Towards a Natural Disaster Risk Management System for Food Security in Africa

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ABSTRACT:

Climate and Disaster Risk Solutions (UN World Food Programme) focuses on quantifying and monitoring weather-related food security risk in Africa. One of its principal products is *RiskView,* a software platfor
m that translates real-time and historical weather data as well as other spatial information into current and potential food security needs and operational response costs, generating information that can help the disaster aid community respond to weather shocks more efficiently. Using this information to initiate timely and appropriate responses could protect lives and livelihoods and mitigate the humanitarian and developmental impact of weather hazards. The objective of *RiskView* is to combine the most applicable operational remote-sensing and spatial information science available together with methodologies for assessing vulnerability and tools for visualizing the data to aid decision makers. Its uniqueness lies not in the models used, which have already been developed by experts in their own fields, but in its interdisciplinary approach and the interconnection of data, models and approaches for a better understanding of natural disasters to support timely and efficient responses.

1. BACKGROUND

The United Nations World Food Programme (WFP) is responsible for three-quarters of the world's emergency food assistance. Two-thirds of all emergency food aid is delivered to Africa and approximately half of WFP's expenditures are a result of weather-related causes, predominantly drought (WFP, 2008). With the support of the Rockefeller Foundation, a project within WFP is exploring new ways of understanding and managing weather risks that affect food security in developing countries with the aim to assist African nations in managing natural disaster risk for vulnerable populations.

In particular, the project, called Climate and Disaster Risk Solutions, has been working on ways to improve the current system of financing emergency responses in Africa with a view to future climate change, focusing on modeling the potential financing requirements of weather-related food security risks. The basic premise of the work is that improvements in the emergency response system – meaning improvement in the reliability, timeliness, sufficiency and appropriateness of responses – have to go hand in hand with improvements in the efficiency and timeliness of financing those responses (Syroka and Wilcox, 2006). To this extent the project is creating two main products: a standard-setting methodology that translates satellite-based information into operational drought responses costs estimates and, based on this methodology, *RiskView* a software platform that organizes the datasets used, runs the algorithms involved and produces outputs in a user-friendly format for decision makers to use operationally. From the project's point of view the aim of the tool is to aggregate cost estimates for sub-Saharan Africa weather-related emergency responses (at first sub-national, country, region and continental level) for historical years, so that financial preparations for potential shocks could be made in advance of a risk season or budgeted year, and also in real time, so that emerging problems and their magnitude can be monitored and managed from a funding point of view in order to deliver timely, equitable and appropriate responses to extreme weather events.

However the outputs produced have broader applications than solely the funding aspects of disaster responses. The steps involved to create *RiskView*, a work in progress, combine four well-established disciplines: crop monitoring and early warning; vulnerability assessment and mapping; humanitarian operational response; and financial planning and risk management to help decision makers and managers make better high-level decisions on where weather-related food security risk is and how it can be best managed.

As a fund management tool, *RiskView* will assist decision-makers in fundraising, assessing financial preparedness as well as making effective and equitable resource allocation decisions in the event of a natural disaster. As a risk management tool, governments and their partners could use the information generated to assess their own national weather-risk profiles and their capacity and potential strategies to manage natural disasters. This paper gives an overview of the *RiskView* platform, its technical components and refinements for future versions as the tool evolves. It concludes with potential applications for the greater humanitarian assistance and development community.

2. METHODOLOGICAL APPROACH

2.1 Introduction

Weather-related food security risk in Africa is predominantly related to drought, but also flood risk and, in the areas of Madagascar and Mozambique, cyclone risk, which together, significantly affect food availability, through impacting food production for consumption directly, and, to a lesser extent, food access and utilization of vulnerable populations. The basic data building blocks required to quantify this risk in Africa are: firstly, weather-based spatial indicators that are meaningful for food security; secondly, spatial vulnerability data on where and how many people are vulnerable to weather shocks; and finally information on current operational response costs for a range of potential and appropriate responses to assist vulnerable populations in need of assistance if an adverse weather shock occurs. *RiskView* absorbs, prioritizes and interprets these three different types of data through a process that defines how these information pieces interact in a consistent and standard way across sub-Saharan Africa, as described below.

The weather data and remote sensing products such as rainfall estimates and vegetation data – the driving, primary variables of this approach – are updated every ten days and fed into the software for each of the 261,135 satellite pixels (or squares of about 100 km^2 near the equator) covering Africa, to be converted into meaningful indicators for rain-fed agricultural production for the vulnerable populations who depend on rainfall for crops and rangeland. Food security risk profiles of the underlying populations are used to convert these weather indicators into estimates of how many people may have been affected by a given shock and the appropriate emergency response. Information about current commitments and costs provide an estimate of WFP's potential operational costs in current dollar terms. Historical records on operational responses can be used to ground-truth and refine the assumptions made to estimate affected population numbers and therefore potential response costs given today's conditions.

To give decision-makers the information necessary to prepare for and manage the risk portfolio financially *RiskView* aggregates these costs over all African countries where emergency assistance may be needed into a "portfolio" to project expected costs for an agricultural season and across all risk seasons within the year. It also allows users to monitor how risks evolve during a season and over the year across the continent in near-real time.

An important principle of *RiskView* is its transparency. Every detail and assumption, whether presented in maps or graphs can be traced back by the user to the original data and models. Wherever there may be a question of accuracy, the user should have the possibility to find out why, "drilling down" from cost estimates, to number of estimated people in need, to crop data and ultimately to rainfall estimates. The philosophy of the project is also not to recreate existing work, but to leverage proven technologies from each discipline the tool draws upon, therefore the project is closely liaising with experts and the knowledge base they have developed, such as the Food and Agriculture Organization (FAO), the Famine Early Warning Systems Network FEWS NET) and their technical partners the United States Geological Survey and WFP's Vulnerability, Assessment and Mapping (VAM) unit to use their existing data, tools and methodologies, to ensure the overall approach is consistent and in line with the greater early warning and disaster assistance community's practices and products. Finally, the methodology and the data used within *RiskView* is flexible to allow for improvements in all inputs provided from each discipline as long as the input data or methods can be used operationally (as defined in the following section). In this vain the tool is a work in progress that can be continually refined and improved as technology and our understanding evolves.

2.2 Rainfall Estimates

In rural areas across Africa, the most vulnerable populations depend on rain-fed crops and rangeland (for livestock). Though numerous repositories of information about weather data and trends in Africa exist, *RiskView* uses datasets that satisfy the following criteria, so that the tool can be used operationally:

- Datasets that are updated on a regular basis. For satellite images, at least once per dekad (10-day period), but preferably more often. For example, receiving the data with more frequency enables the recovery of Normalized Difference Vegetation Index (NDVI) images with cloud cover and other atmospheric disturbances. For rainfall and evapotranspiration estimates, once per dekad (i.e. every 10 days) is acceptable.
- Data that are available in real-time. The data should ideally be available a few days after the end of the dekad they cover. Datasets with a slightly higher accuracy (such as the US National Oceanic and Atmospheric Administration's (NOAA) African Rainfall Climatology, ARC), but made available on a yearly basis, are interesting for studying climate change for example and other non-real-time activities based on the *RiskView* software.
- Data must be provided in a usable form (either point, vector or raster data). For the project's purposes, data are converted to raster data into pixels of 0.1 by 0.1 degrees.
- Information must be uniform (based on one model) and cover the entire continent. Consistent historical data must also be available in order to complete a thorough actuarial understanding of the risk the data represents.
- Data must in principle be free of charge to users. This will potentially make *RiskView* a sustainable system for developing countries.

RiskView enables the use of different dataset alternatives for the same parameter in order to fill gaps in other datasets. This principle is called dataset priority. If data are not available for a certain dataset, then the second best (from a *RiskView* standpoint) is used. In this way continuous records are produced. Through experimentation it was established that for rainfall estimates (RFE), the software ranks RFE1 (1995 to 2000) and RFE2 (2000 to present) as the preferred datasets, both of which are available from the US National Oceanic and Atmospheric Administration (NOAA).

RFE 1.0 (RFE1) 10-Day Africa rainfall estimates were produced for 1995-2000 by the United States Climate Prediction Center of NOAA and are still used as the base of FEWS NET's African early warning products. Estimates were created by combining satellite-derived temperature data[·] and rain gauge measurements, corrected with wind, relative humidity and orography, for the estimation of accumulated 10-day rainfall totals for the African domain (20W-55E, 40S-20N) with a 0.1 degree, approximately 10 km, resolution. The production RFE1 was discontinued in 2000 and replaced by the RFE2 rainfall estimates produced by the same organization. RFE 2.0 (RFE2) uses additional techniques to better estimate precipitation while continuing the use of cold cloud duration (derived from cloud top temperature), and station rainfall data and is produced every 10 days. A full technical description of the RFE products, how they are created and their input data sources can be found in Herman et al. (2006) and Laws et al.

[·] Satellite-derived temperature data is used to measure the duration of cold cloud tops over a region for the determination of accumulated rainfall (3mm of precipitation for each hour that cloud top temperatures are measured to be less than 235 K, see Arkin, P. and Meisner, B. "The Relationship between Large-Scale Convective Rainfall and Cold Cloud over the Western Hemisphere during 1982-84," *American Meteorological Society Monthly Weather Review Vol. 115, Issue 1.* Pp 51-74 (1987).)

(2004).

RFE1 and RFE2 enable a continuous record from 1995. The complete RFE1 archive until December 1999 and the RFE2 rainfall archive from December 1999 to present are preloaded into *RiskView*. New images produced every ten days can be downloaded via the internet at no cost. Efforts are under way at NOAA to potentially extend some of the rainfall estimate (RFE) products, already within in *RiskView* for 1995-2008, back for the period 1983-1995. *RiskView* will incorporate these products when they are ready. Other techniques could also be used to extrapolate the information that exists for 1995-2009 back in time, using various statistical and regression methods, such as Satellite Enhanced Data Interpolation (SEDI) (Hoefsloot, 1999), to blend ground station weather data, which tend to have longer historical records, together with, or to use in some other way, other spatial or gridded products (such as NDVI for example) that exist for longer time periods.

It should be noted that *RiskView* is open to all input rainfall and other weather-related data such as potential evapotranspiration (PET). This creates flexibility and room for improvement and the opportunity to replace the historical data within *RiskView* with hypothetical weather scenarios, for example from regional climate models used to create weather data of simulated future climates, in order to understand – all other held variables constant – the potential humanitarian and financial impact of climate change on food insecure populations in Africa.

***RiskView* Functionalities**

For technical specialists:

- Weather station data can be blended with gridded products (e.g. RFE1/2, NDVI) using a Satellite Enhanced Data Interpolation (SEDI) method to create a potentially superior gridded product.
- Using GIS masks, *RiskView* can aggregate rainfall over any given geographic area (e.g. administrative unit, river basin) over any period and export the information to Microsoft Excel.
- The software allows users to update weather-related datasets over the internet. Converting these data into *RiskView* format gives users the flexibility to stress the data in different ways or export it to MSExcel or GIS for other types of study.
- *RiskView* can create a visualization of rainfall data history by satellite pixel and accumulated over a given period on a map. It also produces graphs for each pixel and crop to allow users to compare current rainfall or water balance values with the average for that pixel over the historical record available in that dataset.

For fund managers:

- *RiskView* can be used to target on-the-ground needs assessments or mobilization of resources.
- *RiskView* allows for real-time monitoring of potential operational costs of assistance as a season progresses, and in the future, will offer refinements of these cost estimates based on seasonal forecasts.

2.3 Crop Data

In order to assess food deficit or surplus, one must first understand how staple food crops grown across Africa such as maize, sorghum and millet interact with the weather over an agricultural season. To date the *RiskView* software focuses only on drought risk – the predominant and most systemic weather risk for food security on the continent, however methods for flood and cyclone risk will are forthcoming in the project timeline. Measuring total rainfall at the end of a season has proven to be too crude an indicator of potential stress of deficit rainfall on production and therefore to livelihoods. A simple water balance model developed by the Food and Agriculture Organization (FAO), which compares the amount of water available throughout the season to how much a plant needs in its different stages of growth, has been shown to relate better to crop yields (Frere and Popov, 1986). Using this simple and transparent crop model, *RiskView* estimates water available to a plant from the soil (through rainfall received and water withdrawn through the plant's natural usage of water and evaporation) and then compares the water available in a given dekad with how much the plant needs during that same dekad. The output of this water balance calculation is the Water Requirement Satisfaction Index (WRSI) for rain-fed crops and rangeland. More specifically, WRSI is defined as the ratio of seasonal actual evapotranspiration experienced by a crop to the crop's seasonal water requirement. It is a meaningful indicator of how a shortage of rainfall will impact yields and availability of pasture by monitoring water deficits throughout the growing season, taking into account the phonological stages of a crop's evolution and the periods when water is most critical to growth (Frere and Popov, 1986).

FEWS NET in Africa, the Joint Research Centre of the European Commission (JRC) worldwide, and FAO for Africa and Asia through their own software, *AgroMetShell* (Mukhala and Hoefsloot, 2004) and subsequent tools, all use the same basic methodology for calculating WRSI and consider the index a meaningful indicator for their similar purposes. FAO-produced Soil Water Holding Capacity (WHC) map (FAO/UNESCO, 1988) and crop coefficients (Kc) that reflect how much water a plant needs at different stages of its growth (FAO, 1998), as well as FEWS NET's cropping calendars and crop masks delineating agricultural production areas from their WRSI-based drought early warning product are all be pre-loaded into *RiskView* to calculate the WRSI for staple crops. In some cases adjustments to these inputs have been made to fine turn the parameters to WFP's purposes (e.g. sowing windows, length of growing periods of staple crops).

RiskView calculates the water balance for every pixel using the same WRSI algorithm as used within the *AgroMetShell* software. This amounts to approximately 260,000 calculations for all of Africa, each dekad. WRSI is calculated throughout the season as a crop gradually reaches maturity. During a season the projected end-of-season WRSI is calculated by using normal rainfall for the remainder of the season or by using each of the historical rainfall seasons available to finish the current season so that the potential uncertainty, or spread, in the final WRSI value in a pixel at the end of the growing period can be observed. Furthermore, these historical seasons can be adjusted by available probabilistic seasonal forecasts to reflect the information they contain in the spread of potential end-of-season WRSI values. Working together with experts in seasonal forecasting such a feature will be implemented in *RiskView* in future versions of the tool. Thus, the model is forward-looking and can be used as a powerful early warning tool. Thus, with a small set of transparent and widely available input data – rainfall, evapotranspiration, soil data and crop data – *RiskView* can track weather impacts on overall production for major crops and pasture in every pixel, in near real-time.

Studies conducted by FAO and others show that WRSI can be related to crop production using a linear yield-reduction function specific to the crop in question (FAO, 1986). WRSI can also be used to monitor forage and pasture for pastoral areas, however to date only agricultural producing regions of the continent that fall within the masked areas, are considered. Rangeland areas will be included in forthcoming versions of the software. However it is important to note that the index is best used on a relative basis, comparing any given year's rainfall as it pertains to WRSI to another year, to the average or another baseline. This is much more useful in the context of translating weather impacts on the food security of vulnerable populations than generating absolute national production estimates for a country with limited data, as often the case in Africa, to enable a thorough calibration of the model to predict absolute yields and therefore absolute production correctly. Food insecurity is also not necessarily related to absolute national production, but rather to the shocks households experience relative to a baseline to which they have adapted their income and consumption strategies.

2.4 Vulnerability

The next step in the construction of a weather-risk portfolio requires an understanding of how weather hazards interact with people vulnerable to food insecurity in order to convert information about the magnitude and spatial extent of weather shocks into number of people affected and the appropriate response. The food security status of any household or individual is determined by the interaction of a broad range of agro-environmental, socioeconomic, and biological factors. Like the concepts of health or social welfare, there is no single, direct measure of food security. However, the complexity of the food security problem can be simplified by focusing on three distinct, but interrelated dimensions of the concept: aggregated food availability, household food access and individual food utilization.

In this framework, exposure to risk is determined by the frequency and the severity of natural hazards, as well as the socioeconomic and geographic scope of those hazards. The determinants of coping capacity include household levels of natural, physical/economic and human assets, levels of household production, levels of income and consumption, and the ability of households to diversify their sources of income and consumption to effectively mitigate the effects of the risks that they face at any given moment.

WFP houses a repository of historical operations data, population studies, household surveys and other datasets to help answer these questions. The agency's VAM unit recently received a grant from the Bill and Melinda Gates Foundation to conduct Comprehensive Food Security Vulnerability Analyses (CFSVA) for many countries across sub-Saharan Africa. Through the CFSVA process, WFP will refine its vulnerability metrics for specific countries to determine more accurately who is at risk and why, how many people there are and where they live. *RiskView* overlays this information onto historical WRSI maps – and eventually maps of floods or cyclone paths – to estimate how historical weather events would have affected today's populations. The same process can be used for WRSI maps for the current season, to estimate the potential situations that are emerging and to be monitored as the rainfall season evolves.

Of all the steps in the *RiskView* calculations, the most challenging is defining how spatial indicators of drought and spatial population vulnerability data interact to estimate how many people have been potentially affected by an observed rainfall event. Little precedent exists in this newly emerging cross-disciplinary field. Despite efforts such as the CFSVA project, household level information on incomes, assets and coping strategies of populations are still sparse even in well studied countries and missing over many parts of the continent. Other critical pieces of information, in particular those regarding food access and utilization – i.e. information on market prices and health status – are unavailable or irregularly and infrequently collected and reported to be used operationally. In addition, information about cash crops and other weather sensitive household activities is also poorly detailed. Even population data may be inaccurate in some areas, although several proxy dataset exist to provide placeholder population density data for the whole continent[*].

Hence large assumptions have to be made in order to develop a standardized approach for estimating food insecurity across the continent. With these limitations is mind, *RiskView* stays at an aggregate level when producing population affected estimates. It must be stressed the tool is not being developed to replace on-the-ground needs assessments, but to provide high-level cost estimates for *ex ante* financial planning purposes and to potentially allocate immediate resources to disasters, addressing initial financial liquidity constraints to enable early responses, before on-the-ground needs assessments detailing the extent of the disaster are conducted. Although WRSI calculations and rainfall data can be viewed at the pixel level, estimates of needs are reported at the first administrative level of each country and above, or at the stratum level to which CFSVA data on vulnerability in a given country is aggregated (which often coincides with the first administrative level). The population within each stratum is divided into various drought risk categories determined according to considerations on two dimensions: exposure and resiliency. Exposure to drought risk is defined by the percentage agricultural activities (in terms of production, casual labour and, for the extreme drought categories, livestock) represent within a household's total annual income. Those with a larger percentage are considered to be more vulnerable to drought. Resiliency is measured in terms of a household's distance from the poverty line, those further above the poverty line have a greater capacity to cope with a drought shock than those closer to or below the poverty line.

CFVSA data is used where available to determine where households within a given unit fall on the exposure-resiliency matrix. Dataset from other surveys and other information sources are used where CFSVA surveys have not been conducted. Where no survey or information on household income and assets exist, proxy data indicators are used to estimate the key parameters required to classify the population according to the outlined criteria. This placeholder data will be used within *RiskView* until better information is found or collected.

For each administrative unit or vulnerability stratum considered, the WRSI is processed to produce an average WRSI value for the unit. Work is currently ongoing to determine which processing technique should be used to give

[*] *RiskView* uses the LandScan dataset developed as part of the Oak Ridge National Laboratory (ORNL) Global Population Project.

the most accurate and robust results. Tested approaches included weighting the WRSI by cropping intensity and/or population density layers, or by considering only pixels which coincide with cropping areas indicated in various remotely sensed agricultural data layers. Currently a weighting approach is implemented into *RiskView* using a FAO cropping intensity mask which provides information consistently for the entire continent as the primary weighting source, however work is ongoing to check the accuracy of this layer and the results it produces.

Once an average WRSI value for the administrative unit is calculated, WRSI trigger levels expressed as percentages below the median WRSI value for that unit, are defined denoting increasing severity of drought. These are applied to the weighted WRSI data such that whenever a weighted WRSI value falls below each of the trigger levels an increasing number of people vulnerable to that drought category within the unit are counted as potentially affected and may be experiencing food security stress. The trigger levels are set to reflect varying degrees of agricultural income loss, meaning as the drought intensifies and WRSI decreases, progressively more of the population begins to experience some kind of livelihood and therefore food security impact. Note, while still a work in progress, the methodology is not ultimately aiming to predict the number of people in actual need of assistance, which is assumed to be a subset of this group that may be experiencing food security stress, but to give high-level indicators pertaining to the nature of the drought shock observed using the information that is readily available. Identifying these individuals would have to be carried out by an on-the-ground needs assessment.

These calculations are carried out within *RiskView* and each of the input parameters, e.g. administrative unit populations, vulnerable profile breakdowns, WRSI trigger levels, can be edited directly within the software via a secure user interface, so that they can be adjusted as new and better information is reported by users with such permission. Early results from *RiskView*, correlate with planned needs estimates from historical WFP responses to drought in Africa to nearly 90% for the past decade for which reliable needs information exists within WFP's historical records. Therefore for the purposes of financial preparedness and management at the aggregate level the approach shows potential. Comparisons are also favorable against the Centre for Research on the Epidemiology of Disaster's Emergency Events Database, EM-DAT CRED.

One of the advantages of housing this work within WFP is access to its vast operational response dataset against which triggers and assumptions can be tested to ensure the methodology picks up past drought events and with the correct order of magnitude, taking into account changes in the underlying factors that impact populations and their vulnerability since those events. The methodology is simple, but given the complex context it is parsimonious to the current information available and can be applied systematically across the sub-Saharan continent to include all countries where basic economic and household data exists. Improving the approach depends on better, more detailed, higher resolution and consistent (in time and space) information on lives and livelihoods and other risk factors in Africa as well a better understanding of the complex interaction between climatic shocks, food production and a household's ultimate need of assistance.

2.5 Estimating Costs and Financial Risk

Once the number of people affected by a drought shock has been estimated and the appropriate food assistance response (e.g. food aid, cash vouchers) identified, *RiskView* can then estimate the potential operational costs for a given situation. For each emergency intervention for a particular country, WFP can determine the current cost of a response and these can be entered into *RiskView* through an input user interface. For example for food aid, the cost of procurement in dollars per metric ton (given current prices), shipping and delivery (given what may be in the pipeline and availability of donor commitments) of relief can be estimated in advance to covert affected population numbers into today's operational response cost terms. This approach allows portfolio costs to oscillate alongside prices and disaster situations.

For each country in the portfolio, *RiskView* uses historical weather data through the methodology outlined above for each vulnerability stratum above to determine a) the average cost of weather-related events in the country, given the estimated impact of past seasons on today's population with today's costs; b) estimated costs from each historical year that makes up this average and ; c) through the application of statistical techniques, the probable maximum cost (the largest cost that is expected to occur in 100 years) that can occur in the coming season. Within a season, as rainfall data is reported every ten days, a new cost estimate is calculated within the software using precisely the same algorithm and by using rainfall from each of the historical seasons to finish the remainder of current season so that the potential uncertainty, or spread, in the final cost estimate can be observed as the risk season progresses. Various visualization tools have developed within *RiskView*, mimicking tools used by financial initiations to manage financial positions, to present this pre-season and in-season data in a way that it is useful to operational practitioners.

Each country has different ways of responding to natural disasters including budget contingencies, cash reserves, strategic grain reserves, and, in some cases, risk transfer products like insurance or catastrophe bonds. The international community, through organizations like WFP, responds when national systems become overwhelmed. The extent of this gap that the humanitarian assistance community must fill and the amount of assistance requested by country governments will determine the final extent and cost of intervention for WFP. While each government could use this information to build a national risk profile and contingency financing strategy, there is a clear financial incentive to pool different types of weather risk across countries and regions. Within the atmospheric-ocean system, it is unlikely that extreme weather events will happen simultaneously or in the same year in every country. This diversification means risks do not accrue in an additive fashion, lowering the cumulative probable maximum costs of an annual portfolio of countries to a more manageable sum than the probable maximum cost of each country added together (Hess and Syroka, 2005). A preliminary analysis based only on *RiskView* indicates that pooling risk could cut the probable maximum cost significantly and the software allows users to aggregate and view the country level information in the same format but for a region or for the whole continent to enable this level of monitoring and management.

3. CONCLUSIONS

Although *RiskView*'s ultimate objective is to use weather data to inform the construction of a financial portfolio to better manage the financial aspects of responding to disasters, many of its functionalities and outputs clearly have other applications, such as emergency preparedness and contingency planning. It can help to target needs assessments and to carry out more thorough risk analyses. *RiskView* outputs for example could ultimately help with pre-positioning and sizing of food stocks for WFP as well as giving early estimates for additional future purchases so that these transactions can be made and managed as efficiently as possible. The outputs and functionalities of the tool are also relevant to organizations that focus on increased agricultural productivity in Africa or governments wishing to invest in agricultural productivity. *RiskView* outputs will contain information as to the spatial distribution of weather risk for crop production, areas most suited to crop production and areas most vulnerable to deficits. This information can guide planning and investment decisions focusing on increasing agricultural productivity and market development.

While *RiskView* quantifies potential costs with the best methodology that is suited to the data available. However as it is refined over forthcoming versions, there will always be technical and operational limitations to ex-ante risk assessments that could lead to imperfect indicators and risk estimates. The limitations, such as observing weather phenomena accurately over all parts of Africa, the uncertainties in converting this data into meaningful weather indicators and then into food security needs estimates that in reality needs can occur from a complex interaction of factors beyond those that can be captured by high-level weather-based indicators mean that traditional needs assessments will always be necessary. However the approach outlined above can provide powerful information to quantify risk *ex ante* at a high level to make preparations and help target and support early responses to ensure as efficient emergency response as possible before the total impact of risk is identified and assessed on the ground.

To ensure that this work will become part of a global public good, Climate and Disaster Risk Solutions methodology and software will be shared as a platform for development of the Climate Services Application Program and Climate Service Information System – both of which are components of the Global Framework proposed at the World Climate Conference (WCC-3) in Geneva in September 2009. The aim is to accelerate the process of risk identification and analysis for the disaster assistance community for the benefit of the world's most vulnerable. There are also plans to run a range of climate change stress tests for African food security using the *RiskView* software.

All aspects of the approach outlined above need to tested, refined and improved, from the input data used to the assumptions made. During the forthcoming seasons ground-truthing by WFP country offices and partners in the field will be critical to calibrate the tool as well as possible to situations on the ground and to guide further development. However better understanding the relationship between the weather variability and human vulnerability will need a concerted effort by the greater international disaster assistance, development and academic community. It is expected that climate change will significantly increase the risks faced by vulnerable populations. Therefore the aim of Climate and Disaster Risk Solutions is not only to work on these issues within WFP with country partners and expert institutions, but also to encourage others to continue to add to the body of knowledge and to grow this emerging field of study to demonstrate the powerful operational applications of investments in enhanced data collection, new data processing techniques and better understanding the human security dimension of natural disaster risk.

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