant role in the livelihoods of the local people. Over the years, these multiple use systems (MUS) are being converted into single use systems (SUS) for commercial gain by economically, socially and politically dominant groups. Economic and ecological functions of MUS change over time and space. These dynamic aspects of water systems are often not fully recognised. Apart from the main designated use, water systems are often used for other purposes. Multi-functionality of the water systems is a unique feature which makes its conservation and management important for the generation of livelihoods for local people. However, except for the main designated use, the economic importance of supplementary uses is often not fully captured in traditional benefit-cost analysis. As a result, investment in conservation and management of the MUS is often sub-optimal. Often, this results in conversion of the MUS into SUS.

Analysis, results and implications for policy and/or research

In Eastern India, surface water reservoirs such as tanks and ponds are the primary source of water for poor rural households for domestic uses, irrigation and fish production etc. These water systems are characterised by competing water needs and are under severe stress owing to the growing population, intensive agricultural practices and extraction of groundwater. In the absence of good governance, the rights to use water from these water systems are often politically contested. The more politically powerful and socially dominating groups often take control of these systems and convert the system into SUS. In India, wetlands are classified according to their location (mountainous, inland or coastal), water quality (freshwater or brackish/saline), physiognomy (herbaceous or woody), duration of flooding (permanent or seasonal), and so on. However, the type of use and multi-functionality of their economic aspects are missing from the present system of classification. The classification of MUS according to their major and minor uses (both consumptive and non-consumptive), and quantifying the benefits from them in economic terms, is crucial for identifying suitable interventions required to improve their performance. This study explores alternative management options for MUS and based on an illustrative case study, captures economic value of multiple functions of a wetland in West Bengal, India. The uses of wetlands are dynamic and type of use varies across different ecological zones. For example, the wetlands of the Gangetic floodplain of West Bengal are mostly used for irrigation, whereas coastal wetlands are mostly used for shrimp culture because of the sea water interface. The uses also change over the years. For example, a tank which is predominantly used for irrigation in a normal rainfall year might also be used for fisheries purposes in a very wet year when the tank inflows become large. Similarly, in a dry year, the same tank bed might be used for tank bed cultivation when the inflows are insignificant.

Therefore, in order to have a comprehensive understanding, evaluation of MUS should cover different ecological setting (spatial) and temporal scale. Further, the existing property right regimes are important for proper management of MUS. The ownership patterns of the wetland (e.g. common property resource, private property - single owner or multiple owner, and public property) greatly influence the economic performance of the wetland. Therefore, it is also very important to evaluate the performance of the MUS under different property rights regimes. Based on literature review, a wetland (Kalobaur Beel) is selected in West Bengal, India. The wetland is an oxbow lake (cut-off meander) and mean depth of water varies from 3.36m pre-monsoon to 8.39m post-monsoon and the water spread area is 32ha in pre-monsoon and 38ha post-monsoon. Since the whole area is under the Gangetic floodplain, it is flooded for three to four months during the rainy season.

Deposition of silt during rainy season makes the land in the floodplain fertile. The wetland is a MUS, which supports six major economic activities, viz. wetland cultivation [area: 15.4ha, beneficiaries: 70 households(hh)], irrigation from wetland (high nutrient content of wetland water helps farmers to fertilise their crops through its use for irrigation, thereby saving on the costs of fertilisers) (14.8ha, 50hh), wetland fisheries (both indigenous and cultured) (32.4ha, owners: 45hh, non-owners: 30hh), jute retting (64ha), fodder collection (50hh), cattle grazing (50hh), collection of leaf vegetable (50hh) and domestic uses (150hh). Apart from its economic importance, the socio-cultural, local recreational and religious importance of the wetland is also significant. The economic value of wetland cultivation was computed using the incremental benefit from wetland cultivation over upland cultivation and the rental value of land used for wetland cultivation. To assess irrigation benefits from the wetland, productivity difference method and differential cost of irrigation and fertilisation from alternative sources are considered. The opportunity cost method was employed to capture the benefits from wetland fisheries and collection of leaf vegetables. The cost of alternatives approach was used to estimate the benefits of using wetland for jute retting, fodder collection and grazing. The estimated annual benefits from
a) wetland cultivation is Rs. 357197,
b) irrigation from the wetland is Rs. 20313,
c) wetland fisheries is Rs. 585370,
d) jute retting is Rs. 1313375,
e) fodder collection is Rs. 74400,
f) grazing is Rs. 15650 and
f) collection of leaf vegetables is Rs.7020.

The study shows that the largest economic benefits that people living in the surrounding area of the wetland derive are from jute retting followed by fisheries and wetland cultivation. As compared to SUS, MUS benefits a larger number of people belonging to different socio-economic strata.

Policy Support Systems for Benefit Sharing Across Landscapes and Communities in Pursuit of Sustainable Food and Water Security

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Keywords: policy support, benefit sharing, CPWF, Andes, ecosystem approach

Introduction and problem identification

Policy options designed to achieve food security can sometimes reduce the potential to achieve water security, especially where such options rely on unsustainable depletion of groundwater reserves or river flows, thereby denying their use downstream in space or later in time. Achieving combined food and water security in the long term requires environmentally sustainable as well as highly productive agricultural and water management policy. In most settings this is extremely complex to achieve given the lack of information on and complexity of biophysical processes and the spatial heterogeneity of landscapes. Even greater difficulties arise from the complexity and capacity of of institutions, the range of potential interventions and their interaction with development trajectories, poverty, education, social justice and global drivers such as climate change and globalisation.

Analysis, results and implications for policy and/or research

Tackling such complex issues using traditional reductionist scientific approaches that examine in great detail only part of these complex systems, can help incrementally to inform policy agendas but can rarely support the process of decision-making around particular policy interventions in specific places. Such support requires (social) science that integrates across disciplines, is applied at policy-relevant time and space scales, bridges the gap between complex scientific data and knowledge and typical policy-making processes and is based on an understanding of reasonably generic environmental and social processes coupled with locally and regionally specific data. Such policy support has to make use of the best of the existing science and data for a region and be capable of supporting policy without significant investments of time and resources in new science and data.

Policy support systems that combine a scientific-technical toolset and a stakeholder process for co-building, adapting and using this toolset within the policy process are one such mechanism to deliver such policy support. We describe attempts to develop such a system for the Challenge Programme on Water and Food (CPWF) Basin Focal Project (BFP) for the Andes, the BFP cross-basin analyses and the CPWF phase II COMPANDES project through the so-called AguAAndes (WaterWorld) Policy Support System. The system is a highly accessible web-based system that is designed to bring a range of stakeholders together and provide a common platform for understanding the baseline water resource situation in a landscape and the likely impacts of a range of potential interventions designed to achieve sustainable water and food security through land use planning and land management interventions directed at better sharing the benefits of water. The system is used to generate scenarios in an interactive way as part of the negotiation process (as a so-called negotiation support system, NSS) and empowers all negotiating parties with the same access to scientific information and knowledge. Though it is designed to be applicable globally, the focus of this paper is application to the Andes system of basins.

One of the most important factors for successful negotiation of benefit sharing in the Andes context is the level of organization of the communities involved and with effectiveness of communication with the institutions that serve them. Where communities are well organised and communicate with a common purpose the resulting, more-effective communication with external agents is more likely to yield better decision making. A proper appreciation and assessment of community organization and cultural context, are critical to understanding the viability of interventions such as those promoted by the CPWF. Benefit sharing mechanisms require empowerment of stakeholders that may not have the upper hand in negotiations through: strengthening community-based organization, capacity building for self-management, scientific policy support for scenario analysis and the facilitation of a process of negotiation. Successful interaction with local stakeholders requires time spent together and knowledge of the historical background that has shaped the current situation. Flying in and out will not work, rather the permanent presence of external agents who promote and facilitate negotiations to better share the benefits of water is critical. Without doubt many research and development projects underestimate the importance of investing resources in this communication and interaction - which may not generate specific and measurable products for donors - but is nonetheless critical to project success.

The paper uses a series of case studies with communities in the Andes to examine the community-project interactions that work and scientific-technical support requirements for effective decision, policy and negotiation support in the area of designing, negotiating and delivering benefit sharing mechanisms for improved water and food security with a particular focus on ecosystem based approaches.

Changing the Lense: GDP/m³ of Water vs Jordanian Agriculture

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Keywords: Jordan River, agriculture, food, synergies, eco-tourism

Introduction and problem identification

The Jordan River Valley offers an acute and urgent example of the tension between three important goals: maintaining a level of food security, protecting ecosystems, and sustaining farmers' livelihoods.In terms of water resources, Jordan is among the world's four poorest countries. Yet, it is a large exporter of high-water input produce. 65% of its water is allocated to agricultural production at the cost of the Jordan River's ecosystem, which before reaching the Dead Sea has been reduced to a trickle of waste water. Meanwhile, water is the limiting factor in agriculture, and with given production patterns, and narrow income margins for farmers, restrictions in water uses would lead to smallholder farmers leaving their land in a country with high rates of urban unemployment.

Tourism development is increasingly put forward as a high-value alternative which would profit from a rehabilitated river, but has been associated with high water waste an inequitable distribution of income.

Analysis, results and implications for policy and/or research

Our analysis of the Jordanian food system, its production, import and export structure showed that food sovereignty in the sense of domestic production meeting the population's daily food consumption seems impossible given dietary patterns. 98% of Jordan's cereals are imported, and bread often constitutes half of a person's daily calorie intake. Jordan's agriculture focuses on vegetables and fruit, where production exceeds national demand and is largely oriented towards exports. Farmers produce highly water intensive and unprofitable crops like tomatoes, or water intensive crops whose value is linked to import barriers only, such as bananas. In Jordan, food security is thus rather a question of ensuring safe and reliable import supply chains for cereals than it is of maintaining levels of national production of fruit and vegetable production. If agricultural production in terms of tons of produce was decreased and its generated income replaced by other resources covering necessary cereal imports, water could thereby be returned to the River. The most visible sign of a need to rethink the sharing of water between people and nature is reflected in the Jordan River's trickling waters. It is estimated that 98% of the River's original flow has been diverted, mainly for agricultural purposes and mainly by Israel and Jordan, and that 50% of the Valley's biodiversity has already been lost. In order to preserve the remaining biodiversity and partially restore disappearing wetland ecosystems, it is estimated that a third of the River's water would need to be returned, necessarily implying a reduction in water use in agriculture. Israel, Palestine and Jordan are expected to establish national master plans for the River's rehabilitation. This raises two sets of questions: would this endanger food security, and what would become of the Valley's farmers?

In this paper, ideas for water-wise development opportunities are explored. Fruits and vegetable production is of very low profitability to farmers in the valley, for whom water scarcity, increases in energy and labor prices, as well as unfavorable marketing channels only allow for very slim and unstable profit margins. In the face of high urban unemployment, migration towards cities does not appear as a solution. ue to its very rich historical, cultural and religious heritage, the Jordan River Valley has a strong tourist potential and is often presented as the valley's economic future.

Tourism, as experienced in many Mediterranean countries is a two-edged sword however, especially with respect to water resources which are being disproportionately tapped from surrounding populations for showers, swimming pools etc. If tourism in the Valley is to be sustainable in terms of water, it would need to be of very light environmental impact. It must itself use little water, and can allow for synergies with sustainable agricultural practices through produce sourcing. A flowing Jordan River combined with a promotion of the specificity of its natural characteristics would invite a more responsible form of low-water use tourism, or "eco"-tourism. This paper does not aim at giving a comprehensive answer or solution, but identifies possibilities of synergies and convergences instead of opposition between food production, farmer livelihoods, eco-system preservation, and responsible tourism. It explores the potential for sustainable and water-saving agricultural practices through new marketing channels, in relation to eco-tourism or even agro-tourism initiatives in the valley. The aim is to explore possibilities for diversification of rural population's income while avoiding a brutal opposition of agriculture and tourism. The methodology followed included extensive interviews of competent actors from civil society, development projects and farmers and focused on case studies of small grant initiatives, permaculture projects, and eco-tourism initiatives.

An important part of the research consisted in talking with existing hotels of different standards - to assess their willingness to source produce directly from farmers at a higher price if related to higher quality and different production practices - to engage in water saving plans, and - to inquire about their customer's acceptance of low-water use behaviors. The main focus of case studies was to identify conditions for success of existing projects and the main obstacles they faced. We find that for sustainable development in the Jordan Valley and a healthy Jordan River, not only will agricultural production need to be constrained and practices revised, but also, a very different form of tourism, less water-intensive and closer to the Valley's ecological and cultural reality will need to be developed. If plans to develop the Valley's tourism potential are to go forward, public authorities will need to play a key role to direct the form tourism will take.

Application Possibilities of Domestic Wastewater with Reuse in Agriculture in Rural Communities of Brazil

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Keywords: sewage treatment, bio-digesters septic tanks, agriculture application, water reuse, agricultural productivity

Introduction and problem identification

The field of Sustainable High Aiuruoca Design was around the National Park of Itatiaia, Itamonte and Alagoa municipalities, Minas Gerais, Brazil. In that region has a decline in production activity and increased tourism. This project aimed to develop sustainable local leading the population to engage in the preservation of natural resources and their own means of production and culture. The focus was to recover riparian forests and reduce river pollution.For disposal of domestic sewage, 78 septic bio-digesters tanks were installed in rural communities of Serra Negra,Campo Redondo, Fragrária, Capivara and Vargem Grande.The tourism requires sustainable production methods and protection of environmental heritage. We tried to devise the applications methods of effluent to more environmental protection and health, increasing agricultural productivity,reducing soil contamination, groundwater and surface water sources, with the advantage of generating effluent for use as organic fertilizer.

Analysis, results and implications for policy and/or research

At the study area, the properties were randomly selected to be interviewed and made checks of the operation of bio-digesters tanks up and running as well as for collecting effluent samples. The following data were collected in the form of direct question and observation location:

a) owner's name,
b) location
c) number of residents in the home;
d) number of boxes installed;
e) the current situation of bio-digester tank, with respect to the enclosure protection, control of weeds and cleaning the place where it was installed;
f) current state of conservation with respect to leaks or broken parts;
g) so that the user utilized the effluent, so that the target type and application system;
h) major aspects of management adopted to control the process of digestion;
i) potential problems observed in the initial installation of the Fossa
j) personal assessment as to the result of application of biofertilizer when applied to crops;
k) as could be facilitated the application of the effluent;
l) what were the strengths and weaknesses of the installation of bio-digesters tanks;
m) how is the maintenance of equipment, as well as the last application of green manure diluted in water and
n) reports on the rate of increase in production from the use of biofertilizer organic effluent.

At the end of the interview, it was collected a sample of the liquid effluent from the third box Fossa, filling a plastic bottle of 250 ml, as APHA, 2005. At the time of sampling it was determined the conditions of some protection, occurrence of odors, presence of weeds, the general condition of the Trench boxes for leaks and damaged parts, and mainly on the hydraulic system and collect the effluentdistribution even in the area of application for the purpose of agricultural use or disposal in soil or water body receptor. In the conditions of this study was conducted, it can be concluded that:
- The premise of improving sanitation generates effluent used as organic fertilizer for crops, was the positive aspect of this initiative, but the results show the need for monitoring and enhancing the awareness of producers, as to the proper management, maintenance and greater control in the use of biofertilizer as a real factor in their increased production cultivated areas. In addition to difficulties occur in the initial acceptance, are currently running 67.69% of the pits, considering the 65 homes where access is allowed during this work.

- There is no allegation of problems in the management, but the pits that are in operation only 29.55% are operated correctly.
- There are multiple uses of the effluent from the same Fossa, indicating some recovery of biofertilizer by some residents, but much of it still makes your disposal on the ground or water course without any use of their nutrients. 52.27% applicable in grass, field 45.45%, 2.27% in gardens, orchards 15.91% and 9.09% in other cultures.
- There is also a very systematic use of the effluent by insecurity and lack of technical knowledge of the relationships water-soil-plant-atmosphere.
- As for the efficacy of treatment was observed the occurrence of pathogens and odors, but the nutrients, Na and K, and other parameters turbidity, pH and EC concentrations were not compatible with NOVAES, et. al. (2002).
- The presence of concentrations of faecal coliform and faecal coliform not, Salmonella and Enterobacteria in power from 104 to 106 CFU/100 mL, shown by bacteriological analyzes reveal the inconsistency in the handling of pits, as its creators had much lower values in tests with this type of bio-digester tank;
- 96.67% of the samples in concentrations below the recommended limits for drinking water, by Ordinance 518/2004-MS;
- The turbidity by 50% of the samples were above the limit recommended for freshwater Class 2, according to CONAMA Resolution 357/2005, while other 50% were below this limit;
- The pH of samples are made between 7.04 and 8.30, revealed slight alkalinity;
- The Electrical Conductivity ranged from 2.5 to 5.7 mS;
- The dissolved oxygen was between 0.2 and 1.0 mg / L, which is presented below what is acceptable for the type Class 2 waters, according to Resolution CONAMA 357/2005.
- To ensure sustainability the project, there should be additional training to strengthen their environmental benefits, health and economic, in the region, in addition to studies of soils and crops, which can provide simplified hydraulic systems for greater convenience and control in the application of effluent.

The Double Role of Agriculture towards the Conservation of Water-Related Ecosystem Services in Andean Watersheds

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Keywords: water-related ecosystem servic, Andes, conservation agriculture, irrigated agriculture, environmental economics

Introduction and problem identification

The agricultural sector is a prime beneficiary of hydrological ecosystem services (HES) in many watersheds. It can also be an important agent driving changes in the delivery of these services. Due to this dual role of agriculture in the provision of water-related ecosystem services, it is a priority to develop ways to assess the effects of agricultural practices on the delivery of these services and of the value of ecosystem services for agriculture. This will allow us to:

i) advance towards the recognition of agriculture as an ES provider if certain agricultural practices are adopted; and
ii) include the agricultural sector in institutional and market-oriented mechanisms aimed at increasing cooperation between different water users in the conservation of the ecosystems and their services.

With this in mind, a research for development project in the Andes, supported by the CGIAR Challenge Program on Water and Food, is anticipating and assessing the consequences of introducing mechanisms for sharing the water-related benefits provided by ecosystems. The different case studies have identified agriculture as an important stakeholder playing a dual role as mentioned above. Consequ

Analysis, results and implications for policy and/or research

In the first case, the impacts of conservation agriculture in High Andean hillsides on the characteristics that drive the delivery of water-related ES have been measured in a study site in Colombia. Research findings highlight the ability of conservation tillage to recover the soil characteristics of the paramo ecosystem - a typical natural ecosystem in the High Andes impacted by conventional tillage practices. Basic physical properties of paramo soils are high organic carbon (C) content, open and porous structure, a very high porosity, a rapid hydraulic conductivity and high water retention. These characteristics make these soils a porous "sponge" that regulates water flows, especially during dry periods. They also enhance water infiltration, minimizing runoff and the resulting loss of Nitrogen (N) and Phosphorous (P) from the soil, which affects water bodies downstream. In this sense, reduction on bulk density or increases on hydraulic conductivity, porosity, C content, available water content (AWC) and water retention in paramo disturbed soils under conservation tillage sites will mean an improvement on conventional tillage. Accordingly, permanent measures in soils under conservation tillage have shown that in potato-based systems these practices improved the soil organic matter by 33% in disturbed soils of the paramos of Colombia over a seven year period. This improvement was attributed to the enhancement of soil physical characteristics that are related to soil water movement and storage such as bulk density, AWC, saturated hydraulic conductivity and mesoporosity.

These improvements reflect that conservation tillage allows the rehabilitation of carbon and water-related soil characteristics compared to conventional tillage systems, improving the water holding capacity and water flow regulation, and reducing runoff in these areas. These are some of the main environmental benefits sought by watershed inhabitants reliant on appropriate water regularity and quality. In the second study, the economic value of maintaining the current regularity of water supply for irrigated agriculture in Peru, a benefit provided by the unique natural ecosystems located upstream, was estimated based on local information and with the assistance of crop growth modeling. The marginal economic benefit was calculated for the use of irrigation water for corn by farmers in the Caete Valley as an indicator of the value of the water. This method was applied based on a crop water production function. Using hydrological models, various future scenarios were modeled indicating projected results of differing levels of reduction in water availability for irrigation. From this, changes in productivity and evapo-transpiration for each scenario were forecast. The marginal value of water (US $/m3) for each stage of the crop was then differentially calculated using data about production costs and benefits. The research findings are informing a broader initiative in these watersheds to design mechanisms for promoting the cooperation of HES beneficiaries to maintain and improve the delivery of these ES. In the first case, providing evidence about the positive impacts of conservation agriculture on soil characteristics that drive the provision of HES is aiding targeting actions that can be supported by HES beneficiaries and other actors devoted to conserve these services. In the second case, the generation of an economic value for the HES benefiting corn farmers is being used a s a 'reference value' for negotiation of a scheme to reward HES providers in this watershed. This negotiation is facilitated by the Ministry of Environment of Peru.

Community Managed Bio-Industrial Watersheds: A Model for Enhanced Livelihoods through Sustainable Natural Resource Management

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Keywords: natural resource management, watershed management, community based approach, agro-ecosystem, food security

Introduction and problem identification

Agriculture continues to be a major driver of Indian economy. With more than 58% population involved in the occupation, agriculture continues to be the main source of livelihood for majority of the population. The long time saying "Indian agriculture is a gamble of monsoons" becomes starker with the fact that more than 60% of total cropped area i.e. 88 mha is rainfed. In this backdrop, many a development progammes devised for bringing agricultural development in rainfed regions through integrated resource management have scarcely yielded intended benefits. In this context, a "Community Managed Bio-Industrial Watershed"Project is implemented in Koraput district of India. The programme aims at creation of improved livelihoods through sustainable use of natural resources in rainfed agro-ecosystems. The programme, visualizing a micro-watershed as an industrial unit of agricultural production, aims at sustainable livelihoods through food security and environmental stability.

Analysis, results and implications for policy and/or research

Koraput is located in the south-eastern part of Odisha state of India. The district extending from 17.4˚N to 20.7˚N and from 81.24˚E to 84.2˚E, is home to rich biodiversity with abundant natural resources occupying its landscape. The mainland of Koraput is contiguous with Eastern Ghats hill ranges and hence has forest cover of 22% out of total area, belonging to tropical semi-evergreen type. The region has undulating topography with Eastern Ghats hills interspersing the landscape with elevation ranging from 150-900 m above MSL. The region is considered as a secondary centre of origin of rice and is one of the important agro-biodiversity hotspots of our country. In this direction, FAO has recently recognized Koraput as one of Globally Important Agricultural Heritage Site, the first in India and eighteenth in the world. Koraput is home to primitive tribal populations with more than 51 tribal groups like Bhumias, Parojas, Gadabas, etc., constituting more than 50% of population. Agriculture is the primary occupation for the tribes practising traditional cultivation systems and majority are illiterate. Poverty is a major socio-economic issue in Koraput and Planning Commission of India has identified Koraput as one among 85 distress districts for integrated development. It is a paradox that inspite of immense ecological wealth, Koraput is also a "poverty hotspot". Severe land degradation, soil erosion, depletion of water resources, depletion of forest cover, lack of storage and market facilities hinder the agricultural growth in this region. In this scenario, the Bio-Industrial Watershed is being implemented in Tolla Watershed region of Koraput since 2007 for bringing improved livelihoods in tribal households through sustainable use of natural resources.

The programme considers the micro-watershed as a unit of agricultural production comprising the following components:

- Sustainable natural resources management specially land and water
- Enhancement in crop production and crop productivity in cohort with local agro-ecosystem
- Post-harvest and value-addition
- Promotion of community level institutions and micro-enterprises
- Provision of backward linkages through technology and forward linkages through market
- Creation of watershed level bio-industries by formation of farmers' collectives for input services and organized marketing

The Tolla watershed, draining into the Kukkadanala stream, has an area of 729 ha spread over 6 villages comprising 272 tribal households living in poverty conditions. The primary occupation is agriculture with all of them being small and marginal farmers. The average annual rainfall is 1440 mm with 73 rainy days. The period of South-west monsoons (Jun-Sep) is the main cropping season. Paddy and finger millet are the chief crops followed by groundnut, maize and vegetables. The Bio-Industrial Watershed programme is executed on a pyramidal framework occupied on the base by sustainable management of natural resources achieving environmental stability leading through enhanced agricultural production achieving food and nutritional security to enhanced livelihoods. Through efficient soil and water conservation measures like compartmental and contour field bunding, contour trenching, the programme was able to reclaim 58 acres of fallows for agricultural use. Rainwater harvesting through percolation ponds, community tanks has enabled a total storage capacity of 9988.5 cu.m catering to irrigation needs of 128 acres rainfed lands providing increased monetary returns. The programme adopts a people-centric approach in sustainable management forming community based user groups for effective maintenance of water structures. All physical structures are constructed with community contribution creating a sense of ownership among the community. Participatory technology development is one important aspect of the programme where modern practices are blended with indigenous methods of tribal farmers for effective technology diffusion in improved agricultural practices, post-harvest and storage. The programme envisaged on a 7 year period is presently in its fifth year. The initial 3 years focused on efficient land and water management practices simultaneously providing capacity building to farmers on improved practices. The next two years focused on sustaining enhanced crop production, saturation of land and water management activities and strengthening of community institutions like water users groups, common property resources and farmers groups. The programme now is in formation of farmer producer organization based on commodities produced by exploring the value chain for better input and market services. Thus, through optimal utilization of the natural resources, the novel Bio-Industrial Watershed initiative has been successful in creating better agricultural opportunities to farmers facilitating enhanced crop and monetary returns evolving sustainable livelihoods.

Support to Sustainable Development in the Lake Turkana Basin for Human Well-Being

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Keywords: governance, conflicts, ecosystem services, hunger and poverty, assemment adn mangement

Introduction and problem identification

Lake Turkana is Africa's fourth largest lake, the world's largest permanent desert lake and the world's largest alkaline lake. It is 250km long with a mean width of 30km and a surface area of about 6 750km^2. The average depth is 35 m while the maximum depth is 115 m. The rocks of the surrounding area are predominantly volcanic. The region is extremely poor and prone to frequent droughts with a history of violence and tension caused by insecurity and competition for water and grazing areas. The area has been a regular recipient of humanitarian aid and relief food. The drought has also resulted in the escalation of armed conflicts over resources amongst the people inhabiting the Turkana region, across borders. Pasture lands are almost extinct. There is no permanent mechanism between the riparian countries to negotiate the issues orginated water resources and use of them in the region.

Analysis, results and implications for policy and/or research

The fundamental environmental challenges and associated issues that need to be addressed in the Lake Turkana basin include first of all the considerable degradation of land, water and biodiversity resources in the Lake basin. The reduced availability of freshwater due to abstraction of river water for irrigation and damming and the degradation of freshwater quality due to its high alkalinity and total dissolved solid concentration, could have devastating effects on biological diversity, ecological life support system in the basin, reduction of fish stocks and other aquatic species in the lake, as well as livelihoods and food supply. The basin has high potential for energy sources, especially hydro power production. Hydro power dependence is yet particularly risky in face of climate change impacts on river and developing renewable energy supplies that are less vulnerable to climate change could diversify the national energy supply as the basin has immense solar, wind and geothermal energy sources that have yet to be exploited. Oil exploration efforts offshore of Lake Turkana are also a prospect which can significantly raise the threat of pollution in the basin. The Lake Turkana Basin could be the key attraction for tourists, major tourism destination areas including Lake Turkana National Parks, listed as a UNESCO World Heritage Site, and other wildlife sanctuaries in the area. UNEP has prepared the project for sustainable development in the Lake Turkana Basin and the aim is to support long-term solutions to the current environmental and social problems facing the Turkana region. The objective of the UNEP project is to assist the countries, and stakeholder of the Lake Turkana to enhance their capacity to sustainably manage the ecosystem services provided by the Lake. Specifically, the project aims at minimizing the expected pressure of natural resources for conflict prevention and disaster reduction, through knowledge-based policy intervention, technology transfer, investment on key infrastructure and monitoring the health of the ecosystem components. The project will be implemented by UNEP in cooperation with the Governments of Kenya, Ethiopia in order to develop a setting up bi- national cooperative management arrangement for Kenya and Ethiopia on lake Turkana and its basin.

Assessing the Private-Economic Costs and Food-Security Impacts of Water Quality Improvement: A Case Study for the Vouga Catchment

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Keywords: diffuse-source pollution, best agricultural practices, abatement costs, food security, catchment management plans

Introduction and problem identification

It is increasingly recognized that diffuse source nutrient water pollution from agricultural activities in coastal catchments tends to have negative impacts on coastal aquatic ecosystems, while these ecosystems are of vital importance from a social, environmental as well as an economic perspective.

The importance of catchment water resources management is addressed in the EU Water Framework Directives (WFD; 2000/60/EC; 2006/118/ECRF), that requires the definition of Catchment Management Plans (CMPs) including actions to meet set water quality standards. The CMPs developed in Portugal focus mainly on the adoption Best Agricultural Practices (BAPs) for diffuse source water pollution abatement. The adoption of BAPs may, however, involve considerable costs due to increases in production costs and/or decreases in yields. This study aims to determine the (long-term) private-economic costs and food-security impacts related to the adoption of BAPs across agricultural land use categories.

Analysis, results and implications for policy and/or research

In this study we apply the Soil and Water Assessment Tool (SWAT) to assess the (long-term) private-economic costs and food-security impacts associated with the adoption of BAPs for Dissolved Inorganic Nitrogen (DIN) water quality improvement across the key agricultural land use categories in the Vouga catchment (Central Portugal). The methodology uses gross-margin analysis techniques for the (plot level) financial-economic assessment of BAPs (based on a detailed description of management practice operations per land use category and corresponding SWAT-based estimates for agricultural production) and, in turn, meta-modeling techniques for the estimation of private-economic abatement cost and food-security abatement impact functions across agricultural land use categories (based on BAP adoption scenarios and corresponding SWAT-based estimates for agricultural production, agricultural incomes, and water pollution deliveries). It is shown that SWAT adequately assesses the relationship between agricultural land use and practice location, agricultural production, local water pollution supply, and end-of-catchment water pollution delivery - hence allowing for the estimation of water pollution abatement (private-economic) cost and (food-security) impact functions across agricultural land use categories. SWAT-based estimates for agricultural production and, corresponding, agricultural income are shown to be responsive to BAP adoption scenarios - resulting in decreasing marginal (water quality) improvements from BAP adoption or, alternatively, increasing marginal costs from water quality improvement.

A result in line with environmental-economic theory as well as various applied studies. Results for the case of DIN surface water pollution by the key agricultural land use categories in the Vouga catchment show that, for all land use categories, the adoption of BAPs leads to a decrease in agricultural production and corresponding production values that are not outweighed by a reduction in N-fertilizer expenditures. Hence, no win-win agricultural practices are identified within the assessed BAPs for water quality improvement. Estimated private-economic abatement costs are quadratically increasing in the rate of DIN water pollution abatement, while noting large differences between land use categories. Abatement costs are largest for the mixed annual crops & vineyards (Category III) land use category (between 41 900 Euro/tDIN/yr and 51 900 Euro/tDIN/yr), and fairly similar across the vineyards (Category II) and annual crops (Category I) land use categories (between 7 300 Euro/tDIN/yr and 15 200 Euro/tDIN/yr). Estimated food-security abatement impacts are largest for corn and oat production (~2.0%-2.2% and ~1.6%-1.8% reduction in corn and oat production, respectively, per tDIN water quality improvement per year), followed by potato production (~0.5%-0.9% reduction per tDIN/yr) and vineyard production (~0.2%-0.4% reduction per tDIN/yr). The CMP for the Vouga catchment aims to achieve a 50% reduction in DIN water pollution deliveries to the Aveiro Lagoon.

Given current DIN water pollution deliveries of 1 084 tDIN/yr, this implies a reduction of 542 tDIN/yr. Achieving this DIN water quality improvement target at least cost across the agricultural land use categories in the Vouga catchment, would cost about 10.6 million Euro per year and lead to a 22% reduction in corn production, a 9% reduction in vineyard production, a 6% decrease in oat production and, finally, a 2% decrease in potato production. Now, while sustainable economic development of coastal regions requires balancing of the marginal (private-economic) costs from coastal catchment water pollution abatement and the associated marginal (social-economic) benefits from coastal aquatic resource appreciation, we argue that food security issues need to be taken into account in the development and implementation of catchment management plans.

How Sustainable are Engineered Rivers in Arid Lands?

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Keywords: river engineering, irrigation, climate change, sedimentation, food security

Introduction and problem identification

Engineered rivers in arid lands share several characteristics: the headwaters supply reliable supply from snow pack or rainfall in the mountains; downstream irrigated agriculture thrives on fertile soil brought by annual floods; major dams and irrigation structures have changed river hydrology. We investigate how water supply and demand will change as a result of reservoir sedimentation, climate change, change of land use from agricultural to urban, and population growth.

Analysis, results and implications for policy and/or research

We have studied how the above mentioned change factors impact the Rio Grande in the United States and Mexico. We found that the the river's reservoirs lose each decade between 2.5 and 6 percent storage to sedimentation, that the mountain snowpack is diminishing, that irrigated land is lost to urbanization, that the basin population will again double in 30 years, and that instream flow continues to decrease. As a result, the river in 2060 will have 40 percent less water. The potential for building large new water storage facilities is limited. Reduced water supply will have the largest impact on irrigated agriculture and the environment. Agriculture will see its water share reduced to meet urban demand. However, agriculture may be able to maintain current yields by practicing conservation, adopting new irrigation technology and shifting to less water intensive crops. Instream flow will be further reduced and lead to additional environmental damage. Using the methodology developed in our Rio Grande studies, we will present plans for an assessment of water supply and demand of engineered rivers in arid regions worldwide. Our timeframe is the year 2060. Based on literature review, visits and personal contacts we plan to study Nile, Yellow, Murray-Darling, São Francisco, Rio Grande and Rhône. Our goal is to assess each river's vulnerability to the physical and social change factors mentioned above and to identify opportunities for doing more with less.

Food Security and Clean Water Under Climate Change: Smallholder Farmers in the Philippines

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Keywords: resilience, smallholder agriculture, climate change, agent-based modeling, organic agriculture

Introduction and problem identification

Ensuring the livelihoods of smallholder farmers is an important aspect of food security in many countries of the developing world, including the Philippines. These livelihoods are threatened by global scale climatic and economic changes which introduce shocks (such as drought, flooding or price spikes) into smallholder systems that normally exist on the edge of viability. Organic agriculture has been proposed by some non-governmental organizations (NGOs) in the Philippines as a more resilient form of rice agriculture which will allow smallholder farmers to better weather these shocks, thereby contributing to food security. In addition, organic systems can potentially improve downstream water quality by retaining more nutrient inputs on-farm and reducing sediment and nutrient runoff.

Analysis, results and implications for policy and/or research

Organic systems in the Philippines incorporate traditional rice varieties which are believed to be more climatically adaptable than high-yielding varieties; also, organic farmers tend to incur fewer debts than conventional (chemical) farmers, incorporate more diverse crop and animal systems, and build up long-term soil quality. If organic rice systems are to be advanced as a solution to climatic and economic vulnerability and as a way to improve downstream water quality, it is imperative to understand why farmers might or might not choose to implement these systems, and what support they would need to maintain organic systems. We developed an agent-based model (ABM) depicting smallholder farmer decisions to implement organic techniques, and parameterized it with qualitative and quantitative data collected from a rice farming community in the upland Philippines. This modeling technique was novel in two ways: first, agent rules were based on focus group data collected in the system of study. Second, a social network structure was built into the model to represent the effects of learning on organic adoption. Model results indicate that there is an upper limit to the number of farmers who may adopt organic agriculture, because most farmers may not be able to generate enough on-farm inputs to ensure yields. Farmers without access to animal manure and with limited land (hence, limited crop residue to use as fertilizer) are less able to practice organic farming techniques. The model output also suggests that conventional farmers are more vulnerable than organic farmers to losing their farms in the absence of credit and inputs. Compared with organic farmers, conventional farmers' viability is more dependent on crop price, which can be volatile in the absence of a consistent market. We suggest that if promoting organic agriculture is a priority in the upland Philippines, local governments and NGOs should focus their efforts on providing access to organic inputs for all farmers interested in farming organically.

Hydropower Development and Food Security in Laos

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Keywords: sustainabilty, hydropower, food security, beneficiaries, holistic planning

Introduction and problem identification

Competition for water resources in developing countries can become critical when the benefits of producing hydro-electric power for export conflict with the needs of local populations for food production. The downstream areas of the Theun-Hinboun Project in central Laos illustrate these conflicting needs but also show how holistic and development planning can address natural flooding events that are exasperated by releases and subsequent changes in water quality and flows.

Analysis, results and implications for policy and/or research

The Theun-Hinboun Power Company is the first public-private partnership venture in hydropower in Laos, owned by Electricité du Laos, GMS of Thailand and Statkraft of Norway. The first project was completed in 1998 as a Trans-basin, Run-of-the-River scheme, producing 210MW, mostly for export to Thailand. Although there were few direct impacts, water releases downstream impacted fisheries and exacerbated natural floods. After the start of operation, THPC carried out a mitigation program to compensate for these losses, including alterative livelihoods, livestock improvement and subsidies for diesel pumps for dry-season rice production. These measures addressed the impacts directly and indirectly but provided no permanent solution. The planning for the Expansion Project (THXP) started in 2004 with operation by mid-2012. Unlike the first project, THXP consists of reesettlement of 12 villages, extensive compensation and a relocation program for downstream areas. The latter proved to be very challenging in terms of finding sustainable solutions for both natural flooding and combined releases from the first and expansion projects (an increase from 100 to 200 cu/sec). THXP was developed in compliance with Lao Law, Asian Development Bank safeguard policies and Equator Principles. This implied sustainability and a consultation process with stakeholders: meetings and discussions were held to identify concerns and to work out solutions. The approach adapted by the Company was one that aimed for long-term sustainability, not just mitigating specific impacts and working out compensation. The participatory process yielded clear ideas about what challenges the villagers faced: they wanted flood-free residential areas, all-weather roads, food security and improved services. The downstream areas were located in a natural flood plain where floods severely damaged or even wiped out rice production every 5 years on average. Most years, however, would result in good production, enough to weather bad years. Water releases from THPC resulted in more losses in some years. Yields in general were low and attempts at dry season production turned out to be costly and continued only with THPC subsidies for diesel pumps. A holistic approach included relocating and consolidating villages on higher ground, building roads to allow access to markets and services, improving services and developing dry-season rice production using improved seeds and electrical pumps. These mitigation measures were included in the Entitlement Matrix for project affected persons and formed part of the License Agreement. Not only were these measures legally binding but income targets were established for all impacted villages. These targets were based on a needs assessment, are 20-50% higher than existing income levels, and are increased annual in relation to the consumer price index.

"Sustainability" was defined as 80% of households meeting income targets for two consecutive years and achieving 15 human development indicator (HDI) targets, several of which are related to food security. By the end of 2012 all villages directly downstream of the powerhouse will be relocated to new sites and have improved food security (ca. 3800 people) with a remaining ca. 4,500 people in areas less impacted to be relocated in the next three years. The entitlements allow for assistance in relocation and improvement of structures as well as options of dry-season electrical pump irrigation or flood-safe wet-season paddy. There have been considerable improvements to houses that have been constructed on new plots where the Company has been responsible for water supply, electricity and roads. The Company has also worked with local authorities to transfer and improve educational and health services. Efforts continue to improve food security with extensive new irrigation systems and electric pump under the supervision of technical staff until Water User Groups are fully established and functioning well. HDI targets for households specifically address food security through the monitoring of rice production, high risk coping mechanisms and ownership of land. The number of months with rice shortage has increased and number of hectares planted decreased during construction since some households prefer to work for wages and buy rice. These indicators will be monitored in more detail after construction is finished. In terms of policy development and implementation, Laos is at an important crossroads where new standards and procedures have been developed but are just starting to be applied to actual project situations. A number of large-scale projects, such as THXP, are good examples of how comprehensive and holistic planning can result in sustainable solutions, and that hydropower can become a catalyst for development if one focuses on development opportunities by looking at food security and other long-term needs, rather than on compensation ofnegative impacts.

Why do Farmers Join Payments for Environmental Services (PES) Schemes? An Assessment of PES-Water Project Participation in Brazil

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Keywords: ecosystem services, environmental services, participation, water management, Brazil

Introduction and problem identification

Policy instruments for ecosystems conservation and rural development based on Payments for Environmental Services (PES) have been increasingly applied by different actors responsible for water resources management in Brazil. This relatively new policy instruments
- first initiatives in the country date from early 2000s
- have been receiving rising attention due to their potential to address food security, rural development and environmental concerns simultaneously. There is a growing momentum in many regions of Brazil for the use of these instruments, which usually involve diverse institutions from different governance levels (national, regional and local), in partnership with private sector and civil society organisations. Even though growing political attention is present, scientific literature and analysis of the efficiency and efficacy of these policies is still scarcely available. One of the main issues relates to the participation levels of farmers and other rural population.

Analysis, results and implications for policy and/or research

Two main analyses were conducted. First, a qualitative analysis of PES-water programmes under the perspective of institutional economics, which favours a more holistic reflexion and includes elements of context observation and facilitation processes, going beyond only procedural rules. Second, a qualitative analysis based on inputs generated by the qualitative exercise, which were used to develop a logistic regression model of revealed preferences applied to farmers that have decided to participate or refuse participation in the schemes.

Variables from the following categories were tested:
i) farmer and household characteristics,
ii) farm structure and practices,
iii) scheme factors. This methodological structure was then applied to scrutinize three different PSE-water projects in Brazil, in collaboration with several regional and local level public and civil society institutions.

Cases were selected under the following criteria:
i) active projects,
ii) active participation,
iii) different governance models,
iv) different farming regions, and
v) similar ecological objectives.

Database consisted of 24 semi-structured interviews with local environmental managers, and a survey applied to 163 farmers distributed between participants and non-participants, and across the three regions. Both data collection procedures were conducted in 2011.

Results indicate five main conclusions regarding farmer participation in PES-water projects arising from this study:
1) Participation and incomprehension of properties of transactions: some properties of transactions, in particular the relationship between riparian vegetation and water flow regulation
- necessary for food production and security
- were not completely understood or recognized by many farmers. The non-recognition of these interactions undermines efforts to engage farmers proactively in PES projects, reduces trust-building processes and might act as a conflict generation factor in the medium term;
2) Farmers' representative bodies and governance structures: the participation of a legitimate and representative organisation of farmers' interests during all phases of project development and execution significantly reduces transaction costs associated with farmers' engagement and subsequent project implementation;
3) Access to information and general environmental concern: effective communication strategies are remarkably important if a greater number of farmers are expected to participate in the projects. These communication strategies shall not only provide basic information about the project, but a comprehensive understanding of policy objectives, ecological interactions, operational procedures, etc;
4) Farmer characteristics and farm structures: logistic regression model results indicate that these are no general explanatory factors per se, but these highly context-based factors can play a role in excluding certain farmer categories, such as women and downstream farmers. Besides, farmers that rely heavier on family labour are facing bigger constrains to adapt their production systems to participate in the PES programmes;
5) Opportunity costs: even though several assumption were made to estimate opportunity costs in this study, results are consistent with economic theory and cases analysed in the literature, indicating that farmers with higher opportunity costs participate less in PES projects. In fact, opportunity costs facilitate the understanding of several non-participant decisions.

Workshop: Securing Water and Food in an Urbanizing World

Wastewater Reuse in Egypt: A Prospective Solution for Water Scarcity and Food Security

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Keywords: wastewater, drainage water, scaricity, reuse, Egypt

Introduction and problem identification

Water is becoming an increasingly scarce resource in arid and semi-arid countries and planners are forced to consider any source of water that might be used economically and effectively to meet increasing demands for water. Whenever good quality water is scarce, water of marginal quality will have to be considered for use in agriculture and groundwater recharge. During recent years, the methodology for managing the reuse of wastewater has shifted from conventional disposal strategies into value added products. With the increase of wastewater reuse for different purposes, concerns over the environmental and health implications of this reuse have also increased. Water is the fundamental element for sustainable and integrated development in Egypt. Horizontal expansion in agriculture is connected to the country's ability to provide the water required for that expansion.

Analysis, results and implications for policy and/or research

Egypt covers a very arid region situated between the Sahara and Arabian deserts. Egypt is extremely dependent on the River Nile, being the most downstream country in the Nile basin. 97% of the population lives on 4% of the land of Egypt, around the river Nile. The most pressing challenge facing water resources development in Egypt are rapid growth and unbalanced distribution of the population, rapid urbanization, water quality deterioration, government's policy to reclaim new land, and unsustainable water use practices. Now Egypt is reaching its limits of available water and this will not be possible anymore and Egypt will have to face variable supply conditions. It is worth mentioning that the availability of renewable water resources in Egypt has dropped from 2189 m^3/capita/year in 1966 to 1035 m^3/capita/year in 1990. At present population growth rate, this will drop even further to 536 m^3.capita/year by the year 2025, if the share of Egypt from Nile waters remains as it is today (55.5 BCM) and levels of per capita consumption are maintained. Various demands for freshwater are exerting excessive pressure on the available water supply. The government of Egypt is committed to develop and manage its water resources in the interests of all Egyptians by reforming the water and wastewater sector. The change concerned institutional and financial aspects. Thus, a Holding Company for Water and Wastewater (HCWW) along with its 23 subsidiary companies was established in 2004 by a presidential decree to develop and implement a holistic policy, which includes expansion of the service delivery, the introduction of modern technology in operations and maintenance as well as management, and increasing the private sector participation in activities which are not core to its mission. Between 2005 and 2009, about 50 billion Egyptian Pounds (around 9 billion US dollars) were invested in the water and wastewater sectors. The Government of Egypt has also assigned 5 billion Egyptian Pounds (around 0.9 billion US dollars) for networks' rehabilitation projects over the coming five years. The capacity of wastewater treatment plants has increased by more than six times in the last two decades. Use of treated wastewater has become increasingly important in water resources management for both environmental and economic reasons. Wastewater use in Egypt is an old practice.

It has been used since 1930 in sandy soil areas like Al Gabal Al Asfar and Abou Rawash, near Cairo. Interest in the use of treated wastewater, as a substitute for fresh water in irrigation, has accelerated since 1980. Currently, 0.7 BCM/yr of treated wastewater is being used in irrigation, of which 0.26 BCM is undergoing secondary treatment and 0.44 BCM undergoing primary treatment. In general, treated wastewater use is of tremendous potential importance for Egypt. The agricultural sector is the highest freshwater consumer, utilizing about 86% of the available supplies. The drainage water from agriculture and the effluents from municipalities and industries are collected, transported and reused by an extensive drainage network which is managed and planned by the Ministry of Water Resources and Irrigation. Reuse of drainage water has already been practiced at a larger scale during the last decades, whereby water from main drains is pumped into main canals. Currently about 5.5 Billion Cubic Meters (BCM) of drainage water are being reused after mixing with fresh water. This amount is expected to increase up to 9.6 BCM by the year 2017. Reuse of drainage water in the Nile Delta started as early as 1930s. Total number of official reuse pumping stations is 21 stations. 2.0 Billion Cubic Meters (BCM) of unofficial reuse is taking place in many locations. Laws and decrees have been issued including guidelines for mixing drainage water with fresh water, regulations for sewage and industrial effluents, wastewater reuse, cropping patterns, and health protection measures & standards specifications. However, the major problem lies in weak regulatory compliance and enforcement. In addition Production of fish and to some extent of water vegetables (macrophytes) in ponds fertilised by human excreta or wastewater has long been and continues to be practiced in many countries in South and SE Asia (e.g. India, Thailand, Indonesia, Vietnam, Taiwan, China), in Western Asia (Israel) and Africa. Many of these schemes and practices may be designated as urban or peri-urban as they make use of faecal sludge's and wastewater collected in urban areas in Egypt. Fish production rates of 1-6 tons/h/year are achieved, depending on the type of fish raised, pond operations and temperature. HCWW is planning to dominate this option in all the stabilization ponds in Egypt, especially in Upper Egypt as potential alternative for food security.

Making the Case for a Yellow Economy: Costing Urine Diversion for a New Urban Area in Vietnam

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Keywords: resource recovery, urine diversion, costing, urban sanitation, phosporus

Introduction and problem identification

In moving towards a green economy that maximises synergies within the water-food-energy nexus, there is significant potential to explore the contribution of a 'yellow economy' - an economy that values urine as a resource to support food security. Urine is a complete fertiliser, containing nutrients essential for food production including phosphorus and nitrogen. Given that the majority of the nutrient content in human excreta is in the urine, there is significant potential for urine to be used more widely to support food production, reducing our reliance on increasingly scarce mineral rock phosphate. Exploration of urine diversion systems has to date focused primarily on low density areas where food production occurs close to sanitation facilities. In urban areas, while the applicability of resource oriented sanitation is beginning to be explored, little information exists on the costs of these systems and their cost-effectiveness compared with traditional sanitation solutions.

Analysis, results and implications for policy and/or research

Recent research focused on Can Tho City in Vietnam investigated the costs of urine diversion for a newly developing medium-high density urban area. The research assessed both costs and likely revenue of urine diversion systems, and compared urine diversion with a variety of sanitation options at different scales and configurations in terms of both cost-effectiveness and a suite of broader sustainability considerations. Costing a urine diversion system as part of the assessment of sanitation options for Can Tho involved a number of steps: undertaking detailed concept design of the urine diversion system for the case study site; identifying cost boundaries and costs for each component of the infrastructure; projecting potential revenue from sale of urine as fertiliser; and comparing urine diversion with a range of alternatives including both centralised and decentralised wastewater collection and treatment. Concept design of the urine diversion system was undertaken in consultation with research partners and local government agencies including Can Tho Water Supply and Sewerage Company and Can Tho University (CTU), and certain design parameters built on previous trials of urine diversion toilets undertaken at a CTU dormitory. With most households in Can Tho using flush toilets, the decision was made to design the urine diversion option using urine-separating flush toilets in each household in the case study area. Results of an end use study were used to estimate the quantity of each wastewater stream including blackwater, urine and brownwater (faeces + flushwater). The concept design detailed a number of steps. After flushing, the urine is collected in underground receptor tanks with one tank for every 40-50 households. Every 3 days, trucks come to pump out the urine and transport it to rural areas, where the urine is stored in large 700m^3 capacity storage units for 6 months to ensure sterilisation.

To ensure a high safety margin and enable use of urine on all crops, 6 months is the storage time recommended by the World Health Organisation (2006). The safe urine is then sold as NPK fertiliser. The process of costing the urine diversion system involved first establishing boundaries of analysis so that the cost-effectiveness of the urine diversion option could be compared to a 'business as usual' reference case. This required collating all system costs and identifying which were common across options and which unique to the urine diversion system. All costs that differed from a 'business as usual' case of non-urine separating toilets were taken into account. Locally relevant costs for each stage of the system were then collated based on unit costs for component parts including labour, pipes, receptor tanks, pumping and trucking costs and storage containers in nearby rural-agricultural areas. Based on this analysis, the unit costs for the urine diversion system were found to be USD 200/household for infrastructure with an additional trucking cost of USD 7,000/year. Revenue from the sale of urine as fertiliser was calculated based on analysis of expected nutrient content of wastewater, estimated using assumed N, P and K loads for Vietnam of 3.13, 0.45 and 1.8 kg/p/a respectively (N and P from Wohlsager et al., 2009 using the formulas of Jönsson and Vinneras, 2003; K from Jönsson and Vinneras, 2003 based on calculations for China). Loads of N, P and K associated with urine specifically were determined based on the distribution of nutrients between urine and faeces as described by Jönsson and Vinneras (2003) where 88% of N, 67% of P and 73% of K are in urine. A locally available chemical fertiliser NPK 20-0-10 Buffalo Head (Dau Trau Brand) was identified as equivalent in terms of the value of nitrogen and potassium. The price of fertiliser per metric tonne in 2010 with 5% Value Added Tax (VAT) was approximately USD 300. Based on this, the value of urine as fertiliser was calculated to be USD 20/yr for each household from which urine is collected. The urine diversion option differed from others included in the analysis in that it was the only one to include a revenue stream. As such, while the urine diversion system proved to be slightly higher cost overall compared with a similar decentralised system without urine diversion, it had a significant benefit in that the projected revenue from sale of fertiliser was almost 5 times the annualised operating costs (which included both operating costs and capital maintenance costs). This was of particular interest in the Can Tho context where ongoing costs are the responsibility of the utility and efforts are underway to move towards cost recovery.

Waste Water Reuse for Peri-Urban Food Security

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Keywords: waste water reuse, peri-urban agriculture, ground water marketing, food and water security, sustainability

Introduction and problem identification

Droughts, explosive population growth and continuing view that water is an infinite resource are reasons for water crisis (quality and quantity). To manage increasing demands alternate sources are to be identified. In water starved cities wastewater reuse finds way in solving water problems. The treated wastewater could be reused in several domains like urban, agricultural, environmental and recreational sectors, non potable domestic uses and groundwater recharge. Though there are alternatives like desalination, wastewater treatment and reuse has multiple benefits. Reuse of wastewater arrests further degradation of environment. It is an economical way to meet increasingly more stringent discharge standards. An ongoing study revealed facts regarding wastewater reuse which implies the social constraints in reusing treated wastewater, mainly for the domestic uses. Reuse of wastewater is thus recommended in industries and agriculture to manage urban demand and to secure food production.

Analysis, results and implications for policy and/or research

Chennai is one of India's fastest growing metro polis. The urbanization is rapid and haphazardly spread in and around the city. The industrial sector is ever expanding since last two decades. The quantity of fresh water used in this sector is also huge and almost the same amount is generated as waste water at the end. The efficient management of this waste water is important, for a sustainable environment and for meeting the future demands. Chennai has undergone rapid demographic growth over last four decades. This urbanization has been driven by industrialization at the city's periphery. As a result, a large number of smaller rural settlements have experienced rapid population growth and diversification of workforce. The population of the city has gone up from 5 lakhs in 1921 to approximately 46 lakhs in 2011. Wastewater is liquid waste discharged by domestic residences, commercial properties, industry, agriculture, which often contains some contaminants that result from the mixing of wastewater from different sources. Based on its origin wastewater can be classified as sanitary, commercial, industrial, agricultural or surface runoff. The term wastewater needs to be separated from the term sewage. Sewage is subset of wastewater that is contaminated with feces or urine though many people use term sewage referring to any waste water. Wastewater mostly consists of pure water (more than 95%), and there are many processes that can be used to clean up waste water depending on the type and extent of contamination. Treated wastewater can then be reused. Without the proper wastewater treatment ecosystem would be severely damaged once the treated water gets recharged back into the environment. Also the recycling and reuse of waste water ensures water security for the future generations. Chennai is endowed with a moderate climate. The average rainfall is 1200 mm. The city mostly depends on seasonal rainfall and faces distress condition in the absence of adequate rainfall. Data required for the study were collected in two phases: primary data collection and secondary. Data analysis is done in order to understand the essence of the data collected and to apply in the study. Primary data were collected through observation, group discussion, key person interview and questionnaire survey.

The analysis of primary data is purely based on knowledge and information gathered. Secondary data were collected from various government departments. The secondary data analysis was done to generate the land use map. Remarkable loss in agricultural activities in the peri urban areas of Chennai was inferred from the land use maps of past few decades. The study area was chosen on the basis of elapse of agricultural activities in peri urban Chennai. The land use map of the selected areas like Pallavaram, Pammal and Nemilicherri was studied for detailed information on agriculture and water market. The peri urban area of south Chennai was chosen for stakeholder analysis. Results were evident that due to groundwater marketing, decline in agriculture has taken place significantly. In order to secure food and water availability for the future generations a sustainable step must be taken. In this regard waste water reuse for irrigation after proper treatment is an economically sound method in achieving sustainable food production in the peri-urban areas of developing cities. A few studies done on the same concludes that the use of treated waste water in agriculture does not cause any health effect to the farmers and also on the food products. The waste water provides required nutrients to the plants and hence saves cost of fertilizers and retains the soil quality. The exploited ground water resource from peri-urban areas is balanced by providing treated waste water to the fields for food production. An experiment was done in lab in which the secondary treated waste water was used in manufacturing ice blocks. This ice was tested for odor and biological pathogens. The result was satisfactory and thus this process was disseminated to the farmers on field. The response was warm and encouraging. It not only saves fresh water resources but also creates employment opportunities for the farm laborers. The other part of the study focuses on the reuse of treated waste water in industries. The industries were grouped into green, orange and red on the basis of type of effluent released. It was seen that the waste of the green industry was less polluted and thus could be used in orange and red industries (for processes like cooling) even without treatment. Such innovative steps in saving fresh water resources are important as they lead to water security apart from protecting the Mother Nature. The water saved from the above said methods may be used to supply safe drinking water to one and all, which is also one of the Millennium Development Goals proposed by United Nations Development Programme.

Wastewater – A Gold Mine for Energy and Agriculture

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Keywords: energy, nutrients, process, biogas, recovery

Introduction and problem identification

Municipal wastewater is a footprint of the society. Therefore we will find basically all the nutrients that is consumed in the upper level of the food chain in our sewer system. 100 years ago these nutrients were (safely or not) recycled to agriculture together with manure. With the urbanization and installations of WC's, improvement of infrastructure like sewer system as well as the development of fertilizer production, the return of nutrients has dropped per capita. Another important source in wastewater is an alternative to the black gold, energy. The organic substances in the wastewater are mainly easily degradable and could be converted to biogas, a zero per cent carbon dioxide footprint energy source. What is glowing in the municipal gold is the water. With the increased urbanization and climate change the water stress becomes a more and more serious issue and water should and is recycled in many places.

Analysis, results and implications for policy and/or research

This paper will focus on the chemistry and energy in wastewater. The potential of recovery will be exemplified based on full scale experiences from different wastewater treatment plants. Today there is not one single plant doing all that is possible for energy optimization and generation as well as recycling of nutrients at the same as recycling the water in a safe manner. So in this paper we will build a model wastewater treatment plant demonstrating the potential value of wastewater. We will show how water treatment process selection is capable to double the biogas production without any significant changes in operational cost. At the same time as, compared with a conventional activated sludge plant, investment costs are a lower and energy consumption is reduced. How nutrients can be recovered in an energy efficient way and how both phosphorous and nitrogen can be recycled to agriculture to a large extent will be exemplified. We will show how the different unit operations help each other to make an extremely energy efficient WWTP. Rather than favouring one type of unit operation the combination of chemical, physical and biological processes gets the most out of the liquid gold.

Sustaining Peri-Urban Agriculture through Polyculture Systems – An IWRM Perspective (A Case Study in Peri-Urban Chennai, India)

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Keywords: urbanization, peri-urban agriculture, organic polyculture systems, food security, environmental sustainability

Introduction and problem identification

In developing countries demographic and economic expansion of cities is taking place through migration and industrialization and this has resulted in the spatial expansion of the city upon the adjacent areas. Rapid growth of cities has caused stress on the infrastructure services including water supply in the cities. Fringe areas which once had flourishing agriculture are now being converted into urban areas. Urbanization has increased the pressure on land and water resources which has highly affected peri-urban agriculture too (PUA). PUA is found to be less profitable and farmers have resorted to sell their lands at high prices for urban uses, or to leave it fallow and move to the cities in search of better jobs.

Analysis, results and implications for policy and/or research

Tamil Nadu constitutes the south-eastern extremity of the Indian peninsula. Chennai is the capital city of the State, besides being an important district. Chennai City has undergone rapid urban growth over the last four decades. This urbanization has been driven by industrialization at the citys periphery, which is largely rural in character. With the emergence of the knowledge sector post 1991, a number of large players in the telecom, software, banking and manufacturing sectors have set up their offices in and around Chennai which has brought about increased job opportunities in the city. In addition to the skyrocketing population in Chennai, there is migration of people to the city in search of jobs. When compared to rural agriculture, peri-urban agriculture enhances food security in Chennai city by ease of access to fresh fruits and vegetables with reduced storage, processing and transportation costs. But rapid urbanization of the city has highly affected peri-urban agriculture causing widening of the citys food demand - supply gap. Vengaivasal is a peri-urban village located 20km south of Chennai. The village had flourishing agriculture, horticulture and floriculture till 2001-02 but after that there was a steady decline in crop land and agriculture due to urbanisation. Since 2005 agricultural activities have stopped in the village and selling of lands have started. The farm lands sold by the farmers have been converted into residential areas and industrial/institutional areas. The major reasons contributing for this reduction is as follows:

1. Selling of crop land by farmers due to lack of labour to carry out agricultural activities: The farmers educated all their children and did not encourage them to continue with farming and hence their children had moved to the city in search of better jobs. This has resulted in lack of agricultural labour in the village. The farmers when they faced such labour shortages, started to hire agricultural labourers from Dindigul, Villupuram and Thiruvallur.

The labourers were hired on contract basis and they were made to stay in Vengaivasal for 15-20 days and carry out all the farming activities. Transportation, accommodation, food and labour charges for the hired labourers were borne by the contractors only. Recently even these hired labourers refused to work on contract basis. This eventually affected the agricultural activities of the farmers. Farmers have resorted to sell their lands at high prices for urban uses. The lands had a high value due to its proximity to the city.

2. High Opportunity Costs of peri-urban lands: The high opportunity costs for peri-urban lands made some farmers to feel that agriculture is comparatively less profitable. The farmers felt that they will obtain more money from selling their farm lands and that it could be invested in constructing residential apartments and purchasing earth movers, loaders and excavators and leasing them for construction purposes.

3. Increased job opportunities in the cities: Urbanisation has increased job opportunities in the city and hence the farmers and their children have started to move to Chennai city in search of better and profitable jobs than agriculture. Due to the above reasons the PUA and the livelihood of farmers are under threat. In order to sustain PUA, a new Organic Polyculture System (OPS) model was designed and tested on field. OPS involves more than two different types of culture practiced simultaneously in the same plot. The greater variety of cultures provide habitat for more species, increasing local biodiversity. Agriculture, aquaculture, vermiculture, algaculture and horticulture were practiced simultaneously in a 2 ha plot and yields from all the five cultures were obtained at the end of six months. OPS is completely organic and hence prevents environmental degradation. Local methods have been used for producing and preparing different organic fertilizers and pesticides. The different culture systems were dependent on each other and the model has a high Benefit - Cost ratio of 5:1. Thus the new system improves the profitability and livelihood of the farmers thereby making them self-sufficient and also able to meet the growing food demands. OPS will contribute substantially to the food production thereby providing food security in the cities. The new system also sustains traditional agriculture and brings about nutritional security. OPS would seem to be an excellent start to regaining some of the relevance of the natural world while putting more healthful food on the table. It is a less water intensive technique and hence enhances water productivity. OPS can be carried out in small land holdings and is highly suitable for peri-urban areas and can be disseminated among the peri-urban farmers where there is a high potential and need for agriculture with suitable policy reforms and funding from the government.

A Case Study of Impact of Declining Water Table in Suburban and Identification of Recharge Zones

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Keywords: extraction, degradation, peri-urban, delineation, artificialrecharge

Introduction and problem identification

The Chennai city is the capital of the Tamil Nadu state receives an annual rainfall of 1290 mm,only about 5 percent of the rainfall seeps into the ground, and the remaining water goes as a runoff to the sea. Recently most of these water bodies disappeared due to encroachment. Today 80 per cent of Chennai's groundwater has been depleted and any further extraction could lead to quality degradation including saltwater intrusion. The number of water bodies that existed was being filled with garbage To supplement the city water supply, huge quantities of groundwater is being transferred from peri-urban areas. The continuous extraction leads to reduction in water levels, and adversely affects agriculture and allied activities. Many people who lost their employment in villages start to migrate to the city.In this study identify the impact of decline of groundwater on the water access and use by local community and declining agriculture.

Analysis, results and implications for policy and/or research

Water Level -2009 13 wells are considered for water level study the water level graph post monsoon the average depth to water level is 3m-3.5m but in pre monsoon the average depth to water level is 9 m - 11 m. It shows the water level is declining in the study area. Through questioner survey and focus group discussion find out the reason for declining groundwater resources and its use (for domestic purposes), sanitation / waste disposal, agricultural details, water market of the village, water resources management practices. The major reason for declining water table is due to more water extraction to sell water to urban areas. Over mining of ground water and lack of proper water management has lead to the continuous decrease in the water tables. There is not only the over exploitation of the ground water but also the inequitable distribution and wasteful utilization which has resulted in declining of the water table. The people those who depends on the public water supply source is the major vulnerable group in fetching water. Due to the water shortage they did not constructed the toilets. Open defecation is done by the people. Water conservation measures are not strictly followed by the people. Further, the storage capacity of the tank has reduced day by day due to encroachment and dumping of wastes. Nowadays, the increase in groundwater draft on account of urbanization and increase in impervious layers and paved areas of the land surface have caused compaction of the top soil because of which the natural recharge has very much reduced resulting in increased runoff even before the subsurface is saturated. This could be the reason for lower water table even in spite of good rainfall in the recent years. Changes in Agricultural Declining trend of agricultural land is observed from 1994 to 2008. An area of 17.832km^2 of agricultural lands got reduced from 1994 to 2004. When we conducted the focus group discussion with the farmers they told, the cultivation cost is very high due to high labour wages and farming operation. Local farmers are not interested to

involve in agricultural activities because of the real estate's owners and builders lead them to think of making huge money in a single time by promoting layouts for urban development activities instead of agricultural production activities. Further wells in agricultural lands are being used to extract water by tankers for the city and urban domestic, industrial and other uses. Further, the farmers are more willing to sell their well water to the tankers for the city/urban domestic and industrial water uses. They feel that selling of groundwater is more remunerative than agriculture produces Improper Conservation Measures The surface runoff calculated for the year 2008 was 3.09MCM in my study area. From the analysis it was found that runoff was more. The infiltration capacity of the catchments was decreased due to urbanization. Another reason increasing runoff was decreasing depth of storage of the tank. In residential area people does not maintain proper drainage facility. So people dump their domestic wastes into the tank. Because of this happening, tank depth was decreased so that storage capacity of the tank was decreased. Hence conservation of the tank is very important to decrease the surface runoff and increase the ground water recharge. Highly educated people (18 per cent) those who are aware of the rainwater harvesting was constructed and maintain the RWH structures. Most of the people (58 per cent) constructed but not maintained properly.16 per cent of the people not constructed RWH structures.8 percentage of the people not aware of the RWH structures. To safeguard the aquifers, vertical shafts can be constructed inside the percolation ponds and tanks, where fractured /weathered zones are identified. This will improve the groundwater quantity and quality in and around the pond/tank areas.

- To safeguard the aquifer vertical shafts can be constructed inside the percolation ponds and tanks, where fractured / weathered zones are identified.
- It is mandatory to construct proper rain water harvesting structures according to the lithology of the respective area and it should be maintained properly. Artificial recharge of ground water by rain water harvesting is the solution to improve ground water potential in order to maintain the sustainable water resource.
- The level of encroachments in the water bodies will be identified and suitable remedial measures will be taken by the government to protect the water resources.
- Tamil Nadu Protection of Tanks and Eviction of Encroachment Act, 2007 should be strictly implemented. Water charges should be collected based on the usage of water.
- To encourage recycling, reuse of water and unwanted wastage can make a large contribution to easing the water demand.
- Beyond this, Community participation will make a tremendous improvement in the water resources and all other aspects.

Preparation of High Quality Water for the Production of Food from the Water for Cities

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Keywords: water for cities, water for food, activated carbon, microbial contamination, regeneration

Introduction and problem identification

It is known that the sources of centralized drinking water supply of the most Ukrainian cities in the Dniper river basin contain a wide range of organic substances both natural and anthropogenic origin. Concentration of dissolved organic carbon (DOC) reaches 30-40 mg/L in this water. A number of toxic organic compounds is formed during the water disinfection with chlorine in the existing technology of drinking water preparation in Ukraine's centralized water supply stations (CWSS). Chlorination by-products with the high genotoxicity such as trihalomethanes, chloroform, p-nitrochlorobenzene, bromoform, etc have been detected and extracted. DOC of the tap water is 7.1-12.5 mg/L after water preparation in the CWSS. This leads to the secondary microbial contamination of water in the distribution pipeline. For many branches of industry, especially for food industry, drinking water is the feedstock for which specific requirements are lodged.

Analysis, results and implications for policy and/or research

Obtaining of high-quality water is especially important in the special drinks production. Thus, water for brewing should meet a number of specific technological requirements in the brewing industry. Compliance of these requirements has a positive effect on the process of making beer. These characteristics are more hard than the standards for drinking water and foremost concern the pH (pH 6.0-6.5), alkalinity (less than 0.5-1.5 mg-eq/L), hardness (less than 2-4 mg-eq/L), content of chlorides, sulfates, nitrates, iron, manganese, etc. With regard to microbiological characteristics, the total microbial count should not exceed 100 at 22 °C (or 20 at 37 °C), and if the coli index should not exceed 3 or 0 at the appropriate temperature. It is known that the quality of CWSS tap water, passing distribution pipeline, often does not meet normative documents requirements and therefore it is necessary to treat water additionally for it's use as a feedstock. Therefore, tap water for drinks production is subjected to further purification using a multi-stage filters loaded with quartz sand, granular activated carbon (GAC) and ion-exchange resins in water treatment technological processes. GAC filters are one of the most effective implements for water post-treatment. However, achieving of required water quality is limited by the several factors. Filter bed retains suspended particles, adsorbs dissolved organic and inorganic substances and microorganisms in the filtering water process. Practically from the first days of the filter work the GAC particles are undergone by microbial colonization which can lead to significant biofilm formation. Such biological activation of the GAC, on the one hand, promotes to more effective removal of undesirable impurities from the water and increases the service life of the GAC filter due to its bioregeneration. However, on the other hand, the abruption of it's some fragments and also physiologically controlled release of the living bacterial cells to the water by increasing biofilm mass. Of course this is undesirable for the subsequent technological processes both in brewing and in other branches of food production using water as a feedstock. Thus, filters with GAC in continuous exploitation can be a source of the constant microbial contamination of the water treatment system.

Biofilms increasing on GAC or any other biotic or abiotic surface is a structured bacterial cells communities included in the polymer matrix. Biofilms have an extreme stability and removing them from any surface is a complicated task. In addition the economic appropriateness of carbon filters using depends on the using of effective renewing method of their adsorption capacity without adsorption filter overloading. To solve these problems in industrial production of nonalcoholic beverages and beer a series of operations on advanced purification of tap water to the standard requirements on GAC and GAC adsorption properties regeneration directly into the adsorption filter have been carried out. The quality of treated water on the content of organic matter and microbiological characteristics were as follows:

- DOC (dissolved organic carbon) <0.18 mg/L;
- PO (permanganate oxidation) <0.2 mg / L;
- pH 6.3;
- chloroform ‰ˆ 5 μg/L;
- trichlorethylene <5 μg/L;
- bromdihloretan <1.5 μg/L;
- dibromochlormethane <2.5 μg/L;
- the total microbial count <20 at 37 °C.

To prevent microbial contamination of purified water and to regenerate the adsorption capacity of AC a washing directly in the adsorption filter has been carried out. It has been determined that the most effective eluent of the solid phase, soluble carbohydrates and other organic compounds is a solution of 1M NaOH, and the the most effective eluent of living biomass is Ringer's solution. It is shown that a two-stage washing of GAC filter is always improves the efficiency of contaminants washing compared to the one-step. 0.85% NaCl after the treatment with 1M NaOH is the most appropriate to use for the maximum removal of solids and soluble organic compounds and 0.85% NaCl after the Ringer's solution is the most appropriate to use for the removal of living microbial cells.

Opportunity and Adverse Impact of Wastewater Reuse in Agriculture in Peri-Urban Areas of Rajshahi, Bangladesh

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Keywords: wastewater, irrigation, impact, acceptance, institution

Introduction and problem identification

Wastewater agriculture has been a traditional practice in the peri-urban areas of Rajshahi city. A network of open drains collects domestic sewage and discharges through three main canals to the Baraonai river about 12km away from the city. Wastewater is lifted from these canals for irrigation and aquaculture ponds. Although farmers enjoy direct economic benefits from this wastewater reuse, residents in these areas have complaints of diseases and degrading air and soil quality. A sewage treatment plant for the Rajshahi City Corporation area is planned to be constructed. If wastewater reuse can be managed under an institutional arrangement between the City Corporation and local water users, effluent from this plant can be used to support agriculture in the peri-urban areas. However, the benefits, risks and social acceptance should be assessed before wastewater is reused in any form.

Analysis, results and implications for policy and/or research

Untreated municipal wastewater is being traditionally used for agriculture in the peri-urban areas of Rajshahi city, located in the drought-prone north-western part of Bangladesh. This study was conducted to identify the benefits, adverse impacts, social acceptance and a long term institutional arrangement of wastewater reuse in the peri-urban areas of Rajshahi. Questionnaire surveys were conducted in the exposed and control sites to collect data on the farmers' perception and responses regarding the agricultural, economic, social, and environmental and health issues. Also, a total of 12 wastewater and groundwater samples were collected from the exposed and control sites for quality analysis. Water analysis results show that all the parameters analyzed to assess wastewater quality do not exceed the WHO Bangladesh recommended limit for irrigation. The most important benefits of wastewater reuse have been found as the availability of wastewater over all seasons and reduced chemical fertilizer requirements in crops field. Yield performance and economic return have been found higher in the study sites than that in the control sites. Cropping intensity is also found to be higher in the study sites than that of control sites. On the other hand, the potential risks of wastewater reuse have been found as the increased pest attacks and crop diseases and health incidents of the farmers. About 25% respondents in the wastewater reuse sites reported health problems such as allergy and skin diseases. They also commented that mainly medical and industrial wastewater is causing these health problems. Farmers and their neighbors reported that, wastewater spread over agricultural lands pose significant odor problem at their site. The farmers reported that the crops grown with wastewater irrigation are socially acceptable as they do not face any difficulties to sell them in the market even from the field. Interviews with the key actors indicate that a long term institutional arrangement for sustainable reuse of wastewater is feasible in the region. In this the study a participatory institutional framework has been proposed for long term wastewater reuse at the study site which may be replicated in other part of the country.

Ecosan and Urban Sanitation Business Models

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Keywords: EcoSan, urban, food security, business model

Introduction and problem identification

Ecological Sanitation (EcoSan) is a targeted solution to the issues of poor sanitation and food security. EcoSan latrines transform human excreta into fertiliser for increased food production. The principle of the EcoSan approach is that human waste need not be a burden, but a valuable resource if approached in a sustainable and innovative manner. The EcoSan cycle promotes the reuse of waste within the food production cycle for the improvement of crop productivity and human health. One of the greatest challenges and opportunities for taking EcoSan to scale is the lack of an organised market for faecal sludge management and fertiliser production in urban areas. Households in urban areas do not have the space for double pit latrines or re-positioning of sanitation facilities (as with arborloos). Urban settlements are the areas of the greatest demand for food and consequently the greatest supply of human faecal waste, providing an excellent opportunity to address urban food security.

Analysis, results and implications for policy and/or research

The use of EcoSan latrines supports increased food production through access to cheap fertiliser; a reduction in the prevalence of sanitation related diseases and improved ecosystems, due to a fall in faecal waste and an increase in safe, organic fertiliser. EcoSan approaches close the loop on the sanitation cycle, ensuring that food production benefits from the unlimited and organic resource of human waste. EcoSan can make a significant contribution to addressing issues of food security, it is estimated that one human's waste can produce 250kg of cereals annually. Urine provides most of the required nutrients, but when properly treated faeces can be a good soil fixer. This is important in Africa where many countries suffer from poor or highly degraded soil. WSA works with national and local governments to promote the use of EcoSan latrines. Together they sensitise communities to both the cessation of open defecation and the benefits of EcoSan as a technology. This is often driven by positive feedback from farmers and market gardeners who quickly see the benefits of a free and effective fertiliser on their crops. WSA ensures that the EcoSan approach is contextualised to the countries and regions it works in. This contextualisation has been demonstrated across WSA country programmes including: Burkina Faso, rural and peri-urban approaches; Ivory Coast, the use of urine in EcoSan; Niger, demand led EcoSan approaches and Benin, EcoSan in schools. WSA is currently looking at adaptations of EcoSan, in particular how it can be taken to scale in urban areas. WSA in partnership with the Gates Foundation is developing an innovative solution for this challenge, in the form of sanitation business models, which will be piloted in Kumasi, Accra and Ouagadougou, Burkina Faso. The project will develop a profitable business model for faecal sludge management that will improve the efficiency and profitability of faecal sludge management throughout the sanitation value chain. Actions will range from creating an enabling legislative environment, technical and business training for entrepreneurs, innovations in technology, market organisation, advertising campaigns and the integration of faecal sludge re-use. Once it is demonstrated that sanitation can provide a profitable enterprise the private sector will take control of sanitation provision to provide a competitive service that will meet the basic needs of the poor and other urban citizens.

Potentials of Rainwater for Water and Foods for the Urban Poor – An Experience of Concern Universal Bangladesh

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Keywords: urban poor, crisis of water and foods, rainwater collection and reser, groundwater recharging, small scale farming

Introduction and problem identification

Crisis of safe water and foods are regular facts for urban poor in Bangladesh caused by rapidly increasing population, migration of climate refugees to urban slums, over-dependency of food supply from rural areas and unused urban lands for farming. Rapidly population growth cause for severe crisis of foods, potable water and sanitation facilities. Reliable source reveals that current trend of urban growth is 5%-6% per annul and will reach at 50% by the year 2025. However, the import food items from rural farmers and sell those to urban people at higher prices. Urban poor cannot afford those by their uncertain limited income. The rural farmers also go for more food production using excessive chemical fertilizers and synthetic pesticides to meet food demands of increasing population, which are harmful for both human health. However, urban poor buy inadequate foods for survival. Consequently, they become affected by severe water borne diseases, malnourished and chemical effects.

Analysis, results and implications for policy and/or research

Bangladesh is a tropical country and receives heavy rainfall during rainy season influenced by monsoon. Average annual rainfall in the country varies from 2000 to 2800 mm, which give better opportunities for collecting and storage of rainwater for drinking water solution and can be used for small scale food production in urban areas. Realizing the situations, Concern Universal Bangladesh (CUB), An International NGO, in partnership with Dhaka Ahsania Mission (DAM), a national NGO has implemented a project named as Water, sanitation & Hygiene Improvements in Schools serving urban poor in Comilla and Dhaka Slums. It was funded by Coca-Cola Far East Limited and UN-HABITAT in support of Urban Partnership for Poverty Reduction Project (UPPRP). The project facilitated in installation of 6 Rainwater Collection and storage system along with groundwater recharger sourced from rainwater out of 35 selected schools (remaining schools installed normal water options system) as innovative model. As a result, it was experienced that the school students have adequate access to drinking water round the year, as they receive safe water around 4-5 months from direct rains and stored rainwater continue about another two months for drinking purposes. Due to groundwater recharging, all the wells work during dry season as the water table did not decline due recharging. It is to be noted that the schools dispose and manage the wastes in a hygienic way and make compost for further use in the flower and vegetable gardens. Using water from direct rains, almost all schools produced various vegetables in school-lane, fields and portions of playgrounds, which facilitated in good quantity of foods. They used compost fertilizers made from wastes in producing fruits, flowers and vegetables. CUB and DAM shared the unique experience among the near by slum inhabitants and facilitated them for practicing that unique learning for rainwater collection and storage using available utenciles and earthen pitchers at home. They also use small pies of cloths and polythene sheets as catchment roofs. CU and DAM also facilitated in promoting kitchen gardens where they used rainwater during rainy seasons and kitchen waste water during dry season.

They also manage their household and kitchen wastes for compost making that helps in keeping their households neat and clean along with using those in small scale vegetable and fruit production to meet up their family needs. Over 200 urban poor families practiced the learning and got access to safe water around five months and got chemical free organic fruits and vegetable round the year, which contributed them in saving money from buying fruits and vegetable from markets. It is roughly calculated that each "rain water harvesting system" can save 2,930,480 liter water annually as its use in the latrine on average 30% students in a school, daily 4 liters consumptions per student and 140 school days. It also saved 732,620 Litter water as its use in the basin for hand washing. By recharging, a school contributes 210,000 liters water at underground level based on 3000 liters intake for 70 days raining in a year. Therefore, the installed rain water harvesting system saved total 3,873,100 liters water (from the lifting of ground water). A household consisting of five members can save 1 member 5 liters per day for about 140 days in a year. The sum stands at (5x5x140) 3500 liters in a year. If those households are supported for groundwater recharger, the amount will stand at almost another 10,000 liters annually which is bigger savings and compensation for underground, as underground water is the main source for both drinking, domestic and irrigation water now a days in Bangladesh. However, CUB and DAM conducted various awareness activities along with imparted use, operation and maintenance training for expected use and maintenance. CUB and DAM also conducted regular monitoring during implementation and continuing follow-up after phase out. Field observations and monitoring reports reveal that reveals that 90% Rainwater tanks are always functional, well-managed by school WASH management Groups and SMC and they are careful for necessary security, hygienic use and environment. As the results of implemented activities, health status of students improved, school attendance increased and dropout number decreased. The parents also feel glad with the arrangements. Field findings further reported that many students have practiced it at home. Few problems were found during implementation the project: unwillingness to pay cost sharing money (5% of the total installation costs) by the school authorities, less capacities of the rainwater tanks, lack of required skills in managing the rainwater system by caretakers, resource constraints etc. Scaling up, replication and sustenance are the major challenges of CUB and DAM in the near future.

Water4Crops: Integrating Treated Wastewater Reuse and Enhanced Water Use Efficiency (WEF) to Support the Green Economy in EU and India

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Keywords: wastewater reuse, water use efficiency, green economy, EU, India

Introduction and problem identification

This paper aims at introducing the new research project "Water4Crops – Integrating biotreated wastewater reuse and valorization with enhanced water use efficiency (WEF) to support the Green Economy in EU and India". The project addresses the EU call for proposals "FP7 - KBBE.2012.3.5-03: Biotechnological wastewater treatments and reuse in agronomical systems in a joint EU-India cooperation". Two "twin" projects (Water4Crops-EU and Water4Crops-India) were prepared by two distinct consortia and simultaneously submitted for funding to the European Commission and the Department of Biotechnology (DBT) of the Government of India, respectively. The European consortium is made of 22 partner institutions, whereas the Indian one has 14. EU and DBT contributions are about six million Euros for each project, respectively. This presentation mainly deals with Water4Crops-EU, although most issues and approaches are also shared and adopted by the Indian project.

Analysis, results and implications for policy and/or research

Water4Crops will last four years (2012-2016) and its main objectives are:

- To develop innovative biotechnological wastewater treatments for improved water use in agriculture.
- To initiate the co-creation of alternative combinations of bio-treatment, recycling of high value elements, and combinations for bio-products leading to a better commercialization of biotechnology and agricultural products in Europe and India as a basis for a "green growth".
- To improve water use efficiency at field level through agronomics, plant breeding and locally adapted new irrigation technologies and accurate crop water requirement measurement techniques. To facilitate and enhance the stakeholder participation (technology producers, technology users, retailers, and regulators), activities coordination and exchange of information within the INNOVA co-creation platforms and beyond.
- To use the collaborative research with India as means towards food and water security and enabling mutual strive of India and Europe towards a Green Economy.

Technologies developed in India and Europe, both in the field of bio-treatment and increased water use efficiency are basically comparable, but their applications are context-specific and require new adaptations and integration. In order to boost the bio-based economy both in Europe and India Water4Crops will provide a comprehensive set of key technologies (reflecting the highest state of the art in Europe and India) to highlight the differences in processes and applications, and finally to identify the best possible modifications to achieve a higher and combined use of technological advances from both at both regions.

Water4Crops aims not just at a further development of individual technologies, but also at understanding their added value in relatively unexploited fields of application (both in India and Europe). Therefore, Water4Crops specific objectives are:

- Production of water suitable for irrigation from wastewater (food-processing, domestic or bio-refineries) and return of nutrients as fertilizer to the land.
- Recovery of specific high added value products from wastewater (e.g. polyphenols), anaerobic conversion of wastewater components into organic acids, alcohols coupled with in situ product recovery, production of bio-plastics (Poly hydroxy butyrate) from high carbon wastewater, and energy recovery from the final treatment.
- Development of easy and cheap microbial monitoring methods to control the irrigation water quality in terms of pathogens.
- Optimize domestic wastewater treatment, recycling and discharge via constructed wetlands with control of heavy metal removal, developing new management of constructed wetlands in terms of improved purification capacity and suitable plants selection.
- Development of improved irrigation technologies, systems and strategies, coupling of irrigation systems with soil moisture control and modelling in saline conditions, and provide an accurate estimation of crop water requirements using new technologies for area-based actual evaporation and soil moisture measurements.
- Modelling the impact of using poor quality water on crop and soil quality.
- Improved water use efficiency (WEF) at the field level through genomics and plant breeding.
- Development of a Green Economy by trans-disciplinary co-creation of agri-business opportunities and water bio-treatment and evaluation and optimization of the proposed combinations of water processing from a perspective of supporting the Green Economy.
- Stimulate cross-fertilization and knowledge transfer between the individual work packages and activities in Europe and India.
- Disseminate the newly developed technologies, the new economical concepts and local business demands, and exchange the experience between India and Europe on advancing the Green Economy.

Urbanization and Climate Change: Impacts and Adaptive Strategies for Water and Food Security

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Keywords: urbanization, climatic variability, water, food, adaptation

Introduction and problem identification

Access to adequate water supply and basic sanitation are fundamentals for an acceptable livelihood. The most visible and direct impact of urbanization has been significant increase in the competing water uses and diminishing water supply. Despite being located at the fringe of the city, the peri-urban areas have the characteristics of being inadequately integrated into the city with regard to social and institutional issues as well as for infrastructure services. Increasing rate of population and growing urbanization has put immense pressure on land and water services in peri-urban landscape which has further been accentuated by climatic variabilities. This paper describes the implication of growing urbanization in combination with climatic variabilities for water and food stress and adaptation strategies of the people at household, community and institutional level in peri-urban landscape of Kathmandu.

Analysis, results and implications for policy and/or research

Through multiple series of focus group discussions and key informant's interviews, the study found that the people in the area have no system of private water supply connection and the entire households at Lubhu depend on public stand posts with water supplied from Chapakharka Drinking Water Supply System. The water supply from this system has been only for few hours a day supplying approximately one thousand litres per day per tap, for their domestic water needs, depending about hundred households in each tap. Being located close to expanding sub-metropolitan city, growing urbanization has increased the people to be served by the existing water supply system while the supply from the source has been adversely impacted and limited especially due to the combined effect of climatic variabilities and urbanization. With the aim of reducing the pressure on existing water supply system, people at Lubhu developed Dovan River Drinking Water Supply System; however, the water quality of this supply is poor compelling them to still depend upon the earlier supply for drinking water. At the community level, the people in the village have envisioned development of filtration system for the Dovan River while at the household level despite poor quality of ground water, dug wells have been their alternative water source which during the days of no supply in public stand posts are their only water source. At an institutional level, Lubhu Drinking Water Supply and Sanitation Committee along with Village Development Committee office have envisioned to focus only on water management in the village for certain years by allocating the maximum budget of the Village Development Committee (VDC) office and holding the other development budget for few years until and unless they ensure water security in the village. Increasing climatic variability, mainly irregularities in rainfall and increase in temperature has further accelerated the situation of water stress in the village. Farming communities have been using water from historical Rajkulo (state sponsored irrigation system) and other small scale irrigation systems with water derived from spring sources and rivers for irrigation needs.

However, these systems have now been dependent on rainfall due to decreased water supply at the source and continued lack of maintenance. Some irrigation systems have been destroyed and become non-functional due to land plotting for building construction and town planning in the area. Farmers have been adapting to this through switching agricultural crops from high water demanding crops to less water demanding crops and even more by deviating towards off-farm activities. People have been even leaving the land fallow because of continuous decrease in agricultural production. Only eight percent of the total households in the village have been able to sustain the family for whole year solely from agricultural productivity whereas fourty eight percent have agricultural production sufficient only for three months or even less. People have been adapting to these circumstances by shifting to adopting alternative occupations like business, service and local labor. The concern for sustainable land and water management is growing among the local community however, strong dedication and unity among the communities is likely to be critical to ensure the water security in the village and improve their adaptive capacity.

Sanitation Without Pipes – The 'Honeysucker' Approach to Human Waste Management Using Vacum Trucks

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Keywords: sanitation, management, nutrient, septage, reuse

Introduction and problem identification

Managing human waste in urban areas has traditionally involved the construction of underground sewage systems which are extremely expensive, difficult to maintain, demand energy, require skill, do not reuse nutrients, have lumpy investments, call for skilled manpower beyond the capacity of local government and are at best 50% effective. What is required is a simple,incremental approach involving more players than the highly skilled sanitation engineers alone. An alternative emerging from the informal sector is the 'honeysucker' model of vacum trucks which empty septic tanks and pit toilets, eliminate manual scavenging and recover nutrients. This model could be applicable to almost all urban areas of India and the developing world if appropriately managed. The correct understanding of the solution and its integration by mainstream sanitation and agricultural engineers is called for.

Analysis, results and implications for policy and/or research

Bangalore a city in South India and the capital of Karnataka State has a population of about 9 million in 2011. Sewerage systems do not reach across to all the households in the city especially the periphery. A recent Survey of the Environment report by the State Government 2008 states 'Of the 1,000 MLD sewage generated in the city only 400 MLD or 40% of sewage is collected and treated by the Bangalore Water Supply and Sewerage Board and the remaining sewage is let out into storm water drains, which finds its way into lakes, tanks and the groundwater. Many buildings including individual homes and apartments on the periphery of the city are not connected to the Underground sewerage network as the lines have not been extended to the suburbs. They manage with essentially pit toilets. Concrete rings are lowered into the ground to a depth of 6 meters. Toilets are connected to these pits. For a long time these pits were emptied manually when full a practise called manual scavenging. With the passing of the Manual Scavenging Act in India and the abolishing of the horrendous practice a small informal economy has opened up which makes the vacuum sucking trucks called Honeysuckers. These are rapidly expanding in numbers as the market they serve demands their service due to the clean job they do and the short duration taken for emptying the sludge as less as 15 minutes. It is estimated that there are up-to 200 such vacuum trucks in the city alone serving over 150,000 buildings. The vacuum trucks themselves are being assembled in small informal workshops. In the absence of a septage management policy and a high charge in dumping the septage in treatment plants, farmers have taken to collecting and composting the septage and using it on their crops. Some enterprising farmers also manage to see the fertilizers so generated at a reasonable price. A flourishing market now operates in the sanitation sector providing an end to end service right from the construction of a toilet and soak pits, evacuating it when full and composting and reusing the septage as fertilizer. The cycling of nutrients completes what would be called Eco-san or ecological sanitation. A 'honeysucker' truck services up-to 5 buildings in a day with about 3000 litres capacity. Assuming a 2 year cycle one truck can cater to approximately 3000 buildings or a population of about 15,000 people.

A small town of 60,000 can do with 4 such 'Honeysuckers'. Each 'Honeysucker' provides employment to 3 people and requires 1 Hectare of land for composting. 4 hectares of land will be sufficient to compost for a town of population 60,000. Each load of 3000 litres converts approximately to a tractor load of fertilizers approximately 1500 kg. with which it is possible to fertilize 1 Hectare of land for a crop like millet or for a coconut plantation. This substitutes for artificial fertilizers which are very expensive and saves money for farmers. Since 'honey-suckers' can target the domestic sector only industrial waste is not picked up and only domestic sewage is composted. This is unlike the sewage treatment plants where both illegal industrial effluents and domestic sewage mix and then have to be treated. The paper seeks to explore the growth of this informal market and draw out an appropriate legal framework for the management of septage. Lessons learnt also can be transferred to almost all small and medium towns in India which lack sewerage and which are not likely to get them in the coming years.

Opportunities and Constraints for Resource Efficient Environmental Management in Rapidly Developing Urban Areas

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Keywords: assessment, conservation, development, scenarios, technologies

Introduction and problem identification

This paper reports about different scenarios for environmental management in a peri-urban area of Mexico City, namely Xochimilco. Xochimilco is of strategic importance for Mexico City for recharge of the depleted aquifers and features a traditional form of agriculture.This paper looks at integarted resources management in the area. The considered environmental sectors are water supply, sanitation and wastewater, solid waste and agriculture. The research question has been to what extent resources (water, nutrients, energy) can be recycled and reused between those sectors. In the geographical area there has been a trend towards urbanisation and little activities have been taken to increase resources reuse and recycling. The scenarios have been developed taking into account the visions of local stakeholders for future development of the peri-urban area. Each scenario has then been analysed according to three dimensions: environmental impact, economic impact and social impact.

Analysis, results and implications for policy and/or research

A scenario analysis was conducted in 2010. The scenario analysis has identified three scenarios for the future development of Xochimilco:
1: Local identity (Protectionist and environmental scenario, closed and local, control of urban expansion and population growth)
2: Economic development (Economic development with a strong focus on agriculture, certification of local products, training of farmers, no use of chemical fertilisers, new products, marketing activities)
3: Urbanisation (Full integration into Mexico city, centralisation of services) In the context of resource efficient environmental management scenarios 1 and 2 would allow for much more reuse and recycling of resources between the considered sectors than secanrio 3. However, the third scenario seems to be the most likely one based on the trend analysis conducted using satellite images since the last 4 decades.

A main research question was to conduct an integarted assessment of the different scenarios with respect to the technical concepts underlying them for the considered sectors (water supply, sanitation and wastewater, solid waste and agriculture), and hence to answer the question whether the overall impact (environmental, economic and social)of resource efficient planning is more advantageous than of increased urbanisation. For each the three scenarios a corresponding technical concept was developed, also building op on the results of participatory workshops conducted earlier.

The technical concept should reflect the philosophy of each scenario:

Scenario 1: In this concept scenario individual technical solution are preferred over centralised ones, to become independent from Mexico D.F. In order to strengthen the local identity, which is very much connected to the chinampas and traditional agriculture, composting and use of local water resources are important components of this scenario, as well as prevention of pollution of channels which are used for irrigation. On-site biogas systems reduce the use of burning wood and make households more independent.

Scenario 2: Economic development with the main focus on agriculture is the main feature of this scenario. Water and sanitation services emphasize therefore on reuse of nutrients and water in the chinampas. The principles are similar to scenario 1, but, where feasible, services are provided on communal level. Water is supplied by a communal RWH system and users get connected to a decentralised (communal) treatment plant within San Gregorio. The effluent can be reused for irrigation. Those who live too far away from the water supply network and sewer, use on-site RWH and Ecosan systems where nutrients can be reused. Organic waste is composted centrally with sediments from the channels and then distributed to all farmers.

Scenario 3: All infrastructure services are centralised as far as possible. Users are connected to centralised water supply and sewer systems. Composting is done on centralised level and then supplied to local farmers. The selection of technical solution is done on higher administrative levels and also resources flow is limited to measures taken by D.F. and not influenced by measures within the case study area. The integrated assessment encompassed the following aspects: 1. Economic impact: A major decision criterion for decision makers will be the economics of a measure. Building up on the concept of the total economic value (Pearce, 1993) the direct and indirect benefits expected from each scenario were identified and valued using different types of economic methods. The considered benefits ranged from improved hygiene to provision of resources and generation of income. 2. Costs Each scenario will need a different set of technologies to be implemented. The costs of these technologies were calculated. 3. Social acceptance Further, the preferences and values of the different stakeholder groups for each scenario and its technical concept were elicited. 4. Environmental impact Finally, the environmental impact of each scenario and its technologies was assessed. The work is currently in its final phase and will be finished by spring. Hence, the full results will be presented.

Sri Lanka – Focus on Food Security and Water Use Efficiency

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Keywords: food security, water scarcity, paddy, home garden, third season

Introduction and problem identification

Sri Lanka is a country with a total land area of 64,740km^2 and situated below the southern tip of India. Country is totally surrounded by the Indian Ocean and consists of moderate climatic conditions. Although the country has a well distributed net work of 103 major river basins, approximately two third of the country experiences periodical water scarcity as the rain fall is of a bi-modal pattern. 30 percent of the total land area of the country is under agricultural crops. Tea , Rubber , Coconut and Spices are major export earning crops. About 65 percent of the population is employed in agriculture related sectors. Rice is the staple food and its production reached self sufficiency level for the first time in last year. Some of the other food items are being imported therefore arrive at self sufficiency level in those is the immediate target.

Analysis, results and implications for policy and/or research

As the most suitable area for field crops are in the Dry Zone which experiences periodical dry periods, the water conservation becomes rather an important factor in the agricultural system of the country. Several measures have been taken by the country to increase production of food crops while using water more efficiently. One of the major measure being rehabilitation and maintenance of the ancient tank cascade systems. These man-made surface water bodies include a myriad of irrigation tanks that dot the islands dry zone to trap and store rain water.This allows the excess water to be collected, stored and distributed for cultivation when required. In certain instances out flow of this process is again used to irrigate some other crop. Several major rivers are also diverted to form large scale reservoirs which provide hydro electricity along with water for agricultural purposes in dry areas. The collected water in the reservoirs is distributed among cultivated area in a particularly fair manner. The authorities decide and announce the possible crops to be cultivated in the season considering the water quantity stored in the reservoir and the water requirement of each crop which makes the water usage more efficient. Second measure is introduction of an extra season for cultivation.This is to plant a short term, low water required crops just after the harvest is collected from the paddy field. This has shown a tremendous success in the last year and will be expanded in this year. Water consumption and land preparation costs are at minimum. Only high value crops are cultivated under micro irrigation systems. At the same time farmers are encouraged to follow primary water conservation practices such as mulching, rain water harvesting and adding organic matter to the soil. Rice is the major water consuming crop cultivated in the country and various measures have been taken to reduce water usage in paddy cultivation. Short term varieties of paddy have been innovated as they require less water, and the farmers are encouraged to use these new varieties. The possibility of using waste water to irrigate rice paddies have been tested in some semi arid areas. At the same time the government has implemented some more programmes to ensure food security of the country. One such famous venue is promotion of home gardens. The government has implemented number of home garden promotion programmes from time to time within the last two decade. As majority of the population live in individual houses and most of them consist of some garden area, these programmes have shown tremendous success.

Supply of seeds on free of charge basis, propaganda work and implementing competitions have contributed for this success. In these home gardens special attention is focused on re use of water discarded by household activities. Animal husbandry is promoted as it provides with organic manure and increases water holding capacity of the soil. Promotion of bio gas use contributes power supply to the household as well as organic manure for cultivations. And another aspect which contributes towards increasing the production is fertilizer subsidy scheme. As Sri Lanka does not produce any fertilizer in the country, cost of inorganic fertilizer is very high. The government has imposed a very heavy subsidy on fertilizer (about 90% of the cost is subsidized). This has been initiated with rice and now has been extended to most of other food crops. Giving only urea under subsidy at initial stages led to imbalanced fertilizer usage and at present all the fertilizer varieties are provided on subsidy to overcome this problem. This fertilizer subsidy scheme has led the farmers cultivating fallow lands and increasing the production. Furthermore it has been observed that around 30 percent of the agricultural production goes waste due to bad post harvest handling, especially during transportation and at the retail market level. Introduction of good agricultural practices as post harvest handling level has been already initiated as it will increase food availability dramatically and will play a major role in food security.

Recycling Grey Water for Rotational Household Vegetable Farming to Improve Food Security in Urban Areas

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Keywords: recycling, water, food, security, urban

Introduction and problem identification

Kampala is the capital city of Uganda with a total population of 1,659,600 covering a total area of 189km^2 (7 Sq mi). Like most of the cities in Africa, Kampala is experiencing a number of problems including a shortage of houses and land due to the rapidly growing population, malnutrition especially among the children under five and high standard of living. According to Uganda Bureau of Statics, the prevalence of food insecurity is higher in urban areas although the incidence of income poverty is higher in rural areas. In his research, Godfrey B. A. Bahiigwa (1999) indicates that food security varies from one season to the next, depending mainly on the weather patterns. Household food security also varies across regions, agro-ecological zones and district. In general, he identified two main causes that cause household food insecurity; inadequate rainfall and pests and diseases.

Analysis, results and implications for policy and/or research

With all the existing problems in Kampala, it is vital that the residents are food secure and that they can readily have a balanced meal at least twice in a day. However, this is not the case in Kampala. Findings from the rapid survey conducted Concerted Efforts for Sustainable Development in 2009 revealed that, due to the high standards of the living conditions in Kampala and high poverty levels, 6 out of every 10 households interviewed could not afford to have two meals a day. The finding further revealed that, if a household managed to have a meal, it was not balanced which has resulted into health negative effects including malnutrition, low immunity to diseases, retarded growth and loss of energy to work. Lack of enough land and space and the effects of climatic changes coupled with unstable global and national economy have exacerbated the situation among the population because the majority cannot cultivate food crops to mitigate their food related problems yet according to Godfrey B. A. Bahiigwa (1999) 95% of households depend on won production as the main source of food. Howver, the citizens of Kampala are not in position to cultivate their own food yet they can not afford to buy all the types of food they require from the market due to financial limitation. The few farmers in Kampala are also challenged because their efforts have been averted by long drought spells with no practical alleviation measures Consequently, with such problems, the population of Kampala must recycle grey water or water refuse for household rotational vegetable farming to improve on their food security and nutrition status. Farmers with some small pieces of land could cultivate the vegetable in 'kitchen gardens' while the farmers limited by land could cultivate vegetables in baskets, polythen paper bags mental and plastic tins which could be hanged and rotated around their households or placed around their homesteads like the balcons or shades. Vegetables like cabbages, 'sukuma witch' egg plants and many others can grow so well on small pieces of land and space all season round and households could save and recycle all the grey water that they could saved from any domestic use.

For example, after washing utensils, laundry, mopping, bathing; and this water refuse could be kept and refined in a simple way to irrigate the vegetables especially during the dry season. Rotational vegetable gardens or Kitchen gardens could grow well in all places in Africa and in all seasons if they are watered and since most of the African cites are not assured of rains all through the year, population need to supplement their few meals with vegetables to balance their diet to fight health related problems that could result from poor feeding. If populations accompanied their daily meals with vegetables or had a vegetable meal it could boost their immunity systems since vegetables are scientifically recommend due to their food value. Besides, guaranteeing food security, the population's health can be improved yet the surplus could be sold to earn some income to purchase other health recommended food stuff for them to be able to have at least two full and balanced meals in a day. Consequently, policy makers should advocate that urban population should endeavor to set up kitchen gardens or use the available rotational planting materials, to enable them cultivate vegetables mainly at household level irrigating using the saved water refuse from domestic household activities. This could ensure that the urban population can easily access food-vegetables in all seasons.

Workshop: Trade and Food Security

Do We Really Need a Water Footprint?

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Keywords: virtual water, water footprint, economics, water-food-nexus, trade

Introduction and problem identification

Virtual water, the amount of water used along a good's value chain, has come under discussion. Fairness and efficiency problems are seen to arise in the reallocation of access to water resources through the means of international trade. Particulyrly, moral concerns are attached to both imports and exports, and even to a country's own consumption of virtual water. Global institutional arrangements have therefore been suggested to regulate virtual water trade. The question arises whether a merely quantitative measure is at all able to provide sound information for guiding both economic and political decisions on water and water-related trade in a sustainable way? What can virtual water measures like footprints or trade flows tell us about sustainable trade patterns or an appropriate utilisation of scarce water resources? Is there really a need for a particular global water governance based on virtual water accounting?

Analysis, results and implications for policy and/or research

The concepts of virtual water and water footprints have gained increasing attention due to their ability to disclose the linkages of local water consumption and global trade. An increasing number of studies assesses the virtual water content of commodities as well as the magnitude and directions of virtual water trade flows, recently differentiating between blue, green and grey water; further refinements to water footprint analysis like a weighting with scarcity indices and shadow prices have been introduced. Despite the potential benefits of trade, virtual water trading has been criticised from various sides. It is feared that poor countries which rely on virtual water imports will reach a problematic state of dependence, while virtual water flows from developing to the industrial countries are equally observed with concern, as the "wasteful lifestyles in the global North allow these countries to put pressure on water resources in other parts of the world. Since trade flows mostly do not match the trading partners' water scarcity, the objective of "global water use efficiency" is feared to be missed. Therefore, the need for a coordination of the global "water market" is seen. The instruments which are suggested in this context range from taxes on virtual water imports to taxes on pollution in a product's waste stage and a scheme of water footprint permits, which are to be distributed according to notions of justice ("virtual water for all").

Additionally, virtual water calculations are supposed to guide local water policies like production and pricing decisions. The contribution of this article will be to analyse the normative implication attached to the virtual water concept as well as the need for and the effects of a "global water governance". The paper will be organised as follows: After having introduced the main concepts of virtual water and water footprints in their various guises (water footprints of products, people or nations, virtual water trade balances etc.), as well as the recent refinements to water footprint analysis, the main normative implications of the concept will be delineated and contrasted with the quantitative indicators of virtual water to give an illustration as to which are the potential problems these figures

might detect. After the policy suggestions which have been made in the context of trade and water will have been introduced, virtual water will be analysed from the viewpoint of international trade theory, to illustrate the potential benefits of trading in a perfect world. In the following, the concepts of virtual water and water footprints will be re-examined to answer the question whether these measures are able to deliver relevant information, especially taking into account the various "refinements" to water footprint analysis. The final questions are firstly, whether the normative "framework" of the virtual water concept is consistent and can be used for policy advice, and secondly, whether at least the presence of bad governance and lacking water prices in the area of production, as well as an imperfect trade regime may justify a global governance scheme regulating trade in virtual water. It is shown that virtual water accounting fails to provide sound policy advice since it lacks relevant economic information about heterogeneous water resources. Since no information about local costs and benefits is given and the role of other production factors is neglected, the "right" direction of virtual water trade cannot be assessed in this way. Secondly, the attempt to apply normative criteria instead to evaluate trade flows turns out to be highly contradictory. When applying these normative criteria almost every conceivable trade relation could be condemned. This reflects the debate about the environmental impacts of trade that has been going on between ecological and neoclassical economists since the 1990s. Environmental problems should be tackled as specifically as possible, taking into consideration local scarcities and preferences. It must be concluded that the actual problems of local water use cannot be addressed properly by unspecific trade restrictions. The policy rules derived are highly presumptive and paternalistic in that they promote ideas of global equality without taking into account the preferences and needs of individuals. Moreover, they deny the ability of developing countries to make production and trade decisions in their own best interests. Thus, policy suggestions based merely on virtual water accounting turn out to be inefficient, ineffective in solving environmental problems and at the same time patronising. The prerequisites for sustainable local water management, including true water prices, fair and democratic decision-making processes about the utilization of water resources as well as a fair regime of world trade have to be dealt with in their respective arenas and not mixed up in global water governance schemes.

Water Management: Export-Import and Food Security

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Keywords: water management, export, import, food security

Introduction and problem identification

The food products are superior and crucial products in the term of export-import, the export value is higher than the import value. For Indonesia's trade report that of food products cannot compete to other Asian country, it shows import value far exceeds the value exports. This indicates that Indonesia will have a high demand on food products which come from abroad. If this is not handled wisely and anticipated at the earliest stage, it will be able to collapse on Indonesia food security.

Innovation, great water management, implementation of agriculture technology and creativity are necessary in order to overcome this matter. Foods will be more meaningful on food self-sufficiency which means that food availability in a kind of Indonesia should be met from its own food products.

Analysis, results and implications for policy and/or research

The food products which have a high demand and strong correlation to the water provision in terms on production process are classified into six groups based on SITC code. The analysis is performed by the method of event history in which the development of exports and imports progress is followed from year to year. The steadily increase in export of food products demonstrates the ability of these products to compete in the international markets, while increasing imports indicate the inability of local products to compete with imported products. Stated above the lowering production yield as the other factor contribute to up and down of the export-import value in a certain country.

1. Food products derived from animals. The export's growth of this group seems gradually decreased, while import continues to increase. In recent years even imported product is almost equal to the export products. This picture shows that over time the live animal products of Indonesia did not attract much interest from overseas buyers otherwise the traders in Indonesia started to buy these animals from abroad. Besides, it also could be due to tighter monitoring of Indonesian export products from trading partner countries of Indonesia.

2. Plant-based food products. In this group, the export value has been surpassed by the value of imports. This suggests that over time the vegetables and fruits of Indonesia cannot compete with the same imported products. This could be the effect of the resulting free trade prices of goods, imported agricultural products (vegetables and fruits) will be cheaper than the price of similar products in local markets. If this policy is not handled properly, it will be able to turn off potential earned income of farmers, which in the long run could lead to loss of land used for agricultural crops. Farmers become less interested in growing vegetables and fruits because they will not be sold on the market that in fact are unable to compete with imported products. Ultimately this will lead to abandonment of agricultural land rather than establishment of beneficial irrigation / watering system management.

3. Beverage products group is processed (industrial) of agricultural crops into beverage products. The trade balance between export-import during recent periods of the year showed an increase in the value

of imports and declining exports of Indonesia's beverages. This trend could be as the impact of the state of export and import of plant-based food products that cannot compete with imported products.

4. Tobacco products' trend of exports and imports were fluctuated in recent years where imports seemed larger than exports. However, in the recent years it shows an increase in export so that its value can beat the value of import. This situation suggests that the tobacco product of Indonesia seemed to be in demand in international markets. This can occur due to the land condition of Indonesia which is matched to the growth of tobacco plants. In other words, the increasing export of Indonesian tobacco products will demand the increasingly required treatment/management of water irrigation in specific way. Those conditional is good to keep the quality of the tobacco plant so it can compete with tobacco products from other countries.

5. Animal oil products groups are becoming worse off by the entry of imported products. Even seen the export of these products has decreased. However, the quantity of exports and imports of these products are only a small fraction of total trade (exports and imports), which is less than 0.5%. And thus the deterioration of export value of these products from its competitors from other countries is not too much effect on overall trade.

6. Trend of vegetable oil products' export showed considerable pride.

The export value is far beating the value of imports. A pretty good prospect of vegetable oil products thus requires good water irrigation system management in order to keep the resulting product can be improved in the quality. In overall export and import of food products, Indonesia looks still pretty good. This is evidence by the high value of food exports when compared to the imports value. The superiority food products from imported products showed that Indonesia was not dependent on foreign products. Indirectly it also shows that food security is still in fairly good extent. From previous reviews it appears that many product advantages meal Indonesia is supported by the product of vegetable oil. The fluctuated export-import report for six groups of food product have shown that food product is not only affected by the quality of food product, but also by agricultural process, particularly the water system management and water treatment for each food product during farming process. Well known that climate change has faced in front of us and will give significant contribution to the water irrigation availability in the crop food production.

Sustainable Use of Water in the Food and Beverage Sector through Product Water Footprint Labeling (PWFL) with Empirical Evidence from Thailand

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Keywords: water for food, water footprint, product labeling, trade, sustainability

Introduction and problem identification

Inefficient water consumption in the food and beverage sector increases unnecessary water use in production as is evident in countries such as Thailand. In Thailand, rice yields averaged 2.5 ton/ha in the period 1997-2001, while the global average in the same period was 3.9 ton/ha (Hoekstra & Chapagain, 2008). This implies that Thailand can improve the way it produces its rice crop in order to increase the yield per hectare and reduce water consumption. The government may be able to create policies that compel all sectors in the country to use less water in their operations. However, these practices often take time to move through the layers of government bureaucracy. As a result, this paper aims to develop the "Product Water Footprint Label (PWFL)" as a market-driver instrument that would motivate businesses in the food and beverage sector to minimize water consumption throughout their supply chain.

Analysis, results and implications for policy and/or research

The PWFL will display how much water is used in manufacturing one unit of a product, categorizing water usage into blue and grey water footprints, because these two types generate more negative effects on water resources than green water footprints. Displaying only two types of water footprints may be advantageous because it reduces complexity and makes it easier to communicate with end consumers. As a consequence, an aggregated figure of total water footprints does not appear on the PWFL. Rather, the animation of blue and grey water drops with small figures represented as blue and grey water footprints appear. For example, the PWFL consists of 7 blue water drops, 2 lighter blue water drops, 5 grey water drops, and 2 lighter grey water drops, with each drop representing 10 liters of water use. It informs consumers that the product consumed 70 liters of blue water along its supply chain, and that 50 liters of water were polluted due to its production processes. At the same time, it shows that this product uses less water than the average water use of 20 liters of blue water and releases less wastewater than the average wastewater of 20 liters of grey water. This implies that the company generates less negative environmental and social impact due to a reduction in grey water, and that the company creates positive environmental and social effects owing to its saving of blue water. However, the label cannot provide highly specific information about positive or negative effects derived from the product's performance, such as the type of pollution generated. According to empirical evidence, there is a misperception about how much water is consumed by the agricultural sector, since respondents estimated that only 40-60% of global water resources is used by that sector, when in fact, agriculture consumes about 60-80% of global water resources. This can be used to guide public perception that if Thailand faces water scarcity, not only the industrial sector, but also agriculture should be focused on and participate in reaction plans. Water problems in Thailand are rated as highly important, which was also perceived to have a significant effect on respondents' personal lives.

Respondents expressed that taking responsibility for causing and solving water problems are included in assignment of the industrial sector and the Thai government.

Nevertheless, respondents felt that participation in solving water problems is considered as consumers' engagement. In conclusion, Product water footprint labeling aims to furnish consumers with the information necessary to make a sustainable purchasing decision, initiate a dialogue in relation to competitors, policymakers, and consumers, and drive the market toward the requirements and goals of PWFL. These include sustainable use of freshwater in the food and beverage sector. If consumers have this information, they are better informed to choose products with a lower negative impact on the environment. All this in turn would force companies to find ways to use less water in their production chains, in order to obtain a PWFL. This would lead to an increase in freshwater for ecological uses and a decrease in contaminated water. In addition to altering consumer behavior, PWFL might compel manufacturers to be more water-concerned, as in the case of the dolphin-tuna controversy and eco-labels. Once a critical mass of businesses has applied successfully for an eco-label within a certain market segment, the remaining companies find themselves under considerable market pressure. Another important possible and expected positive effect on society derived from PWFL includes improvement of human health and welfare through food security. It also has the potential to reduce conflicts about water resources between and within countries, especially those in the Near East.

Access to Fresh Water and International Trade Law

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Keywords: water, climate, change, trade, law

Introduction and problem identification

Addressing the issue of 'access to fresh water and international trade law', the scientifc poster focusses on three main topics, namely 'trade in (bulk) fresh water', 'virtual trade in water' and 'GATS, investment and human rights'. All topics are investigated under WTO international trade regulation.

Analysis, results and implications for policy and/or research

Under the first topic; 'trade in (bulk) fresh water', two important legal questions are still unsolved. Both questions refer to the legal status of fresh water resources. The first question considers the legal status of 'bulk' (large amounts of) fresh water under GATT international trade law and can be formulated as follows: Can 'bulk' fresh water -if artificially transferred- be considered as a 'good' or 'product' subject GATT international trade law rules?. The second question considers the legal status of fresh water resources 'in their natural state' under international trade law and can be formulated as follows: Can 'water in its natural state' -not artificially transferred or putted into commerce- be considered as a 'good' or 'product' subject to GATT international trade law rules? The outcome on both questions is crucial since it touches on the availability (allowable export restrictions under international trade law) of the fresh water resources of a specific country to their international trading partners. The second topic; 'virtual water trade' deals with the negative effects caused by the local production of water intensive (agricultural) products upon the availability of fresh water resources in water-scarce countries. Rather then producing water-intensive crops themselves, water-scarce countries could import these from water-rich countries, thus 'virtually' importing the amount of water needed to produce the goods. This way, depletion of domestic -scarce- water resources can be attenuated to some extent. Here, the question emerges whether 'non trade concerns', such as the protection of the environment, can be taken into account as a criterion for the legal treatment of environmetally harmful irrigation- (and related-) subsidies under the WTO Agreement on Agriculture (AoA). A second question concerns the allowability under WTO rules of distictions between otherwise 'like' products for taxation purposes. In view of saving more fresh water on the global level, physically identical products could be taxed differently according to the higher or lower amount of water which is used during their production cycle (process and production methods or ppm debate). The WTO is reluctant to accept such 'environmental' distinctions for otherwise 'like' products since they could easily hide protectionist measures. Finally, a third question relates to the legal treatment of water footprint labelling under the WTO's Agreement on Technocal Barriers to Trade (TBT). The third main-topic relates to 'access to basic sanitation' and deals with investment- and human rights issues under the General Agreement on Trade in Services (GATS). Most countries are reluctant to open up their 'water (distribution) services' markets to the private sector. This is usually done by making specific commitments in the countries national GATS schedule, with the appropriate 'horizontal limitation' in order to be able to regulate further in the field on the national level in crucial areas. However, many difficulties lay in the interpretation of GATS provisions when they are to be implemented to the water distribution service sector.

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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