KIN
knowledge&innovation network
THE JOURNAL OF MCC & MCA TECHNICAL STAFF
VOLUME 1, ISSUE 1 | SUMMER/FALL 2012

Infrastructure and Climate Change

Improving Air Quality Through Energy Efficiency

Climate Change Resilience in Irrigation Development

Road Design and Climate Change Policy

Water Supply Systems and Climate Change

Making Rural Electrification Investments Pay Off

MILLENNIUM CHALLENGE CORPORATION
UNITED STATES OF AMERICA

www.mcc.gov

Infrastructure and Climate Change

features

4 Improving Air Quality Through Energy Efficiency in Mongolia

10 Climate Change Resilience in Irrigation Development: Approaches from the Sahel Region and North Africa

18 Road Design In the Context of Philippines' National Policy on Climate Change

26 Water Supply Systems and Climate Change: MCC's Approach

34 Illuminating Success: Ensuring Results and Sustainability With Off-Grid Solar Photovoltaic Investments

departments

From the Vice President.....1

Articles at a Glance.....2

Event Calendar.....43

Next Issue.....45

ON THE COVER: The MCC compact with Ghana included a $217 million investment in Ghana's aging transportation network. New segments of the N1 highway evolved from a two-lane road to a six-lane divided highway with pedestrian walkways and safety barriers. Photo by: MCC

knowledge and innovation network

THE JOURNAL OF MCC & MCA TECHNICAL STAFF

VOL. 1, NO. 1 SUMMER/FALL 2012

Mangaging Editors
Jonathan Randall
Yohannes Abebe

Contributors
Rodolfo Arias
Ben Campbell
Courtenay Engelke
Robert Fishbein
Omar Hopkins
Kate Iovanna
Criste Z. Navida
Herve Plusquellec
John Polk
Richard Rapier
Gilberto Reyes

Copy Editors
Scott Fontaine
Linda Smiroldo Herda

Design and Production
MCC Department of Congressional and Public Affairs

© 2012, Millennium Challenge Corporation. All rights reserved. No portion of this journal may be reproduced without the formal consent of the Millennium Challenge Corporation, 875 15th Street NW, Washington DC 20005-2211. The content reflects the views and opinions of the authors and does not constitute a formal endorsement by MCC.

This document is produced in accordance with Section 613 of the Millennium Challenge Act of 2003, codified at 22 U.S.C. §§7701, 7707 (a). Every effort has been made to produce this document in a cost-efficient and environmentally-friendly manner based on industry best practices and government printing protocols. The paper used to print this document includes a minimum of between 10 percent (cover paper) and 30 percent (interior paper) post-consumer fiber as mandated by the U.S. Congress Joint Committee on Printing.

Welcome to Our Pilot Issue

Patrick Fine
Vice President
Compact Operations

MCC's greatest resource is its people, and their knowledge fuels the organization. With that in mind, I am very pleased to introduce this inaugural issue of MCC's new technical journal, *KIN, the Knowledge and Innovation Network.*

The KIN journal provides a platform for the technical staff of MCC, MCAs and partners to share ideas, innovations, lessons learned, and state-of-the-art best practices from MCC investments with an eye on improving our effectiveness and contributing to current trends in international development.

With over $8.9 billion in MCC investments to reduce poverty in 25 countries there is a wealth of learning and information that can and should be applied to future compact development. This expertise can also enhance the capabilities of MCC's growing community of technical staff and partners around the world.

This is especially true for the compacts that have completed or are near completion and provide four to five years worth of lessons in the many areas of MCC engagement: infrastructure, water, agriculture, education, health, energy, technical assistance and capacity building, grant- and commercial-based financing, environmental and social performance, gender, impact evaluation, economic analysis, procurement, monitoring and evaluation, and fiscal accountability.

I expect KIN to contribute to the professional development of MCC and MCA staff, and to provide a voice for technical specialists working within the communities of practice that are critical to achieving development results.

The KIN journal is scheduled to be published twice a year with each issue focused on a particular theme. This pilot issue focuses on the theme "Infrastructure and Climate Change." As you will see from the articles in this edition, many of MCC's investments aimed at reducing poverty have focused on helping communities build their resilience and in doing so have reinforced their ability to cope with some aspects of climate change.

I'd like to especially thank Yohannes Abebe and Jonathan Randall who spearheaded the development of this journal from its inception, Andrew Ladson for applying his keen graphic design and layout skills, and all the authors who contributed to this first issue.

I hope you get as much out of KIN as I have and look forward to a robust and continuing conversation about the themes that shape our work. **KIN**

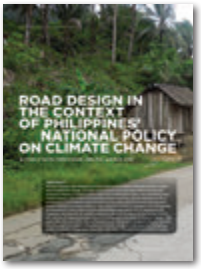
Infrastructure and Climate Change

Jonathan Randall (l)
Senior Program Officer, DCO
Yohannes Abebe (r)
Director of Infrastructure, DCO

With average global temperatures projected to increase in the coming decades, bringing with them increases in the intensity of rainfall, droughts, floods, and other extreme weather events, the international development community is closely following the issue of climate change.

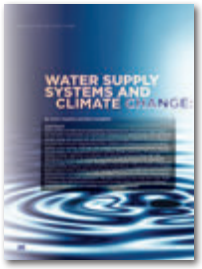
Planning and designing infrastructure in particular has been a key focus of climate change mitigation and adaptation activities. Many types of infrastructure, such as irrigation, roads, water supply, and hydropower depend on reliable weather conditions for economically-viable, sustainable and safe operations. Infrastructure also plays a role in greenhouse gas emissions depending on whether the design—from a coal-fired power plant to a power-intensive water utility—results in the emissions of carbon dioxide and other greenhouse gases.

In this pilot issue of the KIN journal, MCC and MCA authors explore the topic of infrastructure and climate change with case studies from MCC's investments around the world. If there is a common message that emerges from these articles, it is that investing in sustainable economic development and addressing the effects of climate change are mutually reinforcing. Lifting people out of poverty makes them more resilient to the effects of climate change, and integrating climate change mitigation and adaptation strategies into infrastructure planning and design makes such infrastructure investments more sustainable. As one article summarizes, "The most effective [climate change] adaptation and disaster risk reduction actions are those that offer development benefits in the relatively near term, as well as reductions in vulnerability over the long term."



In 2010, the Philippines government upgraded its national road design standards based on climate models that predict increases in the frequency and intensity of typhoons and other extreme storm events. In their article, "Road Design in the Context of Philippines' National Policy on Climate Change" (page 18), **Criste Navida**, **Gilberto Reyes**, **John Polk**, and **Rodolpho Arias** discuss how MCC's investment in the Secondary National Road Project on Samar Island has been planned with upgraded, climate-smart road design standards.

The Office du Niger in Mali, which manages West Africa's largest irrigation scheme, has addressed increased variability and declines in rainfall by discouraging rice cultivation during the dry season and reducing the irrigation fees for horticultural crops that are less water intensive. With examples from MCC's investments in Mali's Alatona Irrigation Project and Morocco's Fruit Tree Productivity Project, **Robert Fishbein**, **Herve Plusquellec** and **Richard Rapier** describe the technical innovations that are increasing household incomes, supporting food security and increasing farmers' resilience to dryer conditions in their article, "Climate Change Resilience in Irrigation Development: Approaches from the Sahel Region and North Africa" (page 10).



At the international level, professional associations and donor agencies have proactively developed strategies to assist water utilities adapt to the impacts of a changing climate. In their article, "Water Supply Systems and Climate Change: MCC's Approach" (page 26), **Omar Hopkins** and **Ben Campbell** apply the climate adaptation strategies of the World Bank, International Water Association and American Water Works Association to MCC's investments in reforming and revitalizing Cape Verde's water sector.

In Tanzania, MCC designed an innovative off-grid solar photovoltaic (PV) system for rural areas that not only supports economic productivity and better education and health outcomes but also has low life cycle greenhouse gas emissions. In "Illuminating Success: Ensuring Results and Sustainability with Off-grid Solar Photovoltaic Investments" (page 34), **Kate Iovanna** describes the critical factors that make rural, off-grid solar PV a success and how these lessons have been applied to the design of the MCC-funded Kigoma solar PV project.

Targeting energy efficiency in infrastructure also has the potential to improve household incomes and reduce greenhouse emissions. In Mongolia's capital of Ulaanbaatar, the air quality in winter is one of the world's worst because of the emission of black carbon, a type of carbon-based, particulate matter from dust, dirt and soot that constitutes the second most potent global warming agent after carbon dioxide. MCC is working to address this problem through a range of interventions, including the replacement of old cook stoves with new, energy-efficient models. **Courtenay Engelke** describes the results to date and lessons learned through this innovative program in her article, "Improving Air Quality Through Energy Efficiency in Mongolia" (page 4). **KIN**

Editor's note: *This is the pilot issue of the KIN journal and we hope you gain some useful insight and inspiration from the work underway by MCC, MCAs and our partners. The next issue is on the topic "Local Food Security, Global Markets." If you are interested in submitting a paper or have other comments, questions or suggestions, please email kinjournal@mcc.gov. Also, please keep this issue within the MCC and MCA reader community as it is not for public distribution.*

IMPROVING AIR QUALITY THROUGH ENERGY EFFICIENCY IN MONGOLIA

By Courtenay Engelke

ABSTRACT

Over the past 10 years, with rising urban migration, winter time air pollution in Mongolia's capital city of Ulaanbaatar has increasingly worsened to the point that the World Health Organization ranks it as having the second-highest level of air pollution in the world. Annual average concentrations of airborne particulate matter (PM10) are two to 10 times higher than Mongolian and International Air Quality Standards, causing higher incidences of respiratory disease and significant health care costs for all city residents. Soot (black carbon) is a primary component of fine particulate matter and results from incomplete combustion of fossil fuels. Black carbon is the second-highest contributor to global warming after carbon dioxide. The burning of wood and coal in traditional stoves in more than 180,000 households in the ger districts (semi-formal settlements that surround the downtown) is a significant contributing factor in Ulaanbaatar's poor air quality and to global warming more generally. Through its compact with the Government of Mongolia, the Millennium Challenge Corporation (MCC) has committed $45.3 million to promote energy-efficient appliances through consumer subsidies, public awareness programs, grants for greening and air quality research, and network-upgrade investments for Mongolia's first commercial wind farm. Early lessons in new market development include the importance of integrating cultural practices and perceptions related to energy efficient stove replacement to catalyze demand and the need to address complexities in local production and logistics.

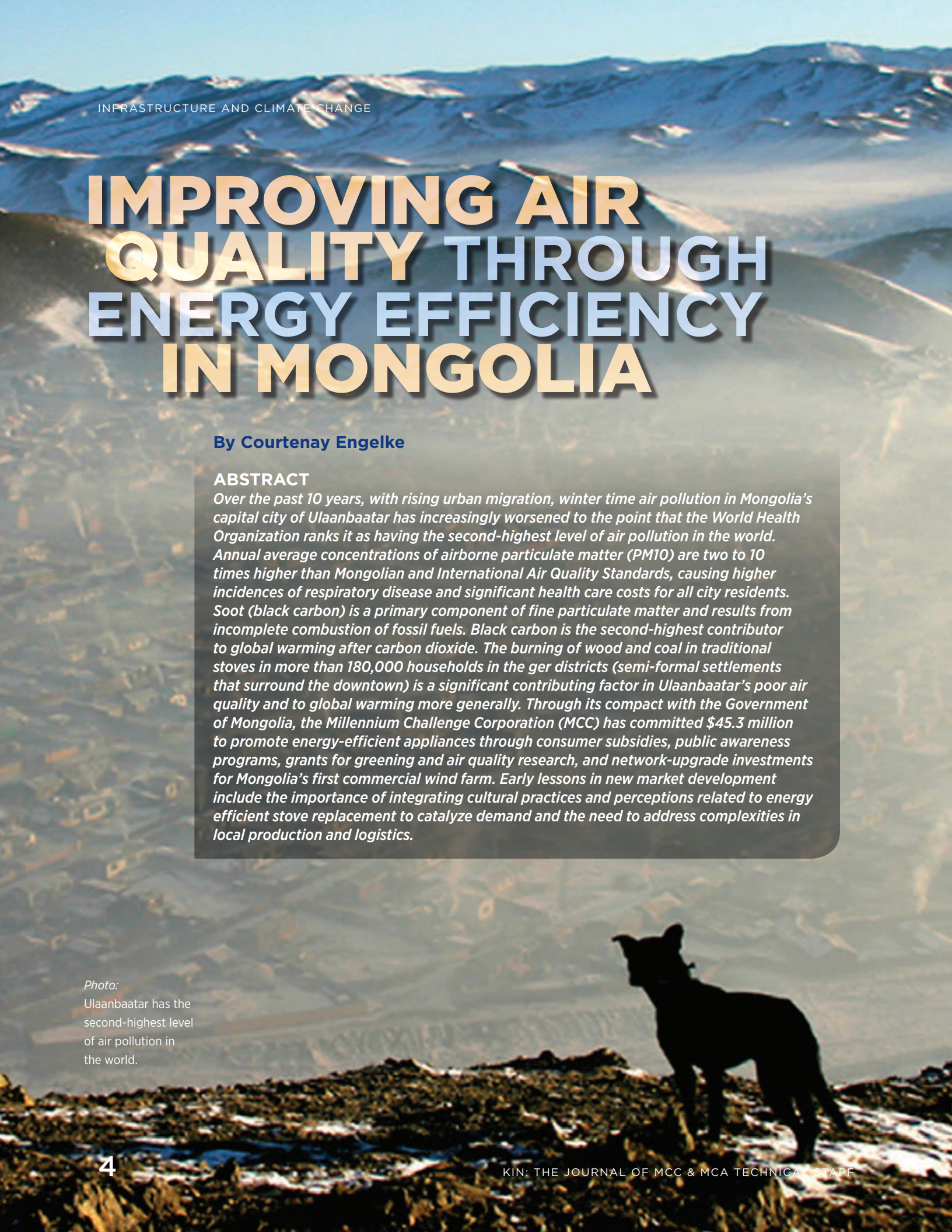


Photo:
Ulaanbaatar has the second-highest level of air pollution in the world.

Ulaanbaatar, the coldest capital city in the world, is home to about 1.2 million people. More than half of city residents reside in ger districts, semi-formal settlements which surround the downtown. The ger districts are characterized by relatively low income households living in traditional yurts (gers), or simply constructed homes with low thermal resistance, each heated with a traditional coal-fired stove. Ger district households have access to few or unreliable municipal services.

Over the past 10 years, with rising urban migration, winter time air pollution in Ulaanbaatar has increasingly worsened—now the second-highest level in the world, according to the World Health Organization (WHO). Ulaanbaatar has recorded PM10 levels[1] of 279 μg/m3. In contrast, Washington, D.C. measured PM10 levels of 18 μg/m3. Scientists say breathing air as dirty as Ulaanbaatar's over the course of a year would be the equivalent of living in a home with somebody who smoked 60 cigarettes a day. Ground-level PM in Mongolia, especially PM2.5, has been demonstrated to be a significant source of respiratory disease in adults and infants.

PM can be a compound of a variety of noxious elements. Sulfur dioxide (SO2) and nitrogen dioxide (NO2) can often be catalysts of PM concentration. A 2006 Country Synthesis Report on Urban Air Quality Management by the Asian Development Bank reported that the maximum 24-hour concentrations of SO2 in Ulaanbaatar were about 2.6 times higher than the national ambient air quality standard, that maximum 24-hour concentrations of NO2 frequently exceed the national ambient air quality standard by as much as 200 percent and that PM2.5 and PM10 levels frequently exceeded the annual average WHO guideline of 10 μg/m3 by 10 to 20 times.

The World Bank estimates that in the most polluted parts of the city, annual average concentrations of PM10 are two to 10 times higher than Mongolian and International Air Quality Standards (AQS), two to five times higher than the national air quality standard, five to 10 times higher than the WHO Guideline Value, and three to seven times higher than the European limit value. Limited samples taken in 2008 showed daily average PM2.5 concentrations exceeding 400 μg/m3 and maximum hourly levels of up to 1300 μg/m3. In most European and U.S. cities, the PM2.5 concentration is below 40 μg/m3. To meet the Mongolian standard in Ulaanbaatar for PM2.5, emissions reductions of about 80 percent are needed. Based on available data, modeling predicts that reducing emissions in the ger districts by half, yields a reduction in PM concentrations by about one-third (World Bank 2009).

In addition to the health impacts caused by fine PM, the black carbon component of PM is the second-most potent global warming agent after carbon dioxide, accounting for as much as 18 percent of global warming (Ramanathan and Carmichael 2008). While carbon dioxide is said to trap the sun's heat energy as it bounces off of the earth's surface like a greenhouse, black carbon absorbs the sunlight as it comes from space, like parts of a blanket (Walsh 2009). While diesel fuel accounts for approximately 30 percent of black carbon emissions globally, industrial processes and small boilers account for about 10 percent, and household coal use accounts for about 6 percent. Because the atmospheric lifetime of black carbon is significantly less than carbon dioxide, measures taken to reduce black carbon can have a more immediate impact on global warming than those directed at the reduction of carbon dioxide, which has

Photo: MCC

1 PM10 refers to particulate matter that is 10 microns in diameter or smaller. PM includes dust, dirt, soot, smoke, and liquid droplets.

already substantially accumulated in the atmosphere. Clean-air initiatives, with a focus on PM and in particular black carbon, and initiatives aimed at reducing global warming are co-beneficial; that is, both health costs and global warming can be reduced through a single initiative aimed at reducing black carbon (Lash 2009).

MCC Energy and Environment Program

Through its compact with the Government of Mongolia, MCC has committed $45.3 million for the reduction of PM in Ulaanbaatar. The 3½-year project was approved in January 2010 and is comprised of three activities: 1) a consumer subsidy program; 2) a broad based public awareness program to assess the performance of and catalyze consumer demand for energy efficient appliances such as stoves, insulation and energy-efficient homes, replace heat-only boilers and offer small grants for greening and air quality research; and 3) the implementation of required network upgrades necessary to bring online Mongolia's first commercial wind farm, aimed at displacing an equivalent amount of coal-fired power generation and thus PM emissions. By reducing PM, the objective of the project is to reduce health costs and increase productivity of almost half of the population of the country who reside in the capital. Added benefits include reduced fuel costs for direct beneficiaries and reduced black carbon emissions. A product review process determines product performance to warrant inclusion in the program and price incentives, public awareness and intense social marketing are used to cultivate a market.

Role of Ger Stoves in Air Pollution and Black Carbon

Mongolia is becoming increasingly urbanized as a result of the harsh economic realities of rural life and the economic boom taking place in Ulaanbaatar. The ease of movement in a historically nomadic society, combined with urban poverty and one of the coldest climates in the world, has created a more systemic problem caused by the needs of thousands of such migrants to stay warm. As the rural poor move into the capital city, they tend to do so with their rural lifestyle: living in a ger and heating with a traditional stove. While an increasing number of city-dwellers live in apartments connected to central heating plants, the provision of municipal infrastructure has not kept pace with migration. As a result, nearly 180,000 households—about 500,000 people—in the ger districts are heating their small homes and gers with wood and coal in poorly constructed traditional stoves.

With the exception of the air pollution they cause, Mongolians have tended to enjoy these stoves. They are portable, heat a ger fairly easily (albeit inefficiently) and are well-suited to cooking traditional Mongolian dishes in large pots over a fire. But historically, there has been no other choice. With few (if any) substitutes, no consumer information, low prices, and little fuel price volatility, there has not been much motivation for change. As information on ger stoves as a significant cause of ground-level PM has been published and as fuel subsidies are reduced and the price of coal rises, there are increasing pressures on the poor to stay warm at least within the same budget, creating a demand for energy efficiency. Using less household coal is expected to reduce PM and black carbon.

Performance Assessment and Marketing

Millennium Challenge Account-Mongolia, the local entity responsible for implementing and managing Mongolia's MCC compact, performed a techno-economic assessment of

Traditional and Approved Stoves

Traditional Stove

Ulzii Stove

Estimated to use 26% less coal and reduce smoke by 89% compared to traditional stove.

Khas Stove

Estimated to use 11% less coal and reduce smoke by 70% compared to traditional stove.

Dul Stove

Estimated to use 19% less coal and reduce smoke by 83% compared to traditional stove.

Golomt Stove

Estimated to use 21% less coal and reduce smoke by 87% compared to traditional stove.

14 stoves and other appliances and found four stove models by two producers that, with proper use, demonstrate a significant and cost-effective reduction in PM emissions. Using a unique airflow pattern, the approved stoves allow coal to burn longer and cleaner per fuel charge than a traditional stove. Most of the coal's particulates are burned up inside the stove, eliminating up to 80 percent of the PM emissions that exit through the chimney. Reduced PM per unit of heat output is good for health and good for global warming.

Once appliance performance was confirmed, MCA-Mongolia contracted with local banks to establish retail showrooms or "product centers" in the ger districts and act as

> **BREATHING SUCH AIR OVER THE COURSE OF A YEAR WOULD BE THE EQUIVALENT OF LIVING IN A HOME WITH SOMEBODY WHO SMOKED 60 CIGARETTES A DAY.**

subsidy transfer agents. It contracted a consultant to develop a broad-based public awareness and social marketing campaign. After a pilot during winter 2010 that demonstrated the viability of the distribution channel and ability of producers, contractors and consultants to handle demand, the program was scaled up to include 51 khoroos (sub-districts), beginning in August 2011. As new stoves are sold to consumers, old stoves are collected, dismantled and recycled to prevent reuse. Resale of the new stoves is strictly prohibited.

The project is again evaluating the performance of new products this winter for possible expansion of consumer choice next season, including radiators or low-pressure boilers, electric and/or gas heaters and cooktops. This winter, the project was for the first time able to test the performance of semi-coked coal and sawdust briquettes (the unconventional fuels promoted by the municipal government as part of a separate limited pilot) in approved stoves. This was important because in the municipal government's pilot zone, where the city has banned raw coal, MCC has not permitted the sale of approved stoves due to uncertainty about their PM performance with alternative fuels. MCC will consider amending that decision if the latest stove/fuel test results yield more positive emissions performance.

Results to Date

The subsidy program has supported the purchase of more than 65,000 stoves, 12,000 ger insulation sets, 4,000 vestibules, and 85 energy-efficient homes. These results are already benefitting more than 70,000 households and are estimated to help households reduce fuel use by up to 27 percent when using an approved stove with proper insulation. Owing largely to the sizeable subsidy levels and social marketing directed toward them, there have been robust sales among women and female-headed households. The project's monitoring and evaluation plan includes monitoring and data collection on actual performance of approved stoves, controlling for insulation levels and user behavior. Insulation levels and user behavior—specifically fueling behavior—can significantly influence optimal efficiency and emissions performance and for this reason are both important parts of the public awareness campaign. A broader air quality modeling exercise is reserved for impact evaluation post-compact. The municipal government continues to measure ambient air quality at four air quality monitoring stations.

The subsidies and the public-awareness program have catalyzed competition, consumer choice and demand for high-quality, better-performing products. While the four models that are being supported are currently imported, Mongolian producers are learning about consumer preferences, improving designs and scaling production capacity based on this experience. Innovative local producers are already working on improved stove designs, as are the two companies currently providing the four models. For example, based on feedback from women regarding the challenges associated with cooking large meals on one model, MCA-Mongolia sponsored an educational cooking program on that model hosted by a local chef, and one of the approved stove producers began exploring how it might improve its design to accommodate larger pots for traditional Mongolian cooking.

Banks are working to monetize carbon credits from project stove sales so that more affordable secured microfinance can be offered on a broader scale and provide a commercial alternative to continued subsidies. MCA-Mongolia has permitted the rights to any carbon credits arising from each sale/replacement to the participating banks—owing to their role as subsidy transfer agent or intermediary—solely for this purpose, as it would support the sustainability of the market. Working closely with carbon financiers, the banks are working on obtaining monetary credit for each confirmed stove sale/replacement. Emissions data and sales are audited and systematized for this purpose. The proceeds from the carbon mitigation are to be used solely to buy down the cost to consumers of financing for energy efficiency, including mortgages for energy-efficient homes and microlending for energy-efficient appliances. It is anticipated that such benefits will be made available as soon as January 2013, which is timely because the project ends in September 2013.

In these ways, the project is catalyzing a commercial market by linking consumers and producers, which in turn will lead to greater competition, innovation and price discovery. This process, aided by forecasted growth in household income, can phase out consumer subsidies.

The government's long-term solution is to convert the ger districts to more permanent housing, with apartments that can be connected to the central heating grid, and to encourage switching to cleaner fuel use in stoves in free standing gers. But years—perhaps decades—will be needed to build the infrastructure required to house 500,000 people. Enforcing a raw coal ban is complicated. Alternative fuels are expensive and have not yet been introduced in quantities and distribution channels needed for sustained supply. It may be the case that with continued growth, Ulaanbaatar—like London, Dublin and Krakow before it—will develop a more formalized and modern district heating system with efficiency and emissions controlled at scale and at the source, in lieu of emissions abatement at the household chimney. However, with coal as cheap and abundant as it is in Mongolia, this may also take many years. Thus, with only 3½ years to design and implement an air pollution project in what some have deemed an emergency situation, MCC's approach in Mongolia is acknowledged as a short- to medium-term bridge to the government's longer-term solutions. **KIN**

Courtenay Engelke *holds an MBA from The Wharton School of the University of Pennsylvania and an MA in International Affairs from Johns Hopkins School of Advanced International Studies, with a concentration in Energy, Environment, Science, and Technology. Prior to MCC, she held various positions in the private sector in banking and project finance.*

References

Lash, John. "Black Carbon an Easy Target for Climate Change." www.policyinnovations.org. Accessed on February 9, 2009.

Ramanathan, V. and G. Carmichael. 2008. "Global and regional climate changes due to black carbon" Nature Geoscience. 1: 221-227

Walsh, Bryan. 2009. "Black Carbon, an Overlooked Climate Factor." Time. November 13.

World Bank. 2009. Air Pollution in Ulaanbaatar Initial Assessment of Current Situation and Effects of Abatement Measures: Discussion Paper. December.

CLIMATE CHANGE RESILIENCE IN IRRIGATION DEVELOPMENT: APPROACHES FROM THE SAHEL REGION AND NORTH AFRICA

By Robert Fishbein, Herve Plusquellec and Richard Rapier

ABSTRACT

This paper reviews two of the Millennium Challenge Corporation's (MCC) irrigation investments in North Africa (Morocco) and the Sahel (Mali) as examples of how development approaches in MCC investments can contribute to building resilience to climate variability and potential long-term climate change effects on irrigated agriculture.

Effect of Climate Change on Water Resources and Irrigation

Agriculture is the cornerstone of rural livelihoods in the developing world. Seventy percent of the developing world's 1.4 billion extremely poor live in rural areas, and more than 80 percent of these rural poor households engage in agriculture either through cultivation or providing labor to other growers (IFAD 2011). Irrigated agriculture contributes to rural economic growth and food security through more reliable water supplies in the face of low and unevenly distributed rainfall. Climate variability and long-term climatic changes can exacerbate existing challenges to irrigation through changes in historical temperature and rainfall patterns, which can alter the timing and amount of annual water flows. These changes can have a cascading effect on water demand through, for example, higher evaporation rates and changes in growing seasons, which ultimately affect crop selection and cultivation techniques.

Climate change projections for the Sahel and North Africa forecast changes in temperature, precipitation and evaporation, based on the few regional models that can provide adequate resolution, parameters and land-surface models sufficient for impact analysis. In the Sahel and in particular in the Niger River Basin, some models suggest that by the latter half of the 21st century, shifts in the West African monsoon system will cause May, August and October to become wetter while June and July would experience a 50 percent drop in mean precipitation (Bates 2008; Patricola and Cook 2009).

In the Maghreb region in North Africa, climate models predict a broader drying pattern fed by a divergence of regional moisture as historic winter precipitation is drawn northward and exacerbated further by decreasing soil moisture that may prolong dry periods through a positive feedback response (Christensen et al 2007 and Bates et al 2008).

Overall, an increase of 3 to 4 degrees Celsius before the end of the 21st century is predicted for both regions while mean precipitation is expected to stay the same in the Sahel and decrease in the Maghreb. Furthermore, inter-annual mean temperature and precipitation variability is expected to increase with the greatest variability affecting the Sahel resulting in prolonged meteorological and agricultural droughts (Agoumi 2003 and Christensen et al 2007).

Although climate model scenarios vary on the extent and scale of potential effects, a common theme is that a high degree of climate variability is expected to continue and may become more pronounced over the long term. The implications for irrigated agriculture revolve around helping farming communities adapt and become more resilient to this variability. In this context, adaptation measures should be part of a broader program to not only increase efficient use of scarce water resources, improve crop productivity and adapt crops and crop management systems to resource and environmental constraints, but also to support income generation and community services that strengthen the rural sector's ability to adapt.

Adaptation Measures and MCC Design Innovations

MCC supports irrigation projects in nine countries with a variety of investments, including: construction of small water retention and water control structures (Cape Verde and Honduras), rehabilitation of existing main irrigation systems (Armenia, Moldova, Ghana, Mali, Morocco, and Senegal) and construction of new irrigated perimeters that expand existing systems (Ghana, Mali, Burkina Faso, and Senegal).

Opposite: An improved tertiary canal operates in Morocco.

Photo: Joost Noordholland

Two of these projects, the Alatona Irrigation Project in Mali and the irrigation component of the Fruit Tree Productivity Project in Morocco, provide examples of how these and other MCC investments, while not designed specifically to address climate change, can contribute to reducing vulnerability and improving resilience to the potential effects of climate change.

Mali Alatona Irrigation Project

In Mali, MCC financed the development of 5,200 hectares of new irrigated lands in the Alatona perimeter in the north of the Office du Niger irrigation complex. Office du Niger refers to West Africa's largest irrigation scheme as well as the government entity that manages it. The Office du Niger zone covers a total irrigable area of 960,000 hectares, of which as many as 250,000 hectares are deemed irrigable with regard to the water availability. To date, about 100,000 hectares are under irrigation, cultivating mainly rainy-season rice, year-round sugar cane and dry-season vegetables. Because MCC-financed new lands are added to areas already served by the main system, the project also funds expansion of the water conveyance capacity of the main canals serving the project area. During the wet season, flows from the Niger River are adequate to serve all developed areas. However, in the absence of additional regulating reservoirs in the upper river basin, available water during the dry season is insufficient to cover all presently developed lands. If climate variability increases and the declines in rainfall observed during the last two decades persist or are worsened as indicated by the climate projection models, dry season water availability will be further limited.

Office du Niger management has taken measures to address increased variability and declines in rainfall by discouraging rice cultivation during the dry season, mainly by increasing dry season user fee to the level of the wet season fee (from 6,000 West African francs to 67,000 West African francs) and reducing the fee for horticultural crops that are less water intensive. In the case of the Alatona perimeter, MCC designs included additional technical innovations, which have the potential to improve water-use efficiency and therefore resiliency to climate variations and water scarcity, as follows:

Double plot land allocation. There is enough water to supply about 20 percent of the land during the dry season, so the project devised a system to efficiently and equitably deliver water to participating farmers during both seasons. As each farmer was allocated five hectares of land, the solution was to assign two land allocations to each farmer: one allocation of four hectares for only rainy-season rice cultivation and a second allocation of one hectare for both rainy-season rice and dry-season vegetable cultivation. The one-hectare plots are concentrated along the first one-fifth length of each secondary canal, so that during the dry season only this part of the secondary canal is being utilized. This considerably reduces seepage and operational losses that would result if the one hectare plots were located throughout the perimeter. It also helps to control aquatic weeds on four-fifths of the secondary canals by drying them out completely.

Improved water distribution technology. Another innovation in the design of the Alatona project was the introduction of a Supervisory Control and Data Acquisition (SCADA) system for computerized and real-time monitoring of water management

Photo: MCC

A farmer brings in the first harvest after MCC's investments in Mali's irrigation.

operations.[1] The proposed SCADA system would monitor water levels and flows at three key water control structures on the Office du Niger's main delivery system, as well as the flow and volumes diverted to each irrigation sector through sensors. This information would then be transmitted to the Office du Niger Operation Center to assess performance and adjust flows necessary to meet farmers' needs based on the statistical treatment of data on water used. Real-time operation has the benefit of better matching water supplies to irrigation demand and reducing or eliminating operational water losses, as well as reducing operation costs. SCADA is now a central part of the modernization program of irrigation systems in developed countries and is slowly being adopted in developing countries. The installation of a SCADA system in the Office du Niger would be the first one in West Africa.

Complementary irrigation investments. The Alatona Irrigation Project includes complementary support to farmer communities aimed at ensuring the sustainability of irrigation infrastructure investments. These include applied agricultural research, extension and farmer training, support to farmer organizations, women's market garden cooperatives, water-user associations, and financial services to strengthen lending and access to credit. Coupled with these agricultural services is the construction of community infrastructure in the irrigated perimeter, including residences for project-affected persons, markets, public water pumps, latrines, grain warehouses, schools, community centers, and health centers. While each of these activities do not directly address climate-induced resource variability, taken together they can contribute to the overall resiliency of farmers and rural communities to adapt to changing circumstances.

1 Note: In May 2012, the MCC Board of Directors approved termination of the Mali Compact due to an undemocratic change in government. The documentation on the SCADA system was turned over to the Office du Niger to implement it at its own expense.

Morocco Fruit Tree Productivity Project (Irrigation component)

Morocco has experienced a decline in water resources due to steadily lower rainfall during the past three decades. This has been aggravated by intensive development and utilization of groundwater resources, which are approaching their maximum withdrawal capacity. In addition, steadily rising temperatures could result in reductions in snowpack and advanced snow melt, increasing the deficit period[2] of water available for irrigation. During the past twenty years, the Government of Morocco has responded by canceling certain large projects and reducing the seasonal allocation of water in large perimeters. More recently, the government adopted a nationwide sustainable agriculture program known as Maroc Vert that includes the conversion of 500,000 hectares of irrigated land from gravity to more water-efficient drip irrigation in the large-scale irrigation sector.

In this context, the MCC-funded Fruit Tree Productivity Project is supporting the traditional and small-scale irrigation sector through improvements to 77 irrigated fruit tree perimeters in which either olive or date palm trees predominate. The project aims to help farmers increase yields and revenues through actions on several fronts: (i) improving water availability by developing or renovating surface water diversion structures and lining existing earthen canals to decrease seepage losses and reduce the transmission time to farms; (ii) improving crop management practices, including on-farm water management to increase efficient use of scarce water; and (iii) improving management capacity and sustainability of farmer-based water management organizations (known in Morocco as agricultural water-user associations). An important feature of the project is that it works with well-established irrigation perimeters in which water and land allocation rules have been developed and practiced

WATER ALLOCATION

Water allocation rules in Morocco's traditional irrigation systems have evolved over many years and vary significantly depending on local conditions. Irrigation water generally is allocated among member farmers using flow-dividing structures to allow fixed volumes of water to each farmer along a canal, water delivery to the fields for a predetermined amount of time or a combination of both. Specific arrangements are tailored to adjust not only to the source of water and its variability (springs, perennial flows, flood waters, or groundwater) but also to linkages between land rights and water rights, participants' contribution to the construction of the canal system and the distribution of lands between ethnic groups.

2 Typically May to September.

Lining existing earthen canals decreases seepage losses and reduces the transmission time to farms in Morocco.

over centuries. The project includes several key design features related to water availability and sustainability that support climate adaptation as follows:

Dry season scarcity and water balance studies. In view of the critical nature of water availability in Morocco, the project includes funding for initial and ongoing water balance studies in the irrigated perimeters. These studies compare irrigation crop water requirements with the available water supply over the course of the year. Initial studies demonstrated that during the rainy season, when there is abundant water supply, lining of canals substantially increases the volume of water delivered to the farm gates. However, during the dry season, the volume of water from the seasonal rivers or springs is significantly lower and the lining reduces, but does not completely eliminate, the water deficit stress experienced by the trees. This situation could become further aggravated should the seasonal flows be further reduced during the dry season due to increased temperatures in the mountains as predicted by climate models, which, in turn, could affect the amount and timing of snowmelt that eventually flows to project perimeters. This data will be utilized to improve knowledge on how trees cope with moisture stress in collaboration with local research and extension organizations, as noted below.

Soil and water management. The infrastructure investments are complemented by extension services in soil and water management, including terracing, fertilization and pruning techniques to maximize use of scarce water availability during the dry season, minimize the water deficit stress and produce optimum crop yields. The project is also collaborating with a consortium of national agricultural research organizations to assess

Photos: Joost Noordholland

the extent to which olive and date trees tolerate varying levels of moisture stress during the growing season without adversely affecting the quantity and quality of their production.

Complementary investments. As with Mali's MCC compact, the Morocco project also finances technical assistance and training to the water-user associations responsible for managing their improved systems and assuring their sustainability. This is complemented with support for cooperative formation and development, marketing, investments in processing, packing and cold storage, and other downstream investments to grow and strengthen targeted value chains. In the long run, these complementary investments should strengthen farmers' ability to adapt to changing circumstances, including climate changes and variability.

The Alatona Irrigation Project and the Fruit Tree Productivity Project provide useful examples of how irrigation under conditions of seasonal water scarcity is being addressed in different environmental, historical, cultural, and cropping contexts. Although individual country situations require locally adapted solutions, these solutions are generally aimed at achieving greater adaptation and resiliency to continuing—and often increasing—risks of extremes and variability in temperature and water scarcity.

In the case of Mali, a new development area presented an opportunity to introduce system design and technology features aimed at reducing operational losses and facilitating efficient use of scarce dry season water for seasonal food and cash crops. These include different land allocations and water distribution rules for rainy- and dry-season production, as well as the introduction of computerized systems for real-time monitoring of water management operations. It should be noted that the double-plot innovation introduced here was easily adopted because it opened new lands for development and was part of a package for participating farmers. In established areas however, such an approach would require a land reallocation from the status quo as well as revised rules for water distribution, which may be difficult to introduce. In these cases, a less intrusive approach might be to set up a seasonal rotation on a multi-year basis. For example, in the case of the Office du Niger, secondary or tertiary canals would get water once every five dry seasons.

Morocco also suffers from a serious shortage of dry season water flows, but in that case, the MCC investments involve physical improvements to established fruit tree perimeters with long-held traditional and sophisticated water allocation mechanisms. Solutions have therefore focused less on structural design and technology changes and more on working with local research and extension services to improve water balance and tree agronomic information and develop strategies for improving fruit tree productivity under water-stress situations.

In both cases, the MCC-funded projects include a set of complementary investments that, while not directly aimed at climate change or water scarcity, focus on strengthening farmer communities' ability to adapt to environmental variations over which they have no control.

While climate change has not been a major driver in MCC irrigation project design, due diligence study of climate factors (such as rainfall, temperature and evaporation) and the need to achieve economic returns have naturally led MCC investments to focus

on improving efficiencies and productive use of limited water supplies—all necessary ingredients for coping with increased climate variability. In parallel, complementary investments may be also seen to contribute to rural communities' ability to adapt and prosper in uncertain times. Looking ahead, MCC's due diligence on irrigation proposals should increasingly address climate variability issues and climate change projections as considerations in determining the correct mix of infrastructure, technology and complementary investments. **KIN**

Robert E. Fishbein *is Director, Infrastructure at MCC. He has over 30 years of rural and urban infrastructure development experience in Africa, Asia and the United States. Since 2005, he has worked on MCC irrigation programs in Armenia, Mali, Senegal, and Morocco.*

Irrigation engineer ***Herve Plusquellec*** *has consulted for MCC since 2007. He retired from the World Bank in 1997 as an irrigation advisor, has worked in most countries with large irrigation development and published a number of articles and books, mainly on management of irrigation systems and the use of geosynthetics in irrigation and drainage projects.*

Richard Rapier *works in MCC's Environmental and Social Performance (ESP) division, where he works on compact operations and oversees environmental and social performance on water resources and irrigation, drinking water, roads, and community development projects. He is the ESP lead for MCC's Water Practice Group and has 10 years of experience in domestic and international water and environment projects.*

The authors gratefully acknowledge inputs and comments by Tim Mooney, Jon Richart and Steve Clarke.

References

Agoumi, A. 2003. "Vulnerability of North African Countries to Climate Changes: Adaptation and Implementation Strategies for Climate Change." Climate Change Knowledge Network, International Institute for Sustainable Development.

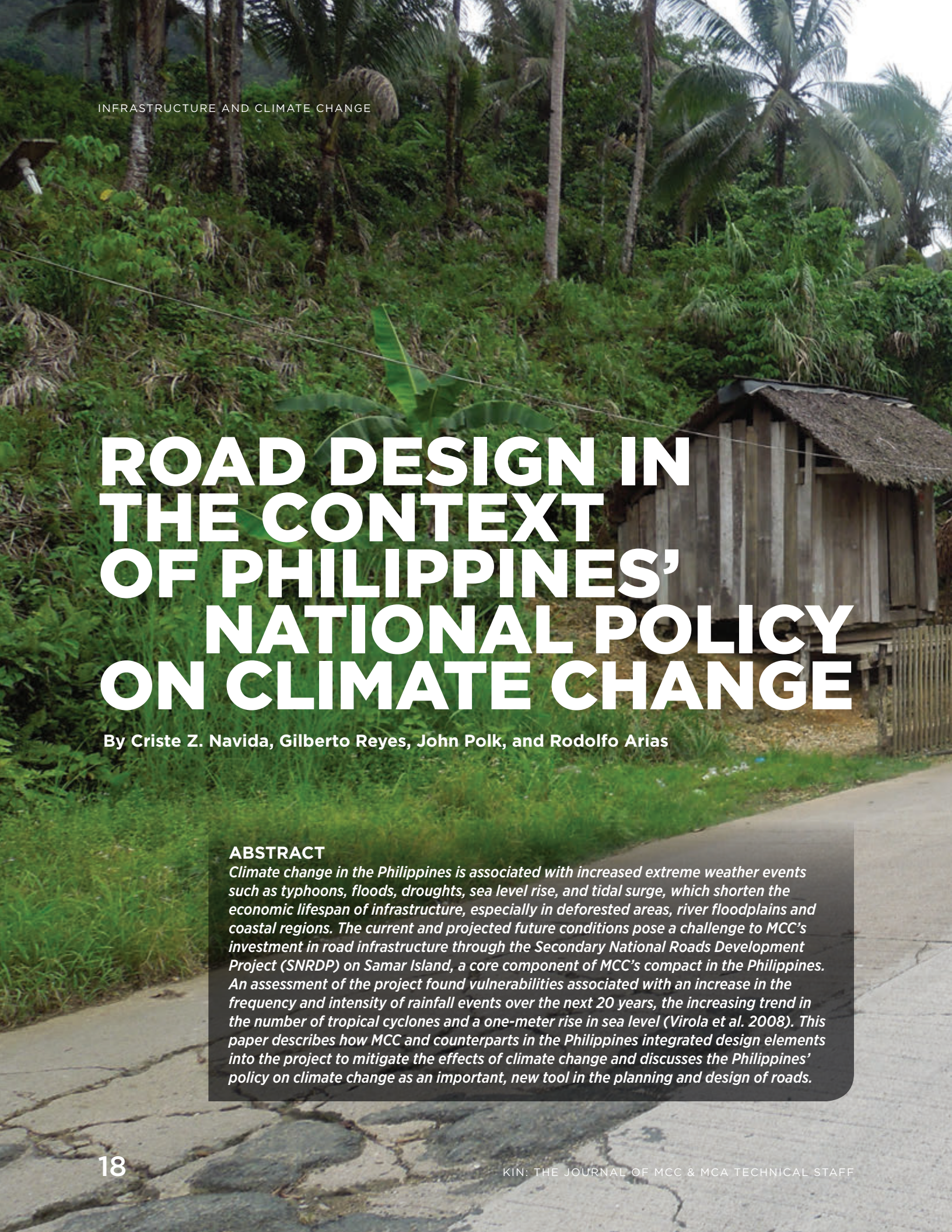
Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds. 2008. "Climate Change and Water." Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp.

Christensen, J.H., B. Hewitson, A. Busuioc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.-T. Kwon, R. Laprise, V. Magaña Rueda, L. Mearns, C.G. Menéndez, J. Räisänen, A. Rinke, A. Sarr and P. Whetton. 2007: Regional Climate Projections. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Goulden, Marisa and Roger Few. 2011. "Climate Change, Water and Conflict in the Niger River Basin." USAID, December 2011.

International Fund for Agricultural Development. 2010. "Rural Poverty Report 2011" Rome, Italy. IFAD

Laugier, M., Means, E., Daw, J., and M. Hurley. 2010. "Climate Change and Adaptation in Southern California." from *Climate Change and Water: International Perspectives on Mitigation and Adaptation.* AWWA / IWA, Carol Howe, Joel Smith, Jim Henderson, Eds. London 23: 251-262.



ROAD DESIGN IN THE CONTEXT OF PHILIPPINES' NATIONAL POLICY ON CLIMATE CHANGE

By Criste Z. Navida, Gilberto Reyes, John Polk, and Rodolfo Arias

ABSTRACT

Climate change in the Philippines is associated with increased extreme weather events such as typhoons, floods, droughts, sea level rise, and tidal surge, which shorten the economic lifespan of infrastructure, especially in deforested areas, river floodplains and coastal regions. The current and projected future conditions pose a challenge to MCC's investment in road infrastructure through the Secondary National Roads Development Project (SNRDP) on Samar Island, a core component of MCC's compact in the Philippines. An assessment of the project found vulnerabilities associated with an increase in the frequency and intensity of rainfall events over the next 20 years, the increasing trend in the number of tropical cyclones and a one-meter rise in sea level (Virola et al. 2008). This paper describes how MCC and counterparts in the Philippines integrated design elements into the project to mitigate the effects of climate change and discusses the Philippines' policy on climate change as an important, new tool in the planning and design of roads.

Photo: Albab Akanda

Background

The Philippines, composed of 7,100 islands, is home to high populations in low elevation coastal areas. This indicates that human development, including infrastructure in these populated areas, would be heavily impacted by climate change. Some projections predict the sea level in the Philippines will rise by as much as one meter by the year 2080 (ADB 2009). With such an impact, most of the islands' circumferential coastal roads will be inundated and bridges damaged or collapsed caused by debris flows and flash floods or potentially made obsolete by shifts in the hydrology of river basins and drainage areas. Current trends also indicate a higher frequency and greater intensity of storms in the Philippines. In 2011, 10 out of 19 tropical cyclones were destructive with total damage to properties approximating US$631 million.[1] In a span of two weeks, three consecutive typhoons (Pedring, Quiel

1 According to the National Disaster Risk Reduction and Management Council, the most destructive tropical cyclones in 2011 were: Tropical Storm (TS) Bebeng (May 8-11); Typhoon Chedeng (May 20-28); TS Falcon (June 21-25); Typhoon Juaning (July 25-28); Typhoon Kabayan (July 28-Aug 5); Typhoon Mina (Aug 21-29); Typhoon Pedring (Sept 24-28); Typhoon Quiel (Sept 29 –Oct 2); Tropical Depression Ramon (Oct 10-14); and TS Sendong (Dec 15-18).

and Ramon) battered the country in 2011, providing an indicator of future conditions where the effects of climate change increase the frequency of extreme events.

The current and projected future conditions pose a challenge to the SNRDP in the provinces of Samar and Eastern Samar. The Wright-Taft section of the project, a stretch of 80 kilometers, is located in a mountainous area, while the Borongan-Guiuan section, stretching 140 kilometers, is located along the island's Pacific coast.

Philippine Infrastructure Sector and Climate Change

Recognizing the vulnerability of the Philippines and its communities, particularly the poor and vulnerable, to the adverse effects of climate change, the government enacted the Climate Change Act (Republic Act 9729) in October 2009. The law prescribes the integration of the concept of climate change and disaster risk reduction in various phases of policy formulation, development plans, poverty reduction strategies, and other development tools and techniques by all agencies of the Philippines government. It also established the Climate Change Commission (CCC), a policy making body headed by the president. In 2010, the CCC drafted the Philippine Strategy on Climate Change Adaptation (PSCCA) 2010-2022.[2,3] The PSCCA specifically targeted infrastructure as a key sector for cross-cutting climate adaptation strategies, and the Government of the Philippines has developed an Infrastructure Sector Action Plan (2010-2022) that is based on the national strategies and objectives as defined in the PSCCA.

Design Standards and Climate Change

One of the target areas for climate change adaptation integration in the Philippines is design standards for infrastructure. In general, design standards for infrastructure around the world are based on historical climate patterns that may not be well-documented or specific enough relative to the geographical area being considered. In the Philippines, as in most countries, building codes and other regulations were developed and used during the periods before climate change was widely acknowledged. Hence, questions arose as to how well the existing system of developing infrastructure—accompanied with a set of business–as–usual procedures, standards and building codes—was likely to deal with potential consequences of climatic changes.

Community-based Climate Risk Assessment

A number of environmental and social risks related to the effects of climate change were raised by stakeholders during the public scoping for the Environmental Impact Statement Study for the SNRDP. These included:

- Landslide in some sections in mountainous terrain of Wright (Paranas) demonstrated by fallen boulders, which will be amplified by extreme rainfall during typhoons.
- Flooding and landslide in Binaloan, Malinao, San Pablo, Maburac, and municipality of Taft.
- Flooding in Patag, Tabucan, Lokilokon, and Tinani and landslides (San Isidro and Tinani).
- Change of drainage courses in waterways in Wright.
- Saturated sub-base due to inundation.

2 Philippines is signatory to the United Nations Framework Convention for Climate Change (UNFCCC).

3 Climate change adaptation, a complementary measure to the reduction of the greenhouse gas emissions, is a mechanism to manage the risks of climate change, adjust economic activity to reduce vulnerability, and to improve business certainty. Climate change adaptation builds the capacity of communities to adapt and to increase the resilience of natural ecosystems to climate change.

Recent flooding caused by typhoons Ondoy and Pepeng in 2009 prompted the Philippines Department of Public Works and Highways (DPWH) to review some of its practices in planning, designing and implementing infrastructure to take into account the climate risks over an extended timeline. As part of this effort, the DPWH revised and upgraded its flood control and road drainage standards for adaptation to climate change through a June 2011 Memorandum on "Upgrades On Flood Control and Road Design Standards." The memorandum required roads to be designed for higher storm frequencies—from a 10-year to a 15-year return period—and introduced detention ponds or retaining basins to manage storm water (Table 1).

Table 1. DPWH Upgrades on Flood Control and Road Drainage Design Standards

1. The Minimum flood return periods for the design of flood control and road drainage facilities as follows:	
a. Drainage pipes	15-year flood with sufficient freeboard to contain the 25-year flood
b. Culverts	
i. Box	25-year flood with sufficient freeboard to contain the 50-year flood (Note: this was upgraded from 1 in 25-year flood prior to climate change considerations)
ii. Pipe	15-year flood with sufficient freeboard to contain the 25-year flood (Note: this was upgraded from 1 in 10-year flood prior to climate change considerations)
c. Esteros/creeks	15-year flood with sufficient freeboard to contain the 50-year flood
d. Rivers	For principal and major rivers (40 sq. km. drainage area and above) – 50-year flood with sufficient freeboard to contain the 100-year flood
	For small rivers (below 40 sq. km. drainage area) – 25-year flood with sufficient freeboard to contain the 50-year flood
2. The minimum spacing of drainage manholes/inlets shall be 20 meters	
3. The minimum size of drainage pipes shall be 910 millimeters in diameter.	
4. The provision of underground detention tanks as part of a storm water management system, particularly in flood prone urban areas, to temporarily store flood water shall be considered in the design of drainage systems.	

Source: DPWH 2011

Vulnerability Assessment of Secondary National Roads Development Project[4]

Relative climate change trends for Samar Island include an increased trend in the number of tropical cyclones and an increase in the number of rain days, according to studies conducted by the Philippines Atmospheric, Geophysical and Astronomical

4 Secondary National Roads Development Project Environmental Impact Assessment, EIA Package A, Volume 1

Services Agency (PAGASA). Samar Island is also part of the Eastern Visayas administration region, which is in the top five of the 17 administrative regions in the Philippines that is most vulnerable to a one-meter rise in sea level (Virola et al. 2008). Samar Island is considered highly vulnerable to climate change with a ranking of high to very high combined risks to climate disaster (Figure 1).

A risk-based approach to climate change adaptation was used for the design to manage the current and future risks associated with a broad spectrum of atmospheric and oceanic hazards. For SNRDP, it is necessary to consider the increasing frequency of heavy rainfall, severity of typhoons and rising sea level, which affect lower-lying sections of road adjacent to the shore, tidal estuaries and watercourses.

Increased Rainfall Events

According to PAGASA, the Philippines has already experienced climate changes based on long-term trend analysis of climatological data gathered from all synoptic and observation stations throughout the country. There have been increases in the number of rainy days (2 millimeters is considered a rainy day) in the top northern part of Luzon, in the Bicol Peninsula except Daet, in the Visayas, and Mindanao.

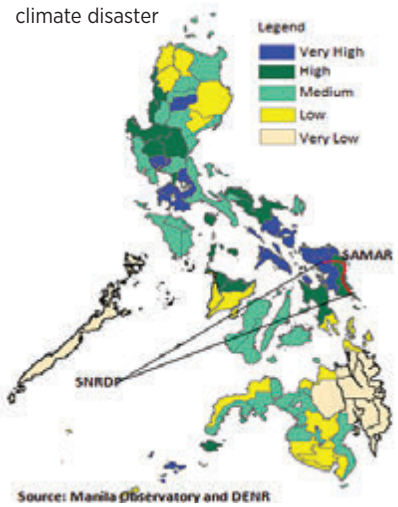
The climate modeling for SNRDP was based on the widely-recognized International Panel on Climate Change (IPCC) Models A and B which identified an increasing frequency of large rainfall events for the Philippines. For example, a rainfall event that historically would be considered a "1 in 10 year (10 percent probability of occurrence) rainfall" may now tend to occur more frequently say, once every nine years, and continuing with increasing frequency. Design can be climate-proofed by factoring the historic stochastic predictions so that the rainfall intensity is increased for any given frequency and duration. The magnitude of factoring can be interpolated for results of climate modeling; the 20 year design horizon of the road suggests the increase will be from 5 percent to 10 percent (USACE and MCC 2012[a], USACE and MCC 2012[b]).

Relative Climate Change Trends For Samar Island:

- Region VIII (Eastern Visayas) is one of the five most vulnerable regions of the country to a one-meter rise in sea level (Virola 2008).
- Increased trend in the number of tropical cyclones in the Visayas (PAGASA).
- Increase in the number of rain days (PAGASA).

The design consultants for the Wright-Taft section of the road assessed the vulnerability of SNRDP to climate change, utilizing both historical climate variability and projected anthropogenic (man-made) climate change. The analysis was done using IPCC Models A and B for predicted climate change scenarios in the Philippines and to identify risks to the road.

Figure 1. Map of combined risks to climate disaster



A similar result is achieved by the DPWH upgrades of flood control and road drainage standards. These require design for a longer return period storm event than that required by previous standards, but based on the historical record. This has the same effect as predicting future increases of storm intensity for any given return period. For the 20-year design life of the road, the DPWH approach is perhaps overly conservative, but the only negative result will be higher construction cost. Marginally oversized drainage provides the required level of service as well as extra capacity for climate-proofing (USACE and MCC 2012[a], USACE and MCC 2012[b]).

Sea Level Rise

Sea level rise is expressed as an averaged observed trend, typically three to six millimeters per year.[5] Rising sea level has the potential to affect the road: Higher tides will flow further up estuaries and watercourses holding back water flowing down the watercourse and effectively reducing the capacity and freeboard of cross-drainage during times of high water. The SNRDP was climate-proofed by establishing the trend in sea level rise along the east coast of Samar, based on records from tide gauges, predictions from climate modeling and other published material. Observed sea level rise at Legaspi on the southeast coast of Luzon from 1956 to 1994 was on average 4.7 millimeters per year and is the closest location with good data on sea level rise. Design for the road assumes the estimated highest tide in 2036 based on sustained sea level rise of 4.7 millimeters per year. It should be noted that the tidal predictions do not include allowance for low pressure, surge, waves, or seiching, all of which could cause significantly higher sea levels for short periods. For the purposes of design and climate proofing a high tide level of 1.31 meters Above Datum (mAD) has been assumed (USACE and MCC 2012[b]).

Extreme Events - Typhoons

Samar Island, along with the rest of Eastern Visayas, ranked eighth of the 17 regions in the country as the most struck by typhoons within the Philippine Area of Responsibility (PAR). From 1948 to 2000, a total of 1,038 typhoons have crossed the PAR. Samar Island experienced 12 tropical depressions, 20 tropical storms and 33 typhoons. Approximately 35 percent occurred in the month of June, and 40 percent occurred in the month of November. As the effects of climate change increase, it can be expected that the number and intensity of the storms affecting the island will increase (Figure 2).

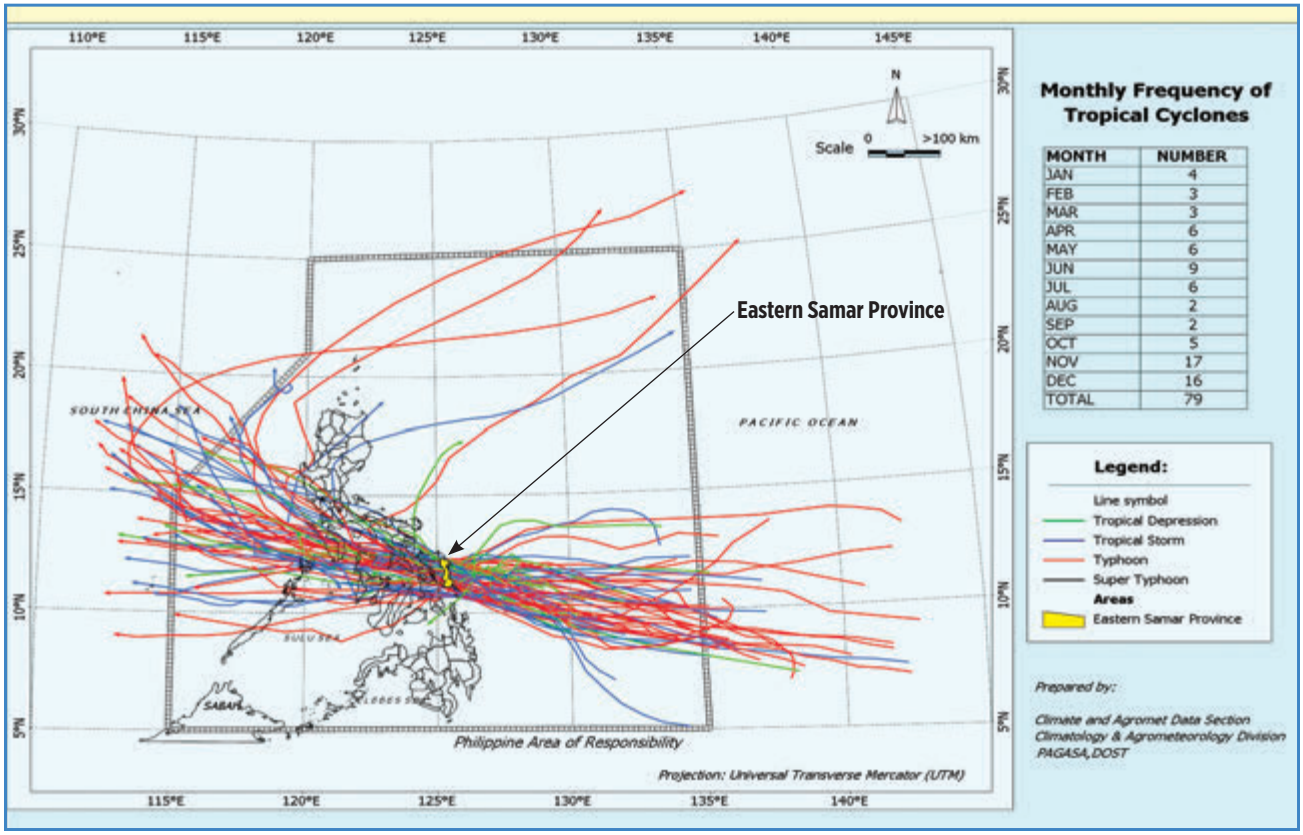
Thus, to ensure that the SNRDP is able to withstand the changing climatic conditions, the expected climatic changes had to be taken into account in the road designs.

Application of Climate Projections to SNRDP

The climate change scenario adopted more frequent and intense rainfall, increased typhoon occurrence and sea level rise. The design consultants based their design on the updated standards DPWH prescribed in June 2011 (including requiring upgraded flood control and road drainage standards). As a result, the designs increased the number of drainage structures, widened water channels and canals, and increased the freeboard in embankments, culverts and bridges. Existing culverts were analyzed for capacity for peak flows using the above standards. The culverts were either replaced or rehabilitated to meet the revised DPWH design standards. In order to determine the adequacy

5 Hulme and Shread (1999) projected an increase in sea level in the Philippines of 0.19-1.04 meters by 2080 relative to mean sea level during 1961-1990.

Figure 2. Typhoon Track Map



of existing bridges, the 50-year design was modeled in the existing river or creek to establish if sufficient freeboard below the soffit of the structure is available.

Climate-proofing has been addressed by establishing the trend in sea level rise along the east coast of Samar, based on records from tide gauges. Bridges and culverts were checked for hydraulic capacity and adequacy of freeboard for Mean Higher High Water (MHHW) elevations. The 50-year flood is simulated with the tail water set at MHHW elevation of 1.48 meters and at a high water level of 1.78 meters for purposes of sensitivity analysis. Storm surges ranging from 60 to 80 centimeters increased the design flood level to an elevation of 2.28 meters for tail water conditions (USACE and MCC 2012[a]).

Reducing climate-related risks is an integral part of sustainable development; thus, for the SNRDP, engineering interventions were considered in the design such as slips and landslides treatment; drainage culverts and cross-drains treatment; bridge rehabilitation, bridge replacement and seismic retrofitting.

By adapting to the effects of climate change, MCC's investment will be more sustainable and more capable of delivering its intended benefits, which means improving the lives of the Filipino people on the island of Samar through economic growth. As stakeholders have raised concerns about the effects of climate change during the scoping of the environmental impact study, it is also important to inform them

about the decisions that were made to mitigate identified environmental and social risks which they raised, why those decisions were made and how they were incorporated into the design. **KIN**

Criste Z. Navida *is a Director of Environmental and Social Assessment at Millennium Account Philippines (MCA-P). Before joining MCA-P she was employed at the Department of Public Works and Highways (DWPH). She represented the DPWH in the Inter-Agency Committee on Climate Change as Head of the Technical Working Group of the Infrastructure Sector.*

Gilberto Reyes *is a Director of the Bureau of Design at the Department of Public Works and Highways. His responsibilities include the upgrading of design standards of flood control and road drainage facilities/structures for the adaptation to climate change. He is a Civil Engineer.*

John Polk *is the Deputy Resident Country Director for MCC-Philippines with experience in engineering services, construction management and international development focusing on roads, water and sanitation, watershed management, forestry, and local community development. He holds a B.S. in Civil Engineering from the University of Notre Dame and masters degrees in International Affairs and Natural Resources and Sustainable Development from American University and the University for Peace in San José, Costa Rica.*

Rodolfo Arias *is the Director of MCA-Philippines' 224 Kilometer Secondary National Road Development Project. He is a Civil Engineer and Urban/Regional Planner with 35 years of experience in both government and private development projects.*

References:

Asia Development Bank (ADB). 2009. The Economics of Climate Change in Southeast Asia: A Regional Review. April.

Center for Global Development. 2012. Mapping the Impacts of Climate Change. Retrieved April 27, 2012 from http://www.cgdev.org/section/topics/climate_change/mapping_the_impacts_of_climate_change.

Hulme, M., and N. Sheard. 1999. Climate Change Scenarios for the Philippines. Climatic Research Unit, Norwich.

Office of the President of the Philippines Climate Change Commission. 2010. National Framework Strategy on Climate Change: 2010-2022.

Philippines Department of Public Works and Highways (DPWH). 2011. Memorandum to Effect the Upgrades on Flood Control and Road Drainage Standards. June.

Philippines Rural Reconstruction Movement (PRRM). 2009. Enabling Activities for the Preparation of the Philippines' Second National Communication on Climate Change to the UNFCC. Supported by UNDP-GEF and EMB-DENR. June.

U.S. Army Corps of Engineers and Millennium Challenge Corporation. 2012a. Environmental Impact Statement for Philippines Secondary National Road Development Project (SNRDP). Volume I.

U.S. Army Corps of Engineers and Millennium Challenge Corporation. 2012b. Initial Environmental Examination Philippine Secondary National Road, Package B, San Julian- Guiuan Road Section. Prepared by Gauff Ingenieure (JBG) in association with SCHEMA Konsult, Inc. March.

U.S. Army Corps of Engineers and Millennium Challenge Corporation. 2012c. Final Design Report for Package A1. Prepared by Tetra Tech in association with Philipp's Technical Consultants Corp and TCGI Engineers. May.

Virola, Rimulo, Estrella V. Domingo, Raymundo J. Talento, Glenita V. Amoranto, and Edward P. Lopez-Dee. 2008. "Gearing a National Statistical System Towards the Measurement of the Impact of Climate Change: The Case of the Philippines." Presentation to the Conference on Climate Change and Official Statistics organized by the United Nations Statistics Division in collaboration with Eurostat, the World Bank and Statistics Norway held at the Oslo Military Society, Oslo Norway on April 14 – 16, 2008.

WATER SUPPLY SYSTEMS AND CLIMATE CHANGE:

By Omar Hopkins and Ben Campbell

ABSTRACT

Water utilities are likely to be substantially impacted by and, through their high energy use and water requirements, are significant contributors to climate change. The impacts of climate change are marked with uncertainty which can make it difficult to reach decisions at a local level and over long periods of time. Utilities in developing countries also face a number of pre-existing challenges that compete for scarce financial and human resources. For this reason, the International Panel on Climate Change found that "the most effective [climate change] adaptation and disaster risk reduction actions are those that offer development benefits in the relatively near term, as well as reductions in vulnerability over the longer term" (IPCC 2012). Strategies to help utilities adapt to climate change and increase climate resilience revolve around four broad themes: engagement across multiple levels of government; including climate change impacts in long range planning scenarios; communication and collaboration between utilities, governments and other stakeholders; and protecting vulnerable populations. This paper presents a case study from Cape Verde to examine how MCC-sponsored interventions can help utilities improve their resiliency, adaptation, robustness, and reliability in the face of climate change.

MCC'S APPROACH

Climate Change Impacts and Contributions

Climate change is predicted to have substantial impacts on the hydrological cycle in Cape Verde. These changes may affect the water cycle through impacts on the total amount of rainfall, the intensity of storms and droughts and the rate of evapo-transpiration. For small island countries such as Cape Verde, sea level rise also threatens coastal areas and can lead to greater saltwater intrusion into existing freshwater aquifers. Additionally, increased storm intensity and sea level rise can threaten coastal infrastructure or require increased investment to protect infrastructure such as desalinization plants and distribution networks.

The Sahel as a whole—of which Cape Verde is a part—has shown significant decrease in rainfall in the second half of the 20th century (Ahmed et al. 2000). Water demand will likely change as water availability patterns and temperatures shift. The Government of Cape Verde (GOCV) Ministry of Environment and Agriculture projects that national temperatures will increase by up to 4 degrees Celsius, rainfall will decrease by 20 percent and storm intensity will increase by the year 2100 (RCV 2007). Changes in water demand, combined with patterns of increased urbanization and changes in economic activity, will increase the reliance on complex water treatment and delivery systems and further intensify changes in demands on water supply and treatment.

In addition to being affected by climate change, utilities also play a role in contributing to climate change because of the greenhouse gases emitted during utility operations. In the context of Cape Verde, water utilities use large amounts of energy to treat water and to move it from sources to points of demand. Desalination, which accounts for 90 percent of the treated water supply in Cape Verde, requires a significant amount of power, most of which is produced by inefficient diesel generation systems that emit CO_2 and other greenhouse gases. Additionally, many of the islands in the archipelago are quite mountainous and, consequently, there are substantial energy requirements to move water. For example, the island of Fogo requires that water be pumped 1,000 meters or more.

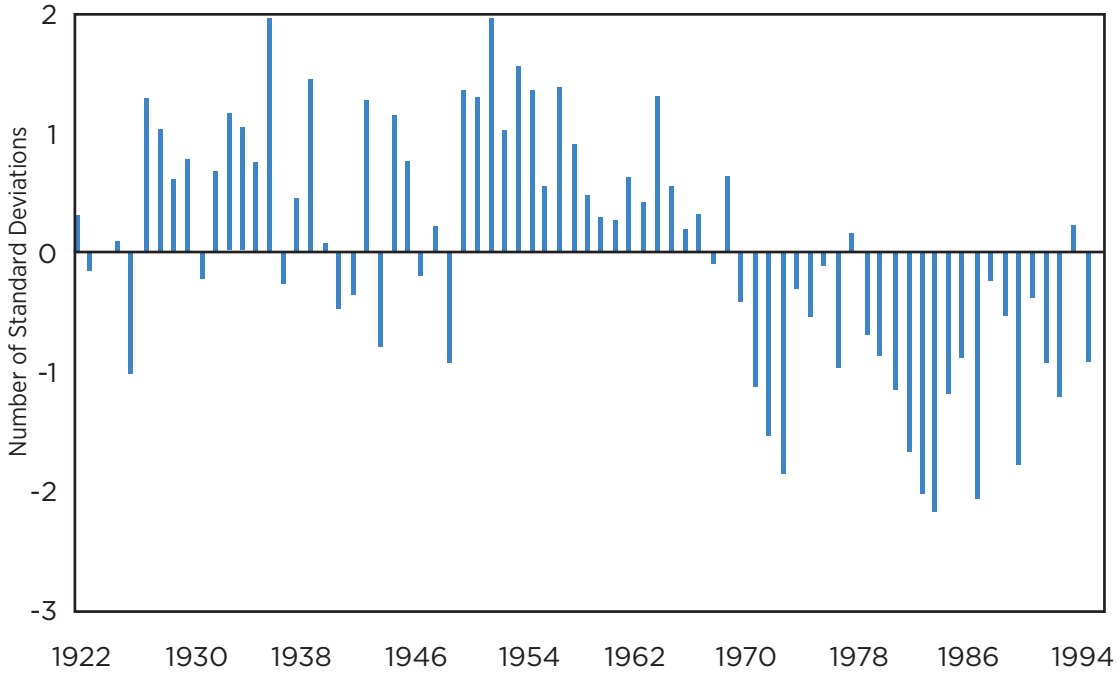


Figure 1. Rainfall variations in the Sahel between 1922 and 1994.

Challenges to Utilities in Developing Countries

A particular challenge to Cape Verdean utilities is that they face numerous, pre-existing challenges that must be considered when developing strategies to address climate change:

Poor policy environment: The national-level regulatory and planning roles and responsibilities are overly complicated with overlaps and gaps. One consequence is highly inefficient and undercapitalized utilities providing relatively low levels of service, resulting in average water consumption in Cape Verde of 35 liters per capita per day, which is below the World Health Organization standard of 50 liters per capita per day and well below the average level of its lower middle income country peer group. The regulatory framework and institutional responsibility are fragmented, leading to poor coordination and unclear standards for water management. This contributes to the difficulty in developing and adopting improved standards for infrastructure construction and water quantity/quality management needed to respond to climate change impacts.

Low utility resiliency: The capacity of utilities is relatively weak, and there are significant gaps in service. Rigid bureaucracies and poor administrative systems make utilities slow to adapt to climate-induced changes in water management. Many utilities have poor records that make auditing their financial balance sheets impossible; the evidence that does exist suggests that the sector as a whole is receiving substantial implicit subsidies (Briceño-Garmendia and Benitez, 2011). Reliance on desalinated water and substantial pumping requirements impose a high degree of reliance on expensive and intermittent energy supply, largely from fossil fuels that have seen prices fluctuate considerably in recent years. Water costs to consumers are only partially linked to energy prices and as a consequence rising energy costs have led to losses for water utilities.

Inadequate infrastructure: While Cape Verde has met its Millennium Development Goals for water supply, the amount of water that is supplied is both limited in terms

of quantity, quality of service (hours of service) and cost. A disproportionate number of households are not formally connected to the piped network and fewer still are connected to the reticulated sewerage system. Poor female-headed households, women and girls are disproportionately affected by poor service levels because services are less likely to reach poor communities, the poor have fewer resources to find alternatives and fetching and managing water tends to be done by women and girls, which greatly reduces their time and opportunities. Politically, there is increased pressure to extend services to these communities and to improve the overall quality of water and sanitation reaching rural communities. While a valuable public good, it results in increased demand for limited water resources in a constrained environment.

Climate Adaptation Strategies

The American Water Works Association, the International Water Association, the World Bank, and other professional associations and donor agencies have developed a generally accepted set of principles for assisting water utilities adapt to the impacts of climate change (American Water Works Association 2010):

- **Engagement across multiple levels of government** is essential to establishing policy frameworks and developing funding mechanisms. While adaptation is inherently local, regional and national initiatives are necessary in order to assess the impacts of and maintain a coordinated response to climate change.

- **Planning and management is critical** to identify adaptation options that enhance system resiliency and maintain management flexibility under a range of possible climate impacts and consider the energy-water nexus. Including climate change factors in decision support analyses is essential for planning and preparing for a range of potential impacts, from average to extreme in nature, and for managing the uncertainty of climate change. Good adaptive management requires scenario planning, good monitoring and tools such as models for decision making support in complex situations.

- **Collaboration and communications** between water utilities, governmental agencies, nongovernmental organizations, and other sectors can enhance the adaptive capacity.

- **Protecting vulnerable populations** is critical because these sectors of society will be more adversely affected by climate change and have less capacity to adapt.

MCC's Water Management Program in Cape Verde

Cape Verdean ground water resources are limited (Heilweil, Earle, & et al. 2006) and water resource management is weak and fragmented leading to over exploitation of groundwater resources. Under the compact with Cape Verde, this led to the termination of an activity to support the drilling of agricultural wells in areas sensitive to saline intrusion. The second compact builds on the first and focuses on introducing integrated water resource management and improving utility performance. Through the activities of the compact with Cape Verde, MCC has had the opportunity to address many of the principles for assisting water utilities with adapting to climate change as follows.

Multi-level Coordinated Approach

The water and sanitation (WASH) sector is marked by dispersed responsibilities across a large number of stakeholders, skewed incentives, a lack of institutional accountability, fragmented and overlapping authority, and conflicting legislation that impedes good planning and efficient operations in the sector. The Government of Cape Verde has recently undertaken a number of important preliminary steps to improve the legal and regulatory framework; however, further significant reform and restructuring of the sector are required to ensure that the benefits of planned infrastructure improvements can be achieved.

Within the islands, there is limited coordination around a strategic infrastructure development plan. Each island consists of multiple municipalities, each independently planning and implementing WASH development projects. Fogo and Brava are a notable exception and were able to create a long-term strategic plan under the Águabrava project funded by the Luxembourg Development Agency. In most cases, however, individual islands independently seek the support of NGOs and international donors. Because of the limited coordination between international aid agencies in the WASH sector, there is a resulting lack of project continuity and sustainability, as well as a duplication of efforts. A number of projects have been abandoned for lack of operational funds and technical expertise. In addition to the obvious loss of resources and reduced efficiencies, little climate change planning is incorporated in the disjointed work of the individual utilities.

In order to address the issue of coordination, the MCC compact has provided assistance at two levels: at the national level by improving national-level sectorial engagement, including developing a strategic water resource management plan, and at the utility level by supporting the strengthening of utility capacity to provide sustainable WASH services.

National-level Reforms

In addition to supporting long-range management plans, the compact is also addressing the challenge of overlapping roles and responsibilities of water and sanitation institutions created by the constant modification of the legal and regulatory framework. At the national level, the compact will support the creation of a larger, simpler, overarching regulatory authority that will include a broad-based consultative stakeholder group and the creation of an infrastructure grant facility to improve integrated, rational and transparent funding of infrastructure investments. MCC is also supporting redrafting water quality, use and discharge standards that will assist in improving water management—all of which are commonly impacted by climate change. For example, MCC is supporting the development of an integrated long-range management plan as a first step in supporting institutional reform, infrastructure planning, water management, and social and environmental analysis. The environmental and social analysis incorporates climate models into its scenario planning and evaluates water availability and distribution into its analysis. This will enable planners to understand the trade-offs associated with proposed projects in an integrated fashion and with an understanding of projected water availability under different climate projections.

Utility-level Reforms

The government also recognized that the existing arrangement of municipal operation and control of water supply and wastewater treatment was not working, in part, because of their small scale. Potential benefits that have been cited by the municipalities resulting from the establishment of a multi-municipal utility include: more efficient usage of scarce water resources, improved and coordinated management administration, increased economies of scale due to the rationalization of operations, increased institutional

capacity, and a reduction in operational losses, leading to improved financial performance and striving toward financial sustainability over time.

Figure 2 illustrates the location of municipalities in Santiago. The compact will target the strengthening of the utility system on Santiago by combining the nine systems currently in operation into one (or possibly two) utilities. In addition to increasing water security for the communities, combining these utilities also provides climate adaptation benefits by increasing coordination, reducing the fragmentation of the existing system and improving planning of constrained water resources over an administrative area that has the ability to manage the water resources holistically. These utilities will be publicly owned but commercially operated following the Agua Brava model pioneered by the Luxemburg Development Agency. MCC is currently assisting the GOCV with securing additional financial resources to replicate this process on other islands.

Figure 2. Existing Catchments in Santiago Island

Planning and Management Flexibility

Throughout Cape Verde, there has been a tendency to construct, or rehabilitate and extend, higher-profile projects such as desalination plants and wastewater treatment works, while not addressing how a continuous service of potable water and sanitation facilities can be provided to the population. Too little attention has been given to the long-term operation and maintenance of some capital investment projects, which has led to poor water management and underutilized assets.

While there are several studies of the water resource and sanitation sectors across Cape Verde, there is no comprehensive water and wastewater master plan with a time horizon of 25 or 50 years. The advantage of such a plan would be to provide a focused, long-term investment plan for the entire water cycle, covering the various water resources (groundwater, surface water and desalination, including climate change impacts on water availability), through appropriate water supplies, sanitation facilities and wastewater treatment to disposal or reuse of treated wastewater and sanitary and economic disposal of sludge. Such long-term planning would also allow Cape Verdean planners to manage water in anticipation of climate change impacts often projected over similar timescales.

In order to support better planning at the utility level, MCC funds are being used to develop a business plan and to support near-, medium- and long-term planning that describes the required investments in infrastructure and human capital. Long-range planning will support the Cape Verdean WASH sector achieve higher levels of service and increased sustainability, as well as build the sector capacity for resiliency and robustness required for climate change adaptation.

The problem of water losses in the existing potable water distribution systems is not being adequately addressed. Consequently, one of the critical outcomes of the planning process is to reduce water losses that are currently reported to be between 40 and 60 percent. Reducing losses is not only important because it affects the financial sustainability of the utility and the ability to deliver more water to consumers, but also because it will be an important aspect of reducing the energy intensity of the sector.

Communication and Collaboration Strategies

Improved communication and collaboration strategies not only support climate mitigation and adaptation strategies in Cape Verde but also help address the multiplicity of stakeholders and the conflicting roles and responsibilities that led to a lack of coordination in the WASH sector.

In response to the MCC compact, the GOCV has established a reform commission to oversee the transformation of the sector. This commission comprises a wide range of government stakeholders, including the Ministry of Environment, Housing and Territorial Administration (MAHOT); the Ministry of Tourism, Industry and Energy; and the Ministry of Rural Development. In addition to managing internal stakeholders, the GOCV is also taking steps to manage external partners; MAHOT has recently hired a sector coordinator responsible for coordinating donors in the sector.

With MCC support, the GOCV has helped move the donor community away from implementing uncoordinated and independent activities toward a more open, comprehensive and government-led strategy. The donor community, which had not had a sector coordination meeting in more than a year prior to MCC's engagement, now meets regularly both on its own and with the government. One of the practical consequences is that the European Union WASH budget support indicators now include water supply and climate change issues.

An example of improved coordination and communication at the utility level can be seen on Santiago, where the utility will be owned by the municipalities and have a board of directors composed of representatives from local governments, private sector and civil society. The new utility is envisioned to have a customer-care unit whose responsibilities will include improving the service and responsiveness of the utility to its customers and communication and outreach to consumers, disadvantaged or otherwise.

Protecting Vulnerable Populations

Disadvantaged households and groups (such as poorer and female-headed households, women, girls, and migrants) can be expected to disproportionately bear the burden of the impacts of climate change on water supply. This will manifest itself in the form of poorer access, irregular supplies, lower quality water, and higher costs. These groups will have fewer resources available to them to adapt to alternatives. Because fetching and managing water and sanitation is primarily women's work in Cape Verde, negative effects of climate change are most likely to affect women's and girls' time and opportunities.

Currently, gender and social objectives (soft interventions) are largely absent from the policies and plans of key WASH institutions. A handful of NGOs address social (and sometimes gender) inequalities in access to and management of water and sanitation; however, their efforts are inadequate to meet the gaps left by the inefficiencies of the sector as a whole.

MCC places a premium on strengthening gender and social considerations in developing and implementing sectoral policies and plans. The MCC-funded WASH project will directly address the marked inequalities that exist in access to and control over water and sanitation and the impact of climate change on service delivery to those households. The compact interventions target those groups most affected by the sector's current failings by improving the national-level understanding of not only the technical dimensions of poor service but

also the importance of the involvement and inputs of different groups and communities in developing and implementing gender sensitive and pro-poor policies and services.

The approach used in the compact begins by supporting the integration of gender and social analysis and objectives into national policies, plans and institutional structures, with support for the development of a social and gender unit within the newly created body which will oversee the national water sector, as well as coordinate and support utility level interventions. At the utility level, the compact supports reforms that will improve utility performance and improve service provision to all populations, including the most disadvantaged. It also supports the development of strategies for mitigating the disincentives to serve low-income populations that may emerge from the corporatized utility model. Finally, specific construction interventions will include social and gender criteria for selection and will include as part of the design targeted education and training activities. Together, these interventions should allow for greater targeting of water services to the needs of the poor and vulnerable and to women who are often the primary persons responsible for water procurement and use in the household.

Supporting the WASH sector adapt to the impacts of climate change is a multi-dimensional endeavor. However, many of the adaptive measures are also simply best practices for utility management. MCC's investments in Cape Verde will lead to a strengthened and more resilient WASH sector. Improved multi-level coordination, strengthened planning, better communication, and emphasis on targeting vulnerable populations will lead not only to improvements in sector performance and movement toward sustainability but also increase resiliency in the face of climate change challenges. **KIN**

Omar Hopkins *is an Infrastructure Director at MCC where he works on compact development and Implementation. He is a Civil and Environmental Engineer with nearly 20 years of experience and received a PhD from UNC-Chapel Hill. His current responsibilities include projects in Cape Verde and Mozambique and co-chair of MCC's Water Practice Group.*

Ben Campbell *is Director of Environmental and Social Performance at MCC. He is working on Cape Verde, Moldova, the Philippines, and Malawi. Ben has over 20 years of experience in development and conservation, two Master's degrees in Environmental Management and International Political Economics and is fluent in Spanish and Portuguese.*

References

Ahmed, Sanders, and Nell. 2000. New sorghum and millet cultivar introduction in Sub-Saharan Africa: Africa: impacts and research agenda. Agricultural Systems: 64: 55-65.

American Water Works Association. 2010. P*rinciples of Water Utility Adaption to Climate Change*. Retrieved from AWWA: http://www.awwa.org/files/GovtPublicAffairs/PDF/2010Climate.pdf

Briceño-Garmendia, C. M., and Benitez, D. A. 2011. *Cape Verde's Infrastructure: A Continental Perspective*. Washington DC: The World Bank.

Heilweil, V. M., Earle, J., and et al. 2006. *Evaluation of Baseline Ground-Water Conditions in the Mosteiros, Ribeira Paul, and Ribeira Fajã Basins, Republic of Cape Verde, West Africa, 2005-06*. Reston VA: USGS.

International Panel on Climate Change (IPCC). 2012. 2012: *Summary for Policy Makers In: Managing the Risks of Extreme Events and Disasters to Advance*. New York: Cambridge University Press.

Republic of Cape Verde (RCV). 2007. *National Adaptation Progarm of Action on Climate Change*. Praia: Ministry of Environment and Agriculture.

ILLUMINATING SUCCESS: ENSURING RESULTS AND SUSTAINABILITY WITH OFF-GRID SOLAR PHOTOVOLTAIC INVESTMENTS

By Kate Iovanna

ABSTRACT

It is well documented that access to electricity contributes greatly to increased income generation and quality of life through stronger economic productivity, additional opportunities for educational study at night and improved indoor air quality and health through reduced reliance on fuel burning. Providing clean, renewable energy to rural communities that are not easily connected to the national electric grid is in many cases a cost-effective solution for achieving electrification that offers significant environmental benefits, including the offsetting or avoidance of greenhouse gas emissions associated with fossil fuels. Careful program design is required for the uptake and long-term sustainability of small scale, renewable energy. This paper explores some important design features that reflect valuable lessons learned from past projects, with an application to a new MCC project being launched in Tanzania.

Rural Energy and Poverty

Up to 1.6 billion people, or one-third of the world's population, lack access to electricity, particularly in rural areas of developing countries. In many cases, this is because rural communities are located too far from the national grid to extend the lines to them cost-effectively, and because of the significant expense associated with common, alternative sources of electric power such as diesel generators, which require costly fuel purchases, or batteries, which require recharging, disposal and replacement. Providing off-grid power to rural households, enterprises and providers of social services supports a broad range of economic growth and development goals. For example, household lighting, a basic need, supports education as it allows for reading and studying at night, and one 15-watt fluorescent lamp or one 60-watt incandescent lamp provides the luminosity of 18 kerosene wick lamps or 60 candles (Van der Plas and de Graaff 1988). Refrigeration allows for critical health services such as vaccine storage as well as cold food storage. Additional health benefits of renewable energy solutions include reduced reliance on kerosene lanterns and candles, which negatively impact health in terms of indoor air pollution and fire hazards. Quality of life improvements can stem from access to radio, television and other appliances.

Access to power also supports the development of income generating activities, or "productive uses," including cottage industries and rural activities such as agro-processing. Even a modest amount of electricity can support mobile phone recharging, a highly valued service for which rural populations often travel long distances and pay high prices to those who can provide it. Off-grid renewable energy projects not only support enterprise development, they also benefit from its integration into program design. Incorporating "anchor clients" such as small enterprises as beneficiaries can improve the project economics by aggregating demand and therefore reducing per person (or beneficiary) program costs.

Renewable energy for off-grid rural electrification often proves to be a cost-effective solution, where a renewable resource is abundant (e.g., solar, wind or hydro potential) and using it avoids the higher total cost of large-scale power infrastructure typically associated with reliance on fossil fuels (e.g., coal, oil) that are expensive and often difficult to find in remote areas.

Solar Photovoltaics and Climate Change Benefits

Renewable energy also has environmental benefits, including a reduction in carbon emissions, a source of climate change. Solar energy is the most abundant of energy resources, and given that solar energy technologies have very low lifecycle greenhouse gas emissions (most greenhouse gas emissions from solar technology are associated with their manufacture), they have the potential to displace large quantities of non-renewable fuels, such as kerosene and diesel (IPCC 2012). Because of the very large number of homes and villages yet to be electrified, and because solar photovoltaic (PV) systems are often a least-cost electrification option, they can play a potentially significant role in greenhouse gas abatement. Although the total direct greenhouse gas (specifically carbon dioxide) displacement per PV system is small, the rate of displacement per kilowatt hour (kWh) is very high due to the high inefficiency of the typical alternative (e.g., kerosene lighting) (REPP 1999).

Photo: In rural Tanzania, only two percent of the population has access to the electric power grid.

Photo: MCC

Critical Factors in Program Design for Solar PV Projects

There are a number of renewable energy technologies that can be deployed for rural electrification, including solar PV systems, small or micro hydropower, small wind power systems, biomass systems, and hybrid systems. The optimal technological choice depends greatly on the scale of local power demand, applications and resource availability. Solar PV is an attractive technology for many applications in off-grid areas, particularly in developing countries that lie in areas with high solar insolation levels. Solar PV offers the added benefit of being a modular technology, meaning systems of different sizes can be installed to provide energy for individuals, dispersed homes, a commercial user, or a cluster of residential or commercial users. As a modular technology, solar PV also provides more options for customers of various income levels and/or very low electricity demand levels, including very small ("pico") systems, typically below 10 peak power in watts (Wp) that may just power a light bulb and/or cell phone charger. The affordability of PV systems has been aided by the decline in prices by a factor of over 50 since the 1970s because of advances in technology, increased supply of silicon and manufacturing capacity and economies of scale in manufacturing (IFC/GEF 2007). Prices fell by close to 50 percent during 2011 alone and are 75 percent lower than in 2008 (Bloomberg 2012).

Critical Factors in Off-grid Solar PV Program Design

Where a renewable energy technology such as solar PV has been identified as the best solution for rural electrification, the success of the investment hinges on several key factors of program design. Previous donor programs (e.g., World Bank, IFC, UNDP) and other investments in small scale renewable energy projects around the world have led to a number of important lessons learned in this regard, including the following:

1. Aggregate demand and include productive uses for project cost-effectiveness.

The market penetration for off-grid renewables faces the twin challenges of relatively high initial capital costs (particularly for poor, rural customers) and limited or nonexistent access to credit among would-be consumers. While the recurrent costs of renewable technologies such as solar PV systems are very low compared to inferior alternatives commonly in use in unelectrified areas, such as diesel generators, the up-front cost of a system is a hurdle for many individual users. By procuring systems in bulk or scaling systems to provide services to a cluster of consumers (e.g., in village markets), project designers can reduce capital costs. An example of this is the Clusters Solar PV Project being implemented by the company Camco in Tanzania, through Tanzania's Rural Energy Agency (REA) with funding from the World Bank. The project focuses on farmer or worker cooperatives, and procuring solar PV products for them on a wholesale basis. REA provides a 20 percent subsidy for each system while the users contribute the remaining 80 percent, paid off over several years. Clustering users and therefore pooling demand in this way can also help foster the users' access to credit by reducing the risk that local lending institutions may otherwise perceive with such projects.

2. Catalyze the market for solar PV by supporting early entrant service providers.

Ensuring both the sustainability of a small scale renewable energy investment and continued market penetration of off-grid renewables depends on building up the

experience, capacity and market share of new and existing service providers through business development services, cost-sharing mechanisms and demand aggregation. In addition to direct investments in PV enterprise development, financing options include credit support for companies, guarantee funds that help distributors work with multiple local retailers and project-based tenders that consolidate larger packages of work for providers to competitively bid on and establish themselves in the market at lower transactions costs (UNDP/GEF 2004). Particularly in a pre-commercial market (or "pioneer stage" marked by early start-up), such activities can help attract and develop a local pool of system retailers, technicians and instructors. Furthermore, developing the local market can help foster the equally important development of policy and institutional support for technical quality control standards to be applied across similar projects. This is very important to ensure the performance of and continued interest in renewable technologies.

3. Include a customer contribution.

Except perhaps in the case of public services such as health clinics and schools, it is generally considered ill-advised to fully subsidize PV systems, particularly those for household or commercial use. When end users contribute a share of the system's capital cost, as well as the cost of periodic maintenance, they are incentivized to maintain the assets and their continued performance. (Note: This may not apply where the program is based on a utility fee-for-service model, whereby the utility retains system ownership). Where credit programs can be developed in partnership with local banks or through service providers selling the PV systems, customers may be able to cover most of or the full cost of a system, with payments spread out over time so as not to exceed their regular (e.g., monthly) willingness to pay for electric service. Spreading out costs over time helps to avoid the perception among customers that an investment in a PV system represents a high opportunity cost relative to normal expenditures.

4. Require end user training to help ensure system operations and maintenance.

Unless a project involves regular, ongoing customer payments to a service provider for system maintenance and repair, sustained operation of solar PV systems hinges on the customer/owner being sufficiently trained and sensitized to operation and maintenance requirements. Even though system components may come with limited manufacturer warranties, experience has proven the importance of training users in first-line maintenance to ensure continued system operations and use until local repair capacity has fully developed. In the case of institutional customers, particularly those benefitting from fully subsidized systems, it is important to ensure they set aside a long-term maintenance budget.

5. Include marketing and consumer awareness programs to promote commercialization and wider dissemination of PV technology.

Early donor-led renewable energy initiatives were primarily pilot projects that did not address the establishment and growth of a commercial market for renewable energy technologies beyond the scope of a discreet project. Financial sustainability and replication were not factored in to ensure a scaling up of electrification using renewables. Achieving some level of economies of scale is crucial for controlling costs and sustaining local provider operations. Concerted attempts to raise consumer awareness about the technology, options and services delivered – as well as quality of service – are needed to build the local market.

MCC Case Study: Tanzania's Kigoma Solar PV Project

MCC is broadening its energy portfolio through the launch of an off-grid renewable energy project in Tanzania that has been designed to address the lessons learned above. The Kigoma Solar PV Project, financed as part of MCC's compact with Tanzania, is designed to address a range of basic electricity needs in the remote western region of Kigoma, where the electricity supply infrastructure is particularly under-developed. The goal is to establish a commercially-orientated, sustainable PV program to serve household, commercial and public sector markets in the region.

In Tanzania, only about 10 percent of the population has access to the electric power grid. In rural areas, coverage is only about two percent of households. Kigoma, located

LINKING SOLAR PV TO PRODUCTIVE USES

Given the diversity within the potential PV market in Kigoma, the project targets several types of customers and will provide a range of modular PV products suited to their needs as follows:

Public facilities
The public facilities to receive PV systems are secondary schools and health facilities. Each health facility will receive two systems, one to support refrigeration for vaccines and one to support lighting and medical applications.

Village markets
For the village market areas, the contractor will design and install up to 45 pico-grids (village productive use systems). The pico-grids will provide outside lighting for open stalls and inside lighting and internal power sockets for specified businesses.

Fishing cooperatives
Beach management units are fishing cooperatives operating in Lake Tanganyika, who fish at night using kerosene lanterns to attract the fish. The intended PV system will replace the kerosene lamps beneficiaries in the program currently use and consist of battery-powered light-emitting diode (LED) lights that can be charged using solar PV.

A solar PV system is installed on a public facility.

A solar-charged LED light for night fishing, replacing the kerosene lamp, is tested.

on Lake Tanganyika, is a predominantly rural and agricultural region. Fishing on Lake Tanganyika and salt mining are other notable economic activities. The region is not yet connected to the national grid. Instead, the Tanzania Electric Supply Company Limited (TANESCO) operates a mini-grid in the Kigoma town area (served by only nine MW of diesel generation capacity that has often proven unreliable), and is currently developing a second mini-grid in the Kasulu town area served by an additional two MW of diesel generation. Because not everyone in these two areas is connected to or located near the limited reach of the mini-grids, access to grid electricity in the region is extremely low (MCA Tanzania 2011). While TANESCO hopes to finance the extension of the national grid to Kigoma at some point in the future, for the time being, rural electrification in the region will have to depend largely on off-grid investments such as solar PV.

Household market

Pico-PV systems (i.e., very small scale) have been specified for sale to the household market. The types of systems for household use range in size depending on customer demand and ability to pay. Some examples of Pico-PV systems include:

- **A basic LED lantern:** This LED cluster light (0.5Wp – 1.5Wp) can be used as a desk lamp or less effectively for ambient lighting. The light will be charged by a small PV module that can be attached to a roof or manually put out in the sun. The LED lantern could be used to charge a cellular phone as well.

- **A small (5Wp) household lighting system:** This household lighting system consists of a number of LED lights, a battery and cellular phone charging capabilities. It could power small radios as well.

A LED lantern and phone charger is at work.

- **20Wp solar home systems:** This is a more conventional solar home system with a battery of approximately 40 amp-hour (Ah) capacity that can power lights (LEDs), a radio and charge cellular phones.

- **50Wp solar home system:** This system includes a battery of approximately 100Ah capacity that will support LED or compact fluorescent lamp (CFL) lighting, a radio or small television, cellular phone charging, and other low-powered electrical applications.

For additional information on the Kigoma Solar PV Project: *http://www.camcoglobal.com/en/jvwintz.html*

Applying Past Lessons to the Kigoma Project Design

The Kigoma project was designed with sustainability and replication in mind, addressing several lessons learned.

Aggregated demand and market development

A key feature of the program design is to bundle demand and focus on the productive, anchor loads of income-generating activities, such as village markets (via systems shared by multiple, co-located users) and fishing cooperatives, along with public services such as schools and health clinics. These various customer groups are bundled into a single package, which is then bid out on a competitive basis. By focusing on key customer groups and bundling purchases, the project can lower costs and attract a broader base of potential service providers.

By expanding the reach of the project through bulk purchases, the project is expected to create additional demand for solar PV systems which will further incentivize the contracted service provider to establish business operations in the Kigoma region. The project is designed to avoid giving the selected contractor an exclusive "franchise" in the area without limiting the potential scope of commercial activities. At the same time, it could attract additional providers to enter the market which will allow a "scaling-up effect" beyond the initial MCC compact investment.

Financial sustainability: Models adapted to user groups

The Kigoma project addresses financial sustainability by varying the level of grant financing according to beneficiary groups. For instance, while public services (e.g., schools and health clinics) will receive fully subsidized systems, the provider will help ensure they establish a budget for maintenance, potentially via some ancillary fee-for-service such as phone charging. Village market systems will be subsidized as an early incentive to be part of the pilot program, but the market organizations will provide a down payment for their system and be responsible for managing the collection of user fees from each market enterprise connected to the system. Before installing the metered systems, the contracted service provider will verify that the market collective is able to pay a fixed daily or monthly charge for system operations. Users will pay the charge to a trained village market committee dedicated to system maintenance.

The solar lantern units to be provided to the fishing cooperatives will be fully subsidized as well as a limited pilot (test) demonstration and, if successful, can scale up on a commercial basis.

The project also offers the service provider, recently awarded a contract, the opportunity to tap into and develop the household market on a strictly commercial basis (i.e., without subsidies toward the system cost) with the provision of a nominal sum to support developing an acceptable business plan for doing so (e.g., partnering with local financial institutions to provide consumer credit). This is intended to incentivize innovation on the part of the provider while supporting the development of a commercially viable household market.

Marketing and training

The Kigoma solar project includes marketing and training to ensure the investment's success and long-term sustainability. The marketing is intended to increase the awareness and interest of all stakeholders in solar electrification, and its potential to

serve their various needs. Training will be provided for system installers, the household system vendors and system end users as follows:

- **Installer training**: Training on good practices, maintenance and troubleshooting;
- **Vendor training:** Designed to ensure that the existing retail infrastructure can support the further development of the PV market, which requires sufficient and reliable retailers who are selling quality products at reasonable prices; and
- **Public and village market system operator training:** Training on effective system operations, routine maintenance and revenue collection for the market systems. The provider will work directly with the village market committees to define their role in system and user management. This will include training on basic maintenance, revenue collection and revenue planning. The village committee will appoint a system operator, to be paid out of collected user fees, to undertake routine maintenance and engage with customers.

  To ensure the long-term sustainability of the systems installed at public facilities, the contractor will verify that the selected beneficiaries have identified a budget and/or mechanism for financing maintenance and parts replacement.

Table 1: Systems Financed Under the Program

System	Quantity	Size per system [Wp]	Total [kWp]
Secondary school	45	1300	58.5
Dispensary (2 systems)	120	420 + 440	103.2
Health Center (2 systems)	10	420 + 440	8.6
Village market productive-use system	25	1 100	49.5
LED night fishing systems	90	220	15.8
TOTAL			**235.6**

The Kigoma solar PV project has been designed to reflect important lessons learned from past experiences among donor-funded projects that facilitate rural electrification with clean, renewable energy technology. While the project is a small part of the larger energy investment made through Tanzania's MCC compact, which also includes transmission and distribution line development and hydropower activities, it is significant among renewable energy programs in Tanzania. If the project succeeds in achieving its target of [235kW] of installed solar capacity in the Kigoma region, it will represent the largest investment of its kind to date in Tanzania (Business Green 2012). It is also a notable investment for the environmental benefits it promises by offsetting some growth in the use of non-renewable forms of electricity in Kigoma, thereby avoiding associated emissions of carbon dioxide, a greenhouse gas. This is in addition to the impact it will have on rural electrification in a particularly underdeveloped and poverty stricken region in Tanzania. In the longer term, the project's success could

mean multiplied environmental and economic benefits through replication and growth in the PV market because of the program's catalytic effect.

Project implementation began in May of 2012 and is expected to be complete by August 2013, prior to the conclusion of Tanzania's five-year MCC compact in September 2013. **KIN**

Kate Iovanna *is a Senior Program Officer in MCC's East and Southern Africa division, where she manages project feasibility analysis and implementation with a focus on electric power and environmental policy. Previously, Kate worked with the Inter-American Development Bank on rural electrification and small scale renewable energy projects in Latin America as well as the Climate Protection Division at the U.S. Government's Enivornmental Protection Agency.*

References

Bloomberg New Energy Finance. 2012. *Solar surge drives record clean energy investment in 2011.*

Business Green. 2012. *Sun rises on Tanzania's largest solar scheme.* Accessed from http://www.businessgreen.com/bg/news/2162454/sun-rises-tanzanias-largest-solar-scheme on 22 March 2012.

IFC/GEF. 2007. *Selling Solar: Lessons from More Than a Decade of IFC's Experience.*

Intergovernmental Panel on Climate Change (IPCC). 2012. *Renewable Energy Sources and Climate Change Mitigation: Special Report of the Intergovernmental Panel on Climate Change.*

MCA Tanzania. 2011. *Final Feasibility Study: a Domestic and Commercially Oriented Solar Photovoltaic Program in the Kigoma Region.* February.

R. Van der Plas and A.B. de Graaff. 1988. *A Comparison of Lamps for Domestic Lighting in Developing Countries.* World Bank Industry and Energy Department Working Paper, Energy Series Paper No. 6. Washington, DC.

Renewable Energy Policy Project (REPP). 1999. Rural Electrification with Solar Energy as a Climate Protection Strategy.

UNDP/GEF. 2004. *Solar Photovoltaics in Africa: Experiences with Financing and Delivery Models.*

INFRASTRUCTURE

FIDIC World Consulting Engineering Conference 2012
The FIDIC World Conference 2012 highlights the consulting engineering industry's successes and achievements in helping society implement sustainable solutions to today's urgent global challenges. FIDIC also provides year-round training courses worldwide.
September 9–12, 2012
Seoul, South Korea
www.fidic.org

★ MCC Infrastructure College
MCC's first infrastructure college aims to: a) foster collaboration between MCA-MCC to enhance management practices on infrastructure projects; b) provide MCA infrastructure project managers the opportunity to share effective management practices; c) establish a forum for sharing implementation experiences and lessons-learned among MCA countries; and d) elevate MCA project management capacity.
October 2–5, 2012
Washington, DC

Asia Development Bank Transport Forum 2012: Inclusive and Sustainable Transport
The forum program includes key sessions on urban transport, road safety, green freight and transport technologies, climate change resilience, mode choice, socially inclusive transport, road asset management, and cross-border transport.
November 6–8, 2012
Manila, Philippines
http://adb.org

Power-Gen Africa
The inaugural POWER-GEN Africa will provide comprehensive coverage of the power needs, resources and issues facing the electricity generation industries across sub-Saharan Africa.
November 6–8, 2012
Johannesburg, Republic of South Africa
http://www.powergenafrica.com

MCC Agriculture College: September 23–28, 2012

The Transportation Research Board (TRB) 92nd Annual Meeting
The TRB Annual Meeting covers all transportation modes, with more than 4,000 presentations in nearly 650 sessions and workshops. Theme for 2013: Deploying Transportation Research - Doing Things Smarter, Better, Faster.
January 13–17, 2013
Washington, DC
http://www.trb.org

EDUCATION/ HEALTH/COMMUNITY DEVELOPMENT

Making Cents International 2012 Global Youth Economic Opportunities Conference
The Making Cents Conference focuses upon the increasing economic opportunities for young people, and features learning tracks on workforce development, youth enterprise development and financial services and capabilities.
September 11–13, 2012
Washington, DC
http://www.youtheconomicopportunities.org

The 40th Annual International Conference on Global Health
The Global Health Conference brings members of the health community together to discuss critical issues and identify common ground.
Dates: TBA, June/July 2013
Washington, DC
http://www.globalhealth.org/

XIX International AIDS Conference
The International AIDS Conference is the premier meeting for those working in the field of HIV/AIDS, as well as policymakers, people living with HIV/AIDS and others committed to ending the epidemic.
Dates: TBA, July 2013
Location: TBA
Previous site: http://www.aids2013.org

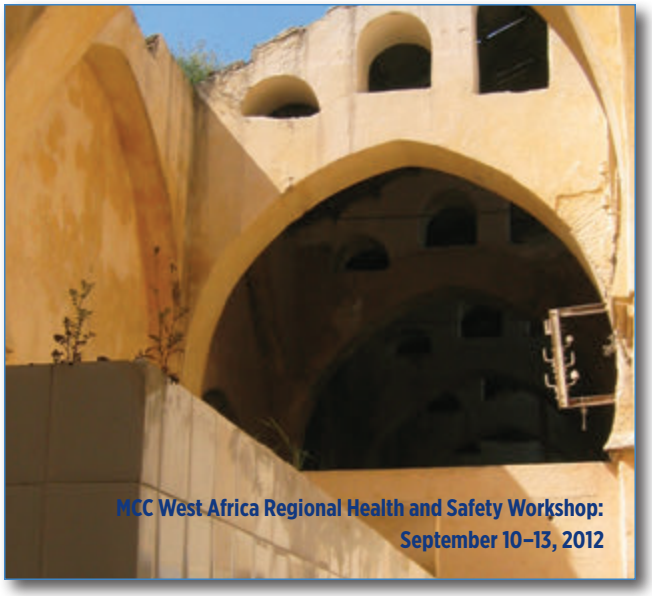
Pan African Reading for All Conference
This conference brings together teachers, writers, policy makers, and more to share best practices in the field of literacy, education and the development of literate environments. Conference occurs every two years.
Dates: TBA, July 2013
Location: TBA
http://www.codecan.org/media-room/event/pan-african-reading-all-conference

PROCUREMENT

5th International Public Procurement Conference
The objective of the IPPC is to advance and share knowledge and best practices in public procurement; the biennial conference is a forum where researchers and practitioners share knowledge and best practices and network with their colleagues.
August 17–19, 2012
Seattle, WA
http://www.nigp.org/ippc5

AGRICULTURE AND LAND

★ MCC Agriculture College
The MCC Agriculture College will showcase the experience of MCC with agriculture and rural development projects. The college will bring together participants to


MCC West Africa Regional Health and Safety Workshop:
September 10–13, 2012

share best practices and improve active and future MCC compacts as well as other U.S. investments in Feed the Future.
September 23–28, 2012
Washington, DC

Making the connection: value chains for transforming smallholder agriculture
The Making Connections 2012 event will discuss and debate how to incorporate small land holders into value chains and create conditions necessary for sustainable agriculture value chains.
November 6–9, 2012
Addis Ababa, Ethiopia
http://makingtheconnection.cta.int

Feeding the World: Africa
This Economist-sponsored conference centers on African agriculture, asking: how can governments spur greater agricultural output, how can farmers be assisted to increase production, and where does technology fit in?
November 15–16, 2012
Johannesburg, South Africa
http://cemea.economistconferences.com

Annual World Bank Conference on Land and Poverty
Conference fosters dialogue and sharing of good practices by showcasing the diversity of reforms, approaches and experiences that are being implemented in the land sector around the world.
Dates: Estimated April 2013
Washington, DC
http://www.landandpoverty.com

ENVIRONMENT AND SOCIAL PERFORMANCE/ SOCIAL AND GENDER ASSESSMENT

★ MCC West Africa Regional Health and Safety Workshop
Specific objectives of the workshop are: a) bring West Africa MCAs together to contribute to improved health and safety practices and performance through shared experiences; b) communicate core MCC health and safety performance expectations, including MCC Health and Safety Policy; and c) promote increased awareness and health and safety culture among MCAs and their contractors.
September 10–13, 2012
Rabat, Morocco

Gender Equality for Development Effectiveness
This 5 day workshop/course guides participants through the links between gender equality and development goals. Discussions of individual experiences implementing gender goals to projects will be a core feature of the workshop.
September 3–7, 2012
Turin, Italy
http://gender.itcilo.org/cms

IAIA Conference 2013
IAIA holds an annual conference for environmental and social impact assessment.
Dates: TBA, May/June 2013
Location: TBA
http://www.iaia.org

Development-induced Displacement & Resettlement
Despite decades of experience and study on development-induced displacement and resettlement, the severity of the problem persists; this conference discusses displacement and resettlement and bridges the gap between research and practice.
Dates: March 22–23, 2013
University of Oxford, England
http://www.didrconference.org

FISCAL ACCOUNTABILITY

International Anti-Corruption Conference
IACC conducts regular conferences on the state of corruption in the world and work being done to combat it. The 15th conference will examine ways in which civil society can be empowered to fight corruption.
November 7–10, 2012
Brasilia, Brazil
http://15iacc.org

International Consortium on Governmental Financial Management – 2012 Winter Conference
The ICGFM is dedicated to improving financial management and sponsors two conferences a year.
December 10–12, 2012
Washington, DC
http://www.icgfm.org/

WATER

Asia Water Week
Asia Development Bank is organizing Asia Water Week 2013 with the theme "Securing Water for All." It will cover topics such as climate change, water-food-energy nexus, civil society, and disaster management.
Dates: March 14–15, 2013
Manila, Philippines
http://adb.org/news/events/asia-water-week-2013

American Water Works Association Annual Conference and Exhibition (AWWA ACE13)
ACE13 is a gathering of water professionals from around the world intent on providing leadership and guidance for the future of safe water.
Dates: June 9–13, 2013
Denver, CO
http/www.awwa.org

Announcing the Winter/Spring 2013 theme for the KIN Journal:

LOCAL FOOD SECURITY, GLOBAL MARKETS

More than half of MCC's obligated investments - $4.4 billion - are related to improving food security, and 21 of 25 signed compacts include food security-related investments.

This theme will explore the innovations, best practices, lessons learned, and technical case studies from MCC's multi-pronged approach to strengthening agricultural and rural economies and promoting reliable access to sufficient, safe and affordable food. A special focus will be on how MCC's investments link the local context to global markets.

By the numbers, MCC's global food security investments* will result in:

- 250,000 hectares under new or improved irrigation,
- 227,000 farmers trained,
- $71 million of agricultural or rural loans disbursed,
- 3,200 enterprises assisted,
- Nearly 6 million hectares of formalized land rights, and
- 3,500 kilometers of rural roads completed.

CALL FOR ABSTRACTS

If you are interested in contributing to the next issue of the journal or getting more information, please email kinjournal@mcc.gov. Proposals are limited to MCC and MCA staff. Expected publication is December 2012.

*As of March 31, 2012

Photo by: MCC

Reducing Poverty Through Growth

2012-001-1085-01