WORLD RESOURCES INSTITUTE

Development Alternatives

ISSUE BRIEF

CASE STUDY

APPLYING INFORMATION FOR ADAPTING THE AGRICULTURE SECTOR IN BUNDELKHAND, INDIA

MUSTAFA ALI KHAN, ANAND KUMAR, AND K. VIJAYA LAKSHMI

INTRODUCTION

This case study documents the issues related to accessing, processing, and applying climate information to help farming communities take robust and low-risk agricultural adaptation measures. It examines two projects being implemented by Development Alternatives in central India's Bundelkhand region, which straddles the provinces of Uttar Pradesh and Madhya Pradesh. This case study highlights the multiplicity of data sources involved in adaptation decision making, provides an analysis of how information was used, and explores the challenges associated with information use for adaptation decision making in the agricultural sector. Project staff addressed these challenges by taking an interdisciplinary approach toward collecting, assimilating, and analyzing data, as well as communicating it effectively to farming communities.

ABOUT THIS SERIES

This case study is part of a World Resources Institute project, Information for Climate Adaptation in South Asia: Identifying User Needs. Each of the case studies in this set explores an aspect of information use in adaptation decision making. The goals of this series are twofold:

1. provide insights into how information (such as climate projections, stakeholder interviews, and environmental monitoring) can be used to support adaptation decisions; and

2. guide investments by national governments and their development partners in information systems that can inform decision making around risks related to climate change.

This case study series was supported by the UK Department for International Development. Case study authors used the same framework of guiding questions for their research, which consisted of literature reviews and interviews. The case studies accompany a World Resources Institute working paper, "Information for Climate Change Adaptation: Lessons and Needs in South Asia," and the conclusions from a 2-day workshop convened by WRI and Development Alternatives, a research and action organization, in Delhi in April 2012. Both documents and the other case studies can be found at http://www.wri.org/project/vulnerability-and-adaptation/information.

A 2011 study by the government-run Indian Agricultural Research Institute indicates the possibility of a national reduction of 4 million to 5 million tons in wheat production (equivalent to almost 5 percent of India's annual wheat production in 2012) per growing season for every 1°C rise in Indian average daily temperature.[1] Wheat is the staple food crop in Bundelkhand, and the states of Madhya Pradesh and Uttar Pradesh jointly contribute 44 percent of India's total wheat production.[2]

Several studies have identified Bundelkhand as being especially vulnerable to climate change.[3, 4] Semiarid and prone to drought, Bundelkhand is one of the least socioeconomically developed regions in India.[5] Increasing demands on natural resources and harsh and worsening biophysical conditions such as low soil fertility, combined with more frequent extreme events such as droughts caused by climate variability and change, further exacerbate the region's vulnerability. For example, crop productivity in the Bundelkhand region is 1.4 times lower than other parts of central India.[6] This pattern of lower agricultural productivity limits farmers' disposable income and capital for investments in more efficient farming methods.[7]

Development Alternatives, a national-level nongovernmental organization, implemented two projects between 2009 and 2012 focused on the Bundelkhand region: (1) Sustainable Civil Society Initiatives to Combat Climate Change, and (2) Vulnerability Assessment and Adaptation Planning for Madhya Pradesh.[8,9] Both projects were carried out in 20 villages of the region, in partnership with more than 280 farming families. The projects' objective was to address the long-term environmental sustainability of agriculture in the study area. Sustainable Civil Society Initiatives was a research effort with three main components: capacity building, on-the-ground action for climate change adaptation, and policy advocacy. Vulnerability Assessment and Adaptation Planning was a

Semiarid and prone to drought, Bundelkhand is one of the least socioeconomically developed regions in India.

research effort focused on better understanding the agriculture sector's vulnerability to climate change and developing a strategy at the state level for responding to climate change challenges.

To encourage better farming decisions in the face of climate change, a critical component of the two projects was providing robust technical information on climate variability to farming communities to inform practices that improve land and water management and enhance crop productivity. Adaptation practices that were eventually implemented in the region during these projects included crop diversification; use of drought-resistant plant varieties; better tillage, sowing, and irrigation practices; and attempts to enhance agricultural productivity by using agroforestry. The selection of these adaptation practices was ultimately driven by the inclination of the farmers, government recommendations, and the expert opinions of agriculture specialists.

A multidisciplinary team consisting of experts in agriculture, climate change, social science, extension, and communications integrated and communicated varied information for the projects.

INFORMATION SOURCES AND USE

The two projects used an array of climatic and hydrological, satellite images, biophysical, socioeconomic and stakeholder data and information to develop recommendations about adaptation practices for farmers in the region. The different types of information and the way they were used are described below. (Table 1 provides more details on information types and sources.)

Climatic and hydrological datasets were used to assess vulnerability of the physical environment and potential impact of climate change on agricultural yields of the study area.

The climatic datasets also helped the project team understand the kinds of climate changes that might be expected in the future (midcentury and end-of-century).

Datasets obtained through satellite imagery led to an increased understanding of the region's land use patterns and other spatial components of the adaptation issues at hand.

To analyze the impact of the physical environment on crop yields, climatic datasets had to be combined with biophysical datasets pertaining to crop physiology and edaphology (soil science). The combination of these two datasets led to a new set of assessments that included simulation studies about the impacts of climate change on crops.

Finally, socioeconomic data were used for multiple purposes. One of these was to assess communities' vulnerability to climate change. Socioeconomic data was also used to understand current coping mechanisms and thus the adaptive capacity of the communities. Data were collected directly from field surveys as well as from sources such as the statistics and planning divisions of the district administrations, part of the state governments of Madhya Pradesh and Uttar Pradesh.

A multidisciplinary team consisting of experts in agriculture, climate change, social science, extension, and communications integrated and communicated the data listed in Table 1. The team also implemented adaptation options on the ground

TABLE 1

TYPES, SOURCES, AND USE OF INFORMATION FOR CLIMATE ADAPTATION IN BUNDELKHAND, INDIA

Type of Information/ Data	Description	Sources	Information Use
Climatic and hydrological information	Projections of future climate conditions	Indian Institute of Tropical Meteorology (IITM), Indian Meteorological Department, Indian Institute of Technology, Delhi[a]	IITM used the PRECIS model based on the Hadley Centre Coupled Model to develop three simulations for the A1B scenarios for the period 1961–2098. The Soil and Water Assessment Tool (SWAT) model was used in order to generate the river flow models in various river basins.[b] The SWAT model was developed to provide continuous-time simulations with a high level of spatial detail by allowing the further division of a watershed or river basin into hundreds or thousands of sub-watersheds.[c]
Satellite imagery	Linear Imaging Self Scanning false color composite imageries were used to generate land-use maps indicating various land-use types such as forests, agricultural land, and water bodies	National Remote Sensing Centre (NRSC)	Analysis and classification of satellite imagery indicated that the region's agricultural sector is heavily dependent on rainfall and supplemented by groundwater.
Biophysical information	Physiological and edaphological (soil-related) data	Indian Council for Agricultural Research, Indian Agricultural Research Institute, Indian Institute of Technology, Delhi[d]	Climatic data sets were integrated with edaphic (soil) and crop physiology data using CROPGRO soybean and CERES wheat physiological models to generate the crop impact models under A1B scenario of climate change in 2030.
Socioeconomic information	Employment, migration patterns, mutual trust and information access, crop yields, agriculture input and output prices	Government statistical publications produced by the District Statistic and Planning Division, direct surveys, Indian Council for Agricultural Research, Indian Agricultural Research Institute	Climatic and hydrological information, satellite imagery, and biophysical information was overlaid with the socioeconomic conditions on ground in the Bundelkhand region, based on expert opinion and stakeholder consultation (including with farming communities). The aim was to identify adaptation options that are feasible in the region given the magnitude of climate impacts and socioeconomic conditions.
Stakeholder information	Existing farm management practices, coping mechanisms, and capacity to take up new technology or management practices based on experience of communities and experts	Community members and experts	

with farmers. Some team members interacted with research institutions such as the Indian Institute of Technology, Delhi, and the Indian Agriculture Research Institute to get access to their tools and data sets. Other team members communicated messages from the research projects to farming communities. A third group of team members provided advice on the on-the-ground implementation of adaptation options through an extension program, including the establishment of farmers' clubs. These clubs helped coordinate activities and facilitate the implementation of various adaptation activities by sharing information on its costs and benefits. Regular interaction and exchange of information was maintained between the various teams to ensure proper understanding of the situation and to develop appropriate responses.

The project team then presented the integrated information to relevant stakeholders such as farmers, local government research institutions, and local civil society organizations, as well as to the field-based agriculture extension team in Bundelkhand managed by Development Alternatives. This interface function of providing integrated information to local communities and relevant stakeholders helped identify and implement various adaptation practices under the two projects.

ANALYSIS OF INFORMATION USED

The project teams analyzed the data and integrated the information identified above to understand the potential climate change impacts on the agricultural sector of Bundelkhand. For instance, analysis by the Indian Institute of Tropical Meteorology, Pune,[10] showed that winter precipitation over the region is likely to decline between 2021 and 2050 but likely to increase between 2071 to 2100 against the base years of 1961 to 1990.[11] Since wheat is a winter crop, this information is critical to the Bundelkhand region and has implications for its food security. Analysis carried out during the projects showed that wheat yields in the region may be expected to decrease by as much as 15 percent by 2030 from the base years of 1969 to 1990, and the yield for soybeans (another important cash and food crop in the region) could decrease by 18 percent by 2030 as compared to the base years of 1969 to 1990.[12] The same climate projection also showed that overall rainfall intensity will increase. This projection, coupled with the expected decrease in winter precipitation, indicated more intense rainfall during the monsoon summer months. High-intensity rainfall in regions like Bundelkhand, where soil capacity to retain water is low, can cause high runoff and higher river flows, leading to the possibility of flooding and erosion. Research at the Indian Institute of Technology has projected increased water discharge in the region's rivers for the period from 2021 to 2050.[13]

> The integrated forms of information generated by the two projects had to be communicated to the farmers in a useable form.

Analysis and classification of satellite imagery indicated that the region's agricultural sector is heavily dependent on rainfall and supplemented by groundwater. Groundnuts, planted in the monsoon months, are almost exclusively rain-fed, while wheat, a winter crop, is supplemented by irrigation using groundwater. The region lacks alternate sources of water for irrigation. A depleted groundwater table and the high costs associated with building and operating irrigation infrastructure means that the region will face these challenges into the foreseeable future.[14]

The integrated forms of information generated by the two projects had to be communicated to the farmers in a useable form. A number of innovative approaches to communicate this information were used, including a community-based radio rural reality show. These communication approaches helped farmers in the region to take pragmatic steps to adapt agriculture practices to changing climate conditions. More than 280 farmers adopted adaptation measures such as sprinkler- and drip-based irrigation, drought tolerant crop varieties, rainwater conservation through the construction of small-scale structures like storage tanks, and raised-bed sowing as a direct result of the information communicated by the project.[15]

Development Alternatives also found that farmers needed a range of socioeconomic information—such as up-to-date market data—to make decisions about planting and harvesting crops that can help decrease their vulnerability to climate change. The Development Alternatives project teams found it easier to convince the farmers to adopt an adaptation option if they could provide compelling information that supported the intervention. For example, when the farmers realized that droughts will keep recurring and might in fact increase in frequency, they were more inclined to adopt efficient water management practices.

BARRIERS TO INFORMATION USE

Development Alternatives faced a number of barriers in the use and communication of information to support adaptation decision making during their projects. We describe these barriers in the following subsections.

Limited data availability and unreliable data quality hindered on-the-ground interventions that Development Alternatives could recommend to farming communities.

Technical Barriers to Information Use in Decision Making

In India, data related to climatic variables are available only for a single point within a district, making it difficult to provide localized information to farmers. Using this information to validate downscaled climate projections for the entire district could provide non-representative results. Even downscaled temperature-rise projections are currently only available at spatial resolutions that consist of two to three districts.

Limited data availability and unreliable data quality hindered on-the-ground interventions that Development Alternatives could recommend to farming communities. Adaptation strategies like altering sowing dates of crops, which could have produced high returns on investment by communities, were not always recommended because the potential for failure can be significantly higher when information is deficient and only available at coarse resolutions.

Beyond the availability of data, there is an inherent uncertainty linked with climatic model predictions. For example, a recent research study published in *Nature*[16] reported that the estimates generated by models such as CERES may underestimate the decline in yields of wheat crops by as much as 50 percent. Agricultural practices are highly site-specific and tend to change from village to village in Bundelkhand. The success of these differing agriculture practices depends on multiple factors, making it difficult to generalize observations and adaptation options across the region. To overcome this barrier, Development Alternatives organized demonstration trials in various villages within the project area. These trials helped scale up the various interventions across all of the 20 villages in the project. Development Alternatives also sought to provide flexible and "low-regret" options. An example was the promotion of crops such as millets (*Sorghum bicolor*), which require less water for cultivation and are traditionally grown in the region. Even in the absence of climate change, increased cultivation of millet could be beneficial given Bundelkhand's propensity to drought.

In many instances, the application and availability of integrated information required communities to act together to implement the recommended adaptation practices.

Institutional Barriers to Information Use in Decision Making

In India, the institutions responsible for declaring drought and flood events are different from those that generate hydrological and climatic information. Data generated by the latter is often not in a form readily usable by the former. For example, hydrological and climatic data provided for the Bundelkhand region by the Indian Institute of Technology, Delhi, and the Indian Institute of Tropical Meteorology, respectively, do not indicate which years experienced flood or drought, phenomena only the Indian Meteorological Department can declare. This institutional division is problematic because the government and civil society need to wait for data interpretation from a second set of institutions before they can begin adaptation action. Flood or drought declarations enable the release of state or federal relief funds. The declaration of floods or droughts tends to be politically motivated. Politicians may use the announcement or acknowledgement of natural calamities to influence voters.[17] The reasoning for maintaining two separate set of institutions is thus more political than functional. People making adaptive decisions must handle a multiplicity of information sources. This process is time consuming and complex, especially since the end-users of this information are most likely rural farming communities. As we indicated earlier, Development Alternatives organized a multidisciplinary team of experts to assimilate and communicate relevant information. This interface capacity was important to facilitate the exchange of information.

Communication Barriers to Information Use in Adaptation Decision Making

Rural farmers in the project understood variations in weather had more difficulty understanding the idea of longer-term changes in the climate. The project teams thus used innovative media such as a community radio rural reality show to enhance awareness of the impacts of climate change and of ways to prepare for and respond to it.[18]

To gauge the effectiveness of such outreach, Development Alternatives carried out an analysis showing that adopting drought-resistant varieties increased wheat crop yield by 10 percent, and using sprinkler-based irrigation in place of flood irrigation reduced water usage by 30 percent.[19]

In many instances, the application and availability of integrated information required communities to act together to implement the recommended adaptation practices. For example, many of the adaptation practices identified are capital intensive and therefore more affordable if communities share the burden. Reaching consensus proved difficult, however, given the fragmented nature of local communities based on caste and other social groupings. In such instances, the use of communication tools such as community radio, street plays, and wall paintings proved useful[20] in inducing behavior change. Though the reach of community radio is large, the project found that street plays, performed in the local dialect, were the most engaging and effective use of communication.

CONCLUSIONS

The multiplicity of information sources and the complexity of processing and communicating this information to farmers were hallmarks of the case study described here. The project played a critical "interface" role in bridging information across the gap between scientists, planners, and farmers. This role entailed the following functions:

- generating usable information,
- validating information and effective adaptation options,
- disseminating information using innovative means,
- facilitating knowledge exchange among the various stakeholders to spark cooperation and effective policy formulation, and
- building the capacity of stakeholders through demonstration and farmer clubs.

As more and more communities engage in climate adaptation, demand for these functions is likely to grow. In places such as Bundelkhand, organizations with these capacities are already working to decrease vulnerability to climate change and help rural agricultural communities adapt. New investments by the government and donors are needed to strengthen and expand the ability of such existing institutions to integrate a wide range of information for climate change adaptation and translate this information into more decision-relevant forms. In places where such institutions are absent, the government and donors should consider creating entirely new organizations to fill this niche.

New investments by the government and donors are needed to strengthen and expand the ability of existing institutions to integrate a wide range of information for climate change adaptation.

ENDNOTES

1 Indian Council of Agricultural Research, *Vision 2030*), (2011, http://www.pdfsr.ernet.in/vision%202030-pdfsr.pdf.

2 Directorate of Economics and Statistics. *Agricultural Statistics at a Glance, 2011,* http://eands.dacnet.nic.in/latest_2006.htm.

3 *Inter-Ministerial Report on Drought Mitigation Strategies for Bundelkhand Region(*2008).

4 The Energy Resources Institute, *Coping with Global Change Vulnerability and Adaptation in Indian Agriculture* (2003), http://www.iisd.org/pdf/2004/climate_coping_global_change.pdf.

5 *Inter-Ministerial Report on Drought Mitigation Strategies for Bundelkhand Region*, 2008.

6 Ibid.

7 R. K. Jain, *Water for Food Security* (n.d.), http://www.google.co.in/rl?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CFsQFjAA&url=http%3A%2F%2Findiawaterweek.water.tallyfox.com%2Ffilefield-private%2Ffiles%2F9250%2Ffield_document_plus%2F5484&ei=WLSsT7HUDpCzrAfbt-jmAg&usg=AFQjCNFl_-SYzffSRdxjpEVFJHRQ3HQ_jA.

8 Development Alternatives, *Final Project Report of the Sustainable Civil Society Initiatives Project* (2011).

9 Development Alternatives, *Vulnerability Assessment and Adaptation Planning for Madhya Pradesh: Project Report, Indo UK Climate Change Research Program* (2012).

10 Three PRECIS simulations for A1B scenario were carried out at IITM, Pune, for the period 1961–2098, to generate an ensemble of future climate change scenarios for the Indian region. These simulations were made at 50 x 50 km horizontal resolution. Q14 ensemble from the 17-member Perturbed Physics Ensembles, based on Hadley Centre Coupled Model, used in the Quantifying Uncertainty in Model Predictions (QUMP) project, was used to drive the PRECIS models. These outputs are used in this analysis.

11 Environment Planning and Coordination Organization, *Madhya Pradesh State Action Plan on Climate Change* (2011), http://moef.nic.in/downloads/public-information/MP-SAPCC.pdf.

12 These results were obtained by running CROPGRO soybean and CERES wheat physiological models under A1B scenario for 2030. The choice of the models was largely driven by national research institutions and the work they had already completed to calibrate certain models once their projections have been checked against ground realities. More information can be found in Development Alternatives, *Vulnerability Assessment and Adaptation Planning for Madhya Pradesh.*

13 Indian Institute of Technology, Delhi, *Hydrological Information System (NATCOM),* gisserver.civil.iitd.ac.in/natcom/.

14 *Indo-UK Climate Change Vulnerability and Adaptation Research Programme,* http://ccindouk.wordpress.com/.

15 Development Alternatives, *Analysis Report of the Farmers Adaptation Cluster* (2012).

16 D. B. Lobell, A. Sibley, and J. I. Ortiz-Monasterio, “Extreme Heat Effects on Wheat Senescence in India,” *Nature, Climate Change* 2 (2012): 186–89.

17 On drought and flood declarations as very political acts, see, for example, http://www.dnaindia.com/mumbai/report_shiv-sena-doing-politics-over-drought-alleges-narayan-rane_1688209.

18 Development Alternatives, “World’s First Rural Reality Show on Climate Change Inspires Green Leaders” (2011), http://www.devalt.org/ruralrealityshow%20.aspx.

19 Development Alternatives, *Analysis Report of the Farmers Adaptation Cluster.*

20 Development Alternatives, *Final Project Report of the Sustainable Civil Society Initiatives Project.*

ENDNOTES FOR TABLE 1

a Raw data sets for various climatic parameters such as temperature, precipitation, humidity, solar insolation, and cloud cover were procured from the Indian Meteorological Department (IMD), Pune. Information regarding the future projections of likely climate scenarios for up to 2100 was provided by the Indian Institute of Tropical Meteorology (IITM), Pune. IITM also provided trends in observed precipitation from 1901 to 2005.

b Indian Institute of Technology, Delhi. Hydrological Information System (NATCOM), http://gisserver.civil.iitd.ac.in/natcom/.

c Climawater. Hydrological Modeling: Literature Review (2009), http://web.iitd.ac.in/~gosain/CLIMAWATER/Report/Climawater%20Hydrological%20Modelling-Literature%20Review1.pdf.

d Information regarding past, current, and future river water flows on a monthly basis was provided by the Civil Engineering Division of the Indian Institute of Technology, Delhi.

ABOUT THE AUTHORS

Mustafa Ali Khan is an Associate Manager at Development Alternatives
Contact: mustafa.climate@gmail.com

Anand Kumar is a Senior Programme Manager at Development Alternatives
Contact: akumar3@devalt.org

K. Vijaya Lakshmi is a Vice President at Development Alternatives
Contact: kvijayalakshmi@devalt.org

REVIEWERS

We thank the following reviewers who contributed to the development of this case study:

Anonymous reviewer

Suraje Dessai, University of Leeds

Liz Drake, United Kingdom
Department for International Development

Guy Howard, United Kingdom
Department for International Development

Bharath Jairaj, World Resources Institute

Brian Lipinksi, World Resources Institute

ABOUT DEVELOPMENT ALTERNATIVES

Ever since its inception in 1982, Development Alternatives (DA) has acted as a research and action organisation, designing and delivering eco-solutions for the poor and the marginalised.

With a deep understanding of the rural market and a strong presence in the Indian heartland, its existence has been a credible and visible one – nationally and internationally – in addressing poverty challenges in a climate-sensitive environment.

A pioneer in sustainable development and the first social enterprise in India, DA realised the necessity of establishing several associated organisations working toward distinct goals that converge on the unified ambition of regenerating the environment and creating large-scale sustainable livelihoods.

ABOUT WRI

The World Resources Institute (WRI) is a global environmental and development think tank that goes beyond research to create practical ways to protect the Earth and improve people's lives. We work with governments, companies, and civil society to build solutions to urgent environmental challenges. WRI's transformative ideas protect the Earth and promote development because sustainability is essential to meeting human needs and fulfilling human aspirations in the future.

WRI spurs progress by providing practical strategies for change and effective tools to implement them. We measure our success in the form of new policies, products, and practices that shift the ways governments work, companies operate, and people act.

We operate globally because today's problems know no boundaries. We are avid communicators because people everywhere are inspired by ideas, empowered by knowledge, and moved to change by greater understanding. We provide innovative paths to a sustainable planet through work that is accurate, fair, and independent.

WRI organizes its work around four key goals:

People & Ecosystems: Reverse rapid degradation of ecosystems and assure their capacity to provide humans with needed goods and services.

Governance: Empower people and strengthen institutions to foster environmentally sound and socially equitable decision-making.

Climate Protection: Protect the global climate system from further harm due to emissions of greenhouse gases and help humanity and the natural world adapt to unavoidable climate change.

Markets & Enterprise: Harness markets and enterprise to expand economic opportunity and protect the environment.

In all its policy research and work with institutions, WRI tries to build bridges between ideas and action, meshing the insights of scientific research, economic and institutional analyses, and practical experience with the need for open and participatory decision-making.

WORLD
RESOURCES
INSTITUTE

10 G STREET NE
SUITE 800
WASHINGTON, DC 20002, USA
+1 (202) 729-7600
WWW.WRI.ORG