Clean Energy and Water: an Assessment of Services for Adaptation to Climate Change - CCW Research Project

Phase 1: Exploratory Study

The project in a nutshell: The project aims to address, through a number of research reports, case studies and a workshop, some key research gaps in the use of renewable energy technologies for water services in developing countries. The purpose is to analyze the way those services can be improved, so as to enhance the resilience and adaptive capacity of communities to climate variability and change. Focus will be put on the socio-economic, environmental and policy implications of different technological choices. The two main outcomes of this work will be (1) a series of four high-quality research reports related to the gaps identified in this document; and (2) a better sense of possible entry points for further investment within the CCW program.

Abstract

As a result of climate and other human induced changes in the hydrological cycle, the availability and quality of water as well as the availability and reliability of energy generated through water resources is being disrupted. Given the importance of energy in managing water supplies, the adaptive capacity of communities in developing countries is being impacted. Renewable energy sources offer a way for countries to move away from carbon intensive fuel resources (including fossil fuels, charcoal or unsustainably harvested biomass). Decentralized renewable energy, as opposed to fossil based large scale systems, can lead to better, more equitable and more climate resilient water services. However, the social, economic and policy implications of an envisaged technological and behavioral shift are not very well understood. The purpose of this project is to analyze the way water and renewable energy services can be combined in order to reduce vulnerability and enhance the resilience of resource constrained communities to climate variability and change. Research into the diffusion, affordability and equity of such services, as well as associated risks, will be supported.

The project is designed as an exploration comprised of four in-depth assessment reports and a workshop of knowledgeable experts. The research reports will be complemented by a number of smaller case studies by independent researchers. Three main research gaps to be addressed will include: 1) The analysis of factors limiting or promoting decentralized renewable energy technology uptake; 2) The role of policies, regulations and information and communication technologies (ICTs) in enhancing the efficiency and equity of water and energy services; and 3) The consequences of renewable energy uptake by local communities.

IDRC will host a final workshop to discuss the outcomes of the research reports and present the regional case studies. A publication of the workshop proceedings and of the reports is foreseen.

General Objective of the project:
To assess the potential of - and barriers to – the use of decentralized renewable energy technologies for water services to help communities better adapt to climate change.

Specific Objectives:

- To foster and support the development of knowledge to explain why decentralized renewable energy technologies for water services are not used and what would happen if they were used more extensively.
- To determine the challenges and opportunities for such research to inform policies and initiatives aiming at enhancing the climate change adaptation capacity of people living in areas under present or projected climate related water stress.
- To communicate results of the exploratory assessment reports to key stakeholders in Canada and in targeted developing regions.
- To use the assessment results to define clear entry points for further investment within the CCW program.

Rationale

Robust and informed solutions for a complex problem
Climate variability and change are affecting both energy availability and the hydrological cycle (IPCC-1 2007, IPCC-6 2008). Given the importance of energy in water supply and management and vice versa, these changes will and already do influence in particular the vulnerability and the adaptive capacity of resources constrained communities in the developing countries. Among some (by no means exhaustive) examples: the excessive use of aquifers for agricultural needs in some states in India, due to myopic water and energy policies; river runoff depletion due to irrigation services and groundwater saline intrusions in low-lying and sinking coastal areas along the Nile Delta; tribal and communities' conflicts over pastures and (often trans boundary) ground water points in arid and in semi-arid zones in Sudan, Chad, Northern Kenya and Southern Ethiopia, decrease of aquatic ecosystem productivities in the Great Rift Valley Lakes and exacerbation of the commercial effects of agriculture on desertification and global dust fluxes; rural-urban migrations in Colombia and along the rest of the Andean region (Bohannon 2010, O’Reilly 2003, Verburg 2003, Mulitza 2010). Global warming has been increasingly addressed by researchers as a consistent contributor in the raising risks of natural resources related social conflicts, civil wars, trans-boundary tensions and migrations (Zhang 2007, Burke 2009, McLeman 2009, Brown 2009).

Despite the increasing availability of data of the effect of climate variability and change on water resources and on the adaptation capacity of communities from the local to the national level, a few key points are worth noticing:

- For a complex system to adapt, it needs to increase its resilience and robustness to varying events. This is common to social, economic and physical systems. Robustness, in turn, needs a degree of redundancy which, however optimized, comes at a cost. So,

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1 Prof. Upmanu Lall, director of the Columbia Water Centre (The Earth Institute), private communication.
the economic and social costs of adaptation need to be taken into explicit considerations.

- Therefore, in order to decrease vulnerability, resources are needed, energy and water being the most basic ones. So, addressing the problem of adaptation to climate change jointly with that of the development gap in energy availability and equity is a mandatory strategy.
- Communities should be free to make the technology choice they deem more appropriate and closer to their traditional knowledge and cultural habits. However, due to the complex interdependencies in the systems in which these technologies will act, those choices need to be well informed.
- Very few of the authors cited in the References section of this proposal work in developing countries institutions, even if some of the best ones do. Efforts to change this have been at the core of IDRC mission from its birth. Clearly, the effort is still worth undertaking.

After the 15th Conference of Parties in Copenhagen in December 2009, it is becoming accepted that efforts to adapt to climate change should be coordinated and implemented by strategies promoting efforts at the level of local communities.

Local Focus
In many rural and peri-urban areas of developing nations, the determinant response of communities will depend on the capacity of small farmers' agriculture and livestock activities to maintain and increase the productivity under growing uncertainty on rain precipitation, moisture, river flow, temperature patterns and quality of environmental services, keeping the crops and livestock yields high enough to sustain increasing demands from growing urban areas, but without depleting groundwater or other key freshwater resources whose replenishment time-cycles are much larger than those of current human activities.

If adaptation is a global endeavor to be undertaken at the local level, an approach strategy is to strengthen sustainable development leveraging on the resilience and robustness of local social and economic networks, facilitating the conditions under which energy and water services responsible for enhancing adaptation capacities are understood, managed and possibly owned by the communities themselves.

In the case of water services, the necessary local energy production could be ensured through the promotion of decentralized off-grid or mini-grid connected renewable energy technologies. Accordingly, it is mainly on the conditions enabling their diffusion and uptake that this project focuses, including an analysis of possible positive or negative consequences of such diffusion.

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2 In this manuscript, the term renewable energy refers to modern technologies based on solar, wind, biomass, geothermal, and small hydropower. This definition excludes traditional biomass, large hydropower as well as nuclear fusion. Decentralized and off-grid energy are often used as synonyms in the document. They refer to energy production and delivery technologies that are not connected with the main grid. The term “decentralized”, however, has a more flexible flavor, since it includes the possibility for isolated and smaller production points to connect in an alternative network, or to feed in the main grid, where present.
Problems arise in the recognition that decentralized renewable energy technologies (DRETs), while promising, are often still not competitive with widespread greenhouse gases intensive sources (i.e. wood, coal). Most of the times the technology is mature, but ill designed policies, uninformed community choices or excessive capacity fragmentation are hindering its diffusion and preventing costs from being reduced. Additional challenges are the low level of involvement of beneficiary communities into the design of projects, as well as the excessive importance given to technology transfer from developed to developing regions as opposed to the promotion of local capacity and research.

These constraints need to be overcome in a number of key areas, but primarily in those of safe water extraction, delivery and treatment in urban and growing metropolitan areas and in those of sustainable runoff and ground water catchment and management in agriculture and livestock activities in rural areas under growing climatic risk. Where grids are present, improving the efficiency of energy and water distribution services is equally important, together with the support to policies and tools ensuring the resilience and quality of those services in conditions of growing climatic uncertainty.

Finally, some large scale solutions to energy production – namely large hydro-dams and intensive bio-fuel plantations – often advertised as renewable and clean, are highly water intensive, where the term intensity is defined in environmental engineering as the volume of water used per unit of production or service delivery, and it is used here in a broader sense so as to include the amount of water whose changes in temperature, pollution, salinity, nutrients contents and flows in the hydrological cycle are long term or irreversible. The choice of relying on such sources and the way projects are implemented are dictated by energy security priorities at the national and regional scale, but often negatively affect the adaptive capacity of most vulnerable people.

The analysis of non-trivial consequences of a technology shift at the local level

However, due to the complex interdependencies in the systems affected, adaptive and mitigating measures – including those based on renewable energies - could do harm, when implemented disregarding human rights, gender and social implications; or without accounting for side effects triggered at a systemic level. A solution to one aspect to the problem could reveal or create others, demanding further solutions. In proposing alternatives, for instance, the water intensity of decentralized technologies and related improved services needs to be carefully studied - in particular in households farming, water catchment and livestock activities. At the same time, data are missing on the non-trivial socio-economic, gender, demographic mobility and environmental consequences of the development and large scale diffusion of technologies previously not present in a certain region or community, and to their impact on water and natural resources flows sustaining new markets at the informal, semi-formal and formal levels.

We expect the research reports to take into central consideration that the search for solutions should move away from the perfectly optimized one: in dealing with the highly non-linearly case of human-environmental coupled interactions, the often single best solution to a problem usually

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3 Both during the energy production process and its uses, for instance in irrigation.
coincides with a state that is incredibly costly and long to search for, and that is in a very unstable and fragile equilibrium, when found. “Best practices” should focus on the methodology, and look for sub-optimal but robust states, easier to achieve and usually implying a modular and decentralized distribution in the functionality of the system itself.

In this framework, the project aims to support the assessment, in a number of world regions under climate driven water stress, of the present status, strength, shortcomings and further research needs of initiatives promoting decentralized renewable energy in agriculture and water treatment. Moreover, the project will look at the role of better energy services in preparing communities to deal with water risks such as floods, droughts and shortages, power cuts and decline or quality impoverishment of shared resources. In the same regions, the scope of the research reports will also be to discuss how interlinked energy and water infrastructure is at risk to be affected in specific times of crisis or extreme climatic events, so as to provide guidance to specifically targeted research and to open windows of opportunity for the involvement of and support by policy makers to decentralized and more robust alternatives.

Background

The energy and water nexus: problems or solutions?

Energy and water resources are two faces of the same Janus: we need energy to extract, treat and purify, transfer, heat and cool water. In this case, renewable and decentralized energy production and delivery systems can contribute to overcome obstacles encountered in the fulfillment of these needs. We need water to produce electricity, extract fossil fuels, and store potential energy that can be used to run hydroelectric power plants, cool turbines, grow and treat maize, sugar cane and other biomass in order to cope with the increasing demand of bio-fuels (US 2006; Searchinger 2008; Voinov 2009). Water must be used with care, so as not to deplete aquifers; weaken ecosystem services; drain resources from food agriculture, fisheries and the health sector; degrade water quality in term of pollutants and temperature, in particular in the face of changing and increasingly erratic climatic events.

The energy production cycles are linked with the hydrological cycle in different ways depending on the water intensity and scale of technology used, and they influence its equilibrium through shifts in water flows from one geographical region to the other. From this point of view, energy production and distribution are problems impacting negatively on water resources and on the human environmental adaptation capacity depending on them.

Finally, we need more energy to prevent and repair the damages made by climate change-driven events. To cite some examples (ISET-1-7 2008-2009): floods, droughts, disrupted rain patterns, variations of minerals in basins and aquifers, lake pollution and retreat, land loss due to rising sea water intrusions and storm surges, erratic river capacity, soil erosion and deforestation, sinking delta regions. Some of these events impact in turn on the resilience of energy and water services themselves. Because of these interconnections, water and energy cannot be treated in a disaggregated fashion, as it is common today with both markets and policy makers.
With increasing population and corresponding demand, the issues of energy and water security at the national and regional level, and deployment of socially and economically equitable services for citizens – in particular for low income or marginalized communities – need to be addressed more strongly. This calls for choices in which energy technologies are instrumental to economic development and adaptation at the same time, instead of contributing to the conflict between the two.

Intertwined energy and water security issues are becoming evident in particular in the disputes rising around the management of regional river basins such as the Nile, the Rio de la Plata, the Mekong, the Congo, the Ganges-Brahmaputra and the Zambesi, to cite some major examples.

Similar tensions are summing up due to unsustainable use of trans-boundary groundwater aquifers, or to the diversion of water resources from rural areas to growing metropolitan ones. The resulting highly unbalanced distribution of water and energy services is not addressed dynamically enough by national regional and local policies.

Moreover, the energy production and distribution infrastructure currently in place is costly and cumbersome and often at risk of damages that undermine the production and delivery capacity, and bear further environmental burdens (See text box on hydro-dams for an example). This results into higher water and energy tariffs for a lower quality and intermittend service. Moreover, in many cases energy regulations and policies still neglect areas where grid extension costs are prohibitive.
In terms of primary energy, biomass – under the form of fuel wood or charcoal – represent more than 50% of consumption in a large number of developing countries, in particular in Sub-Saharan Africa. This results in unsustainable harvesting of trees affecting the availability and quality of land and water both in the fragile arid and semiarid lands and in remaining forest areas.

Large hydro-dams, an example: The case of dams (IR-2 2009) is a paradigmatic example of the energy and water conundrum in the face of climate change: though hydroelectric power is attractive for many reasons (for example for many countries dams are seen as the answer to climate adaptation through large water storage infrastructure, new fishery basins or regulation of floods), it is least reliable during droughts when the need for drinking and irrigation water may take precedence. With this respect, the energy sector is particularly vulnerable to climate change in relation to water: hydro-electricity accounts for a large part (in some cases up to 80%) of the power generated by many developing countries (IPCC-2, 2007). During periods of droughts the level of water in the dams drops resulting in reduced power supply, less water available for other uses ,power shortages and rising tariffs (since the cost of power generation depends roughly linearly on the water level in the basins).

Large dams can negatively affect both upstream and downstream water sources, in their regulatory role is not matched with varying rainfall patterns and shifting. dry-wet time periods Basins emit greenhouse gases and a large quantity of pollutants and heavy metals such as mercury, arsenic and lead are released in the water basin and impact on the food chain (via construction materials, decomposition of methane coming from submerged biomass or concentration of water discharged by nearby mining and industrial sites, along what is known as the reservoir effect). Furthermore, dams contribute to forced land eviction and population displacement (Skinner 2009, Kakerezi 2009) in areas where communities remain disconnected from the benefits of the electric grid. Some of the largest or more impacting existing or projected dams are in countries where water resources are already highly stressed or that are predicted to undergo longer droughts or flooding patterns in the near future. Finally, dams themselves are facing adaptation challenges due to land degradation around the water basins and shift of rain and river flow patterns, sharing a common fate with other types of power plants in areas at risk (Paskal 2009). For example heavy rains coupled with poor soil management practices in the surrounding farming areas contribute to a decrease in the volumes of water in many basins, due to siltation (AFREPREN 2009).

Decentralized renewable energies in developing countries today: During the decade 1980-1990 IDRC’s Energy Research Group collected and analyzed an extensive amount of work stemming from the following premises: energy research for local communities must be related to the research on the entire economy and society; energy sources must be studied in the context of demand for them; energy saving is as important as energy production. The work did not explore the connections between energy production and water use. Nevertheless, its premises are still valid, together with some of its key findings. Namely:

- The importance to analyze buyers’ preferences, the social factors and the role of informed users influencing the technology uptake process;
- The importance of research and interventions being situation and country specific.

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Concerning off-grid renewable energy, the output also stressed the low level of technological maturity and its large set-up capital costs, together with its comparative smaller market. This is only partially valid today (Lorenz 2008): technological advances\(^5\), coupled with the alignment of renewable energy with poverty alleviation agendas, increased awareness of decentralized energy benefits, and increased international support for off-grid initiatives have spurred research and a number of projects worldwide. This is true in particular in rural areas, given the prohibitive costs of expanding the grid, the abundance of renewable energy resources in most of developing countries and the improved efficiency and reliability of technological solutions. Also, markets are enlarging thanks to subsidies for renewable energy\(^6\), lower costs, and innovation. Renewable energy technologies are also being developed in rapidly growing economies, such as the BASIC\(^7\) group.

Some examples of initiatives in rural and peri-urban areas for local electrification, irrigation, food conservation, health and water treatment are: the Millennium Villages, the Barefoot College grass-roots capacity building solar-homes projects, the solar lanterns, solar ovens and micro-windmills programs implemented by NGOs like SolarAid, Light Up The World or Practical Action in Sub-Saharan Africa or South Asia, the World Bank Lighting Africa and Solar Homes programs, the TERI\(^8\) led Lighting a Billion Lives project, the Energy Poverty Action joint initiative\(^9\) and various Improved Woodstoves initiatives\(^10\) (For a significant list of off-grid renewable energy applications and in southern countries the reader is referred for instance to Burney 2010, SciDev 2010, IR 2010, Karekezi 2002, Enable 2007). Most of these initiatives target food security, education, health and vulnerability communities, contributing indirectly to strategies for the adaptation to climate variability and change.

In spite of the large investments on renewable energy science and programs, global production capacity of off-grid systems has been rising linearly in the past 15 years, as opposed to the exponential increase of the grid-connected supply. Research is needed on approaches (Karekezi 2009) that emphasize the use of a broad range of renewable sources (wind, biomass co-generation, micro or non-dam hydropower).

The field of technology transfer is crowded, and a lot is being done on local capacity building and on development of low cost technologies in situ and in a format acceptable by local users, in particular for household and small landholders. India is pioneering the market through the work of social enterprises such as SELCO. In two areas in particular, water purification and low water intensity solar powered irrigation (Burney 2010), technologies are mature, but more research is needed to clarify the mechanisms facilitating their diffusion and impact.

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\(^5\) For instance the cost of electricity per kWh produced by grid-connected solar plants has been dropping exponentially in the past 10 years.

\(^6\) In turn facilitated by the decline in the energy conversion and storage costs, greatly due to more efficient PV cells and batteries. As an example in some countries such as India, the long-term costs of using solar-powered lamps are already considerably cheaper than traditional lighting fuelled by kerosene. It must be said, however, that subsidies have often been badly designed or are starting to be prematurely phased out.

\(^7\) Brazil, South Africa, India, China.

\(^8\) The Energy Resource Institute, New Delhi, India.


\(^10\) Introduced privately in some countries like Kenya from the 50s, they have become the focus on many development agencies programs. Kenya has recently seen successful solar homes programs as well.
On the financing side, initiatives such as the US-Indian S$^{3}$IDF (Sustainable Small-Scale Infrastructure Development Fund), the Grameen Shakty and the Bright Green Energy Foundation are increasing. Microfinance institutions such as the Grameen banks have specialized into selling off-grid renewable energy packages inclusive of maintenance technical training and business support, even though the efficacy of the micro-credit approach can be limited in the absence of a clear and result-oriented national policy. Still in India, firms as First Energy are commercializing mini-grid electricity co-generation via waste biomass, with consequences on the agricultural market yet to be fully understood. On a larger scale, the attainability of MDGs and the success of the Clean Development Mechanism (Scheider 2008; Paulsson 2009) related to renewable energy depend on the existence of markets that are usually informal and loosely regulated in developing countries. In this framework, it has been argued that a single sector approach might not work in ensuring the needed scalability and regulation of the technologies. A multi stakeholder approach – including the active role of NGOs and civil society organizations – is needed.

Before focusing on a specific intervention, the goal of the current project is that of understanding if, where and how, in the long run, decentralized, renewable energy technologies (DRETs) can form the basis of a network system of energy production nodes and distribution links with the following advantages:

- Energy is produced locally, where it is consumed, and users become at the same time producers and owners of the technology. This has the potential to increase energy equity and security of a community, and to facilitate diffusion via an enhanced sense of ownership. Dependence on imported energy is a huge economic burden on developing countries with implications on their economic and political stability, and an equal burden has become that of production of out-flowing energy that benefits growing neighboring economies. Developing energy sources at both a local and national but decentralized scale promises to free up financial resources for local development and to enhance national energy security.
- Addressing community vulnerability, food security, health, education and business opportunities, DRETs can help mitigate rural-urban migration and prevent resettlement to areas at climatic risk. DRETs fulfill a variety of services including irrigation, water purification and treatment.
- A decentralized energy production network is more resilient to local nodes/links failures due to a climate change dramatic event. DRETs could eventually be connected to the grid on a tariffs parity ground.
- The water cycle involved should be less disrupted (but the nature of the impact of DRETs on the water cycle will be at the core of the research reports).
- The increased awareness of marginalized communities of their rights on the production assets can guide policy reforms.

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11 A related project of the Innovation, Policy and Science (IPS) IDRC Initiative will look at the nature of the development and scalability partnerships driven by NGOs in the case of Solar Lighting. We expect to be able to integrate the outcomes of this project with the results of the assessment studies.

12 The point at which renewable electricity becomes equal to or cheaper than grid power.
DRETs can be managed by the same social networks (Rotberg 2010) on which communities rely in their adaptation effort to climatic variability, making them stronger.

**Major identified gaps intersecting with the CCW Program objectives**

*In spite of the large amount of work on adaptation recently (ISET-1-7 2008-2009) and ongoing research on renewable energies for development (UNDP 2003, Sims 2003, Da Rosa 2009, REN21 2007, 2009), not enough has been done to integrate energy production with local adaptation to climate change and variability, nor with water research.*

Three specific gap areas were identified for investigation within this project for their central role in the water-energy discourse. They reflect different aspects of a common issue: Firstly the need to understand the socio-economic feasibility of a structural change and how to transition from carbon dependent energy sources towards low-carbon and climate resilient DRETs as much as possible in a controlled way. Equally important is the need to understand how users can be encouraged to become technology owners, energy producers and distributors, in a decentralized but networked world. Finally, how energy and water service, regulations, investments and policy can support such a transition. The payoff could lead to more reliable services that would maintain a more stable equilibrium with the environment, and gain that resilience and robustness to external change that characterizes well designed systems.

The main driving idea is that the poor have the right to access technologies to improve their own lives, at the lowest possible cost. The use of these technologies should be adapted to and harmonized with the endogenous knowledge of communities using them.

Energy fields under assessment will include: community scale bio-fuels and biomass co-generation processes, solar, wind, small and micro hydro-power, energy from wastewater processes, energy from and for rainwater harvesting, preservation and recycling, sustainable biomass and charcoal use, and in general solutions allowing different social players – government, markets, civil society NGOs, research and policy institutions, community based organizations and traditional authorities – to participate with their informed choice of technologies.

**GAP 1: The analysis of factors favoring and limiting decentralized technology up-scaling.**

Some exceptions: the analysis of the potential for DRETs to enhance availability and quality of water in regions under particular climatic stress and the understanding of the social benefits compared to cases where the interventions have not been made; the understanding of how DRETs can be instrumental to the enhancement of social adaptation networks and gender empowerment; the integration or lack of integration of DRETs into participatory governance processes looking at supporting local communities to use water resources in more sustainable ways.

13 Some exceptions are represented by the work of southern policy oriented institutions like AFREPREN (Kenya), The Asian Institute of Technology (Thailand), the GNESD (Brazil), The Energy Research Centre (South Africa), The Energy Resource Institute (TERI- India) and the Energy Research Institute (ERI- China) and the ENDA (Senegal).
Importance will be given to assessment of DRETs as adaptive measures for local agricultural and livestock activities in rural areas, and to the cost of those adaptive measures, due to the fact that the majority of water resources are used in or affected by those activities (Amede 2009).14

Consequently, the studies will assess the policy, regulatory and communications tools15, the needed cultural stimulation and socio-political agreements - and the barriers to uptake - to improve the efficiency and the equitable offer of water and energy services (both grid and off-grid) to resource constrained and climate vulnerable communities.

Some opportunities for research supporting the diffusion of DRETs are in the following areas:

- The integration of DRETs into participatory governance processes.
- The elucidation of the economic, social and environmental costs of action (adoption of DRETs) versus costs of inaction (non-adoption), when DRETs are of could be used for water efficient measures and water treatment;
- The potential for DRETs to decrease water evaporation and transpiration during agricultural activities, decrease groundwater use and increase water savings in irrigation. And, vice-versa, the dangers of increased water stress (ex. too much pumping) due to more efficient and capillary availability of energy sources;
- The potential for DRETs to become part of the communities' cultural habits, changing behaviors towards less water intensive farming activities, easing competition between different water users;
- The potential for the development of a network of services points that better overlap with and link to the geographical spreading of the human income activities, with areas under stress and with the energy and water resources on the ground. This would lead to optimize resources allocations, avoiding overexploitation problems due for instance to: concentration of livestock around inadequate watering points; expansion of food and feed crops in key ecosystems areas; water and soil pollution or degradation due to manure, waste and fertilizers mismanagement.
- In the context of managing risks and surprises: the analysis of the potential for the diffusion of DRETs networks to act as stabilizers and buffers, so as to minimize risks of large water losses due to loss of crops, death of livestock or water contamination due to weather catastrophic events.
- The potential for the diffusion of DRETs to reduce water contamination, to preserve nutrients content and to implement food treatment processes and harvesting practices that use less water.

In all points above, the need is not for research on the technologies per se, but for investigating how and at what levels (local and completely decentralized technologies at the household or village level, promotion of mini electricity grids, promotion of new formal or informal energy

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14 Around 75% of water resources in sub-Saharan Africa, for instance (Amede 2009).
15 At times, a technology is rejected just because it does not look appealing, or because its advantages are not well publicized.
resources markets, etc.), costs and risks innovations can be diffused, and which priorities should be targeted.

The studies may focus on the following main questions:

1) What is the relation between energy demand of communities and water resources under pressure (such as key watersheds, lakes, river basins, aquifers and vulnerable flood plains, semi-arid lands and coastal zones) and how could DRETs play a role in reducing such pressure, or in increasing it?

2) What are the drivers and barriers to decentralized renewable energy technologies for water services in the region, including the integration or lack of integration of DRETs into participatory governance processes looking at supporting local communities to use water resources in more sustainable ways? This will include the analysis of the initiatives and strategies adopted so far to overcome those barriers.

3) What are the best examples and scales of successful or failing initiatives (including those in the framework of international donor programs), their transferability and long term implications, in particular in the agriculture and food security sector, and how can these initiatives be compared to or learn from other examples in other regions of the world bearing similar climatic stresses or sharing common water resources?

4) What are the perceived reasons for the success or failure of such initiatives and how have them practically increased water availability or decreased the vulnerability communities in the face of climate change?

5) Are there in the regions under study opportunity windows that should be seized so as to promote DRETs, and what are the mechanisms that can prevent or promote the opening of these windows?

**GAP 2:** The analysis of the efficiency and equity of water and energy services: The role of policies, regulations and communication technologies (ICTs). Inefficiencies in water and energy distribution services reflect on higher prices, poorly designed payment schemes, discontinuous provisioning, lower penetration depth among users, low quality of the good delivered and poor robustness of the distribution networks (King 2008; Webber 2008). Often, the absence of concerted regulations leads providers to compete for the two connected resources of energy and water, further lowering the level of services. In this framework, it is of paramount importance to analyze how to support innovations and regulations enhancing the correlated efficiency of existing services in view of the costs to be faced under growing climatic uncertainty.

Some areas of intervention may be: reduction of leakages (both at provider and at the user level), better records keeping, better planning of resources rationing, use of modern meters, reduction of installation costs and waiting times, rapidity in repairs, offer of pro-poor tariffs and more affordable connection costs repayment plans, harmonization of interventions and better communication among energy and water companies, better data organization and flow, so as to generate knowledge useful to policy makers.
In many cases, the diffusion of alternative, decentralized renewable energy services that are truly economically viable and that can be integrated with traditional practices would be of paramount importance. In certain cases, friendly policies in this direction are already in place, but communities are unaware of them and research is needed to uncover feasible and robust ways of translating existing policy into practice, instead of focusing on ideal best practices.

Related to the above areas, some key questions are:

1) How has the performance of existing energy and water services been affected by environmental variability in recent years, both in metropolitan and in rural areas?
2) How and to which extent is there a weaving of energy and water regulations and governance, concerning the quality of existing services, into climate change interventions, and what are the lessons that can be drawn by a comparative analysis in the region under study and with other countries around the world?
3) Which roles are information and communication technologies (ICTs) playing or could potentially play in supporting water and energy distribution and availability of services, for instance facilitating the organization of data from communities to institutions and among institutions?
4) Where only one part of the community is reached by services, are there compensating ways through which the communities optimize their energy and water use, enhancing the users’ adaptive capacity in the face of climatic variability?
5) Under which conditions could DRETs complement, enhance and stabilize existing services under growing climatic uncertainty, and are there examples of existing initiatives in this direction in the region under study?

GAP 3: The non-trivial consequences of renewable technologies diffusion processes. The potential offered by DRETs is important, but equally is the analysis of the potential consequences of the technology on: markets; consumers’ and providers’ behavioral shifts; possible further pressure on water resources; communities’ mobility, income and social structures. Only a proper understanding on these factors can ensure that DRETs can contribute to long term adaptive capacity, instead on exacerbating the resources scarcity struggle.

On the issues of water intensity and resilience to climate change, DRETs are more flexible in design, but limited studies have been done so far. However, the hydrological cycle is a paradigmatic example of complex system where good intentions can lead to negative outcomes\(^\text{16}\). A key question is whether more capillary and decentralized availability of energy

\(^{16}\) In contrast to widely held beliefs, some recent results show that water conservation subsidies are unlikely to reduce water use in conditions occurring in many river basins (Ward 2008), mainly because the adoption of more efficient irrigation technologies reduces valuable return flow and limits aquifer recharge augmenting plant water uptake and consequent evapo-transpiration (In general, defined as the sum of evaporation from the soil and transpiration from plants’ parts, mainly leaves). From the farmer’s economic point of view the new water technology is good and promises access to dry areas (Burney 2010). However, basin-level consumptive use of water can increase, leading to overexploitation of resources similar to the one faced by the Nile delta agriculture (Bohannon 2010). Finally, where
may threaten to add pressure on water resources and what are the conditions under which this threat can be avoided.

Changes in time and resources allocation influence and are influenced by gender differences in intra-household income management roles. Will these changes be in favor of the more vulnerable? When these changes can be beneficial to the communities’ adaptation capacities to unfavorable climatic events, how will other development issues related to gender (women and youth) social and economic rights, personal security and health be affected?

The diffusion of biomass co-generation in India and Brazil, or of micro-hydropower or solar decentralized energy for irrigation in Nepal, for instance, and the related increased local energy availability, have induced communities to demand for more and more reliable services, ending up in abandoning the original decentralized technology despite its advantages, and pushing for the connection to the grid, which however often comes at a slower pace and higher environmental costs. The integration and strengthening of grid services through DRETs could probably be the best and economically viable solution in the long term, but the conditions for this to happen are still to be understood.

Equally important is the issue of infrastructural robustness: the uncertainty on the extent of climate change and its effects on water supply make it difficult to develop the right adaptive measures. With this respect, better is to adopt practices and techniques that allow for a degree of robustness, redundancy and self-dependence. Redundancy, however, comes at a cost that needs to be taken into consideration assessing the potential for decentralized technologies to correct for the negative impacts of climate change on the availability of resources and on the affordability of water and electricity tariffs. And it needs to be compared with the cost of inaction when affordability problems are due to the lack of performance of large scale infrastructure and obsolete grids.

As a part of the assessment, but only if in relation with the previous points, place can be found for the analysis of the reasons behind the continued choice of large scale energy solutions such as hydro-dams, bio-fuel plantations in ecologically vulnerable areas and unsustainable traditional energy sources.

Albeit the CCW Program does not include working on larger scale infrastructure projects, a an analysis of the reasons behind their preferred choices of new hydro-dams projects and large scale bio-fuels plantations - instead on the promotion of DRETs - can help elucidating adaptation counter-measures at the community level and will support the promotion of alternatives. Large hydro-dams and large scale bio-fuels share the following common issues:

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less water is used in agriculture, its transfer to urban areas may further shift global vapor flows (Gordon 2005). Ways of fixing these problems still need to be found.

17 For instance, among others, the possible decrease of risk of rape or physical assault due to reduced need of large displacements in isolated areas, in order to look for energy and water.

18 CCW Prospectus page 6.
Both are often considered as clean resources, but when looking at the GHGs intensity along the complete technology life-cycle, emissions are often comparable to if not higher than fossil fuels.

Both are considered as renewable, but highly water intensive. However, the assumption can be questioned once the concept of renewability takes into consideration not only the primary resource, but all ecosystems services ensuring the sustainability of the technology: above all, the reversible use of water resources in the affected hydrological cycle.

Both are attracting considerable investment in developing countries endowed by suitable land and river basins. A large part of these investments comes from companies belonging to the BASIC group. They are marketed as viable investments so as to power developing economies out of energy insecurity and poverty. However, large-scale projects bear socio-economic costs in terms of migrations, land eviction, loss of resources for food agriculture, unemployment and health. These consequences often affect rural communities not directly benefiting from the energy produced.

Both have smaller scale options (small hydro and community managed bio-fuels feed sticks), whose viability needs still to be fully understood.

Some key questions addressing this gap may be the following:

1) How and to which extent is there the possibility that diffusion of DRETs for water services threatens established socio-economical equilibria, leading to further marginalization and vulnerability in particular of women?

2) What are the environmental risks of an envisioned successful uptake of DRETs for water services among communities?

3) What are the factors influencing current choices in terms of large hydro-dams, bio-fuels plantations or non-renewable energy sources, and why are these factors so strong today, despite their environmental and social drawbacks?

4) How will the relative importance of these drivers change with shifting climatic conditions, and how in this framework can decentralized technologies play a role in building more resilient energy and water service networks that can contribute to national energy security bottom up?

Relevance of the gaps to the CCW priorities
Each identified gap is coherent with one or more priorities of the IDRC CCW Program. The first gap focuses on the diffusion of DRETs as potential solutions for better availability and quality of water (priority 1) and on their potential of enhancing communities resilience capacity in the face of climatic uncertainty (priority 2: reducing risks and surprises). The second gap focuses on local policy and regulations options (priority 3) aiming to enhance existing services and promote the efficient co-management of water and energy (priority 1 again). Finally the third gap focuses on the study of the consequences of the envisioned technological shift on the capacity of countries and communities to manage increasing climatic risks and surprises (priority 2).
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