Intertemporal and geographic risk spreading[1]

Alessandra Giannini, Upmanu Lall, Brad Lyons, Megan McLaurin, Dan Osgood, Chet Ropeleski, Andy Robertson, Cal Turvey, Marts Vicarelli

Scaling up insurance programs both in space and time would expand risk-spreading opportunities at the insurance and reinsurance level. Spatial scale up would allow to pool together contracts from different areas with anticorrelated or non-correlated seasonal climate signals, thus reducing the cost of insurance programs. Scaling up in time translates into intertemporal risk spreading strategies using climate proxies and forecasts to design insurance (reinsurance) contracts in (between) regions with observed interannual climate variability patterns. By reducing potential losses over time, geographic and intertemporal risk spreading through insurance and reinsurance is potentially valuable for national (or regional) adaptation and mitigation planning to cope with climate variability and change.

At this stage, current precipitation-indexed insurance programs are exploring the use of climate proxies (e.g. ENSO indexes) however they do not actively use forecasts in their contract designs. However, interannual climate variability is an important component in modulating the rainfall regime in several regions of the world and the possible use of proxies and forecasts is receiving more and more attention. The available literature on the potential integration of seasonal forecasts in index-based weather insurance schemes is still very limited. Mjelde and Hill (1999) explored the farm value of ENSO-based forecasts in the context of common crop insurance contracts. Cabrera et al. (2006) studied the interactions between conventional crop insurance and ENSO-based climate information for increasing farm income stability in a hypothetical Florida farm, and concluded that for high risk-averse farmers the best insurance strategy depends on the ENSO phase. ENSO indexes have also been explored for use as proxies of extreme rainfall in one district of Peru` (Khalil et al., 2007). Index insurance for droughts are being applied to Millennium Village locations, as port of the Millennium Villages Project, providing results in a variety of agroecological and climatic zones in Africa.

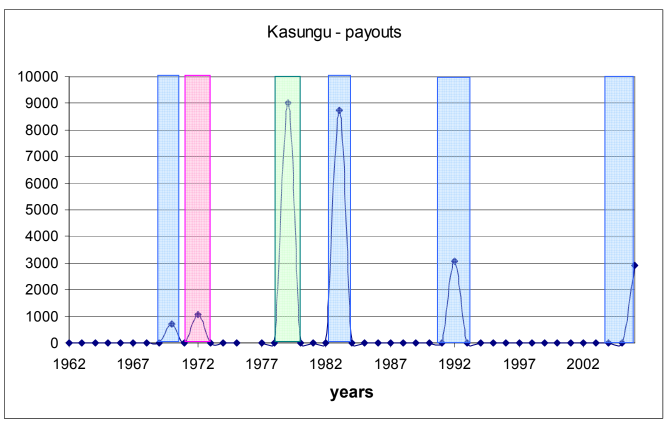
In collaboration with IIASA Risk and Vulnerability Group we developed an exploratory exercise to study the potential for integrating forecasts in indexed-insurance contracts for regions with opposite climate patterns. In our exercise we analyzed payouts associated to contracts for maize, with respect to ENSO index NIÑO 3.4, in Malawi, Kenya and Tanzania. ENSO signals, generated in the Pacific basin, are an important factor in determining inter-annual precipitation variability in Southern and Eastern Africa both directly via an atmospheric bridge – *atmospheric teleconnection* – (Glantz et al. 1991; Wallace et al. 1998) and indirectly, via the response of the Indian and the Atlantic Oceans (Klein et al. 1999; Alexander et al. 2002). Ropelewski and Halpert (1987, 1989) suggested two areas of ENSO related precipitation effects: equatorial eastern Africa (which includes Kenya and Tanzania) and south-eastern Africa (including Malawi). A

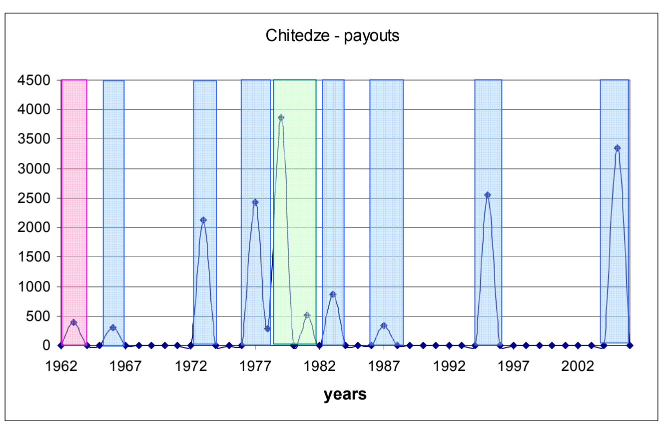
[1] We are very grateful to Chat Ropelewsky, Alessandra Giannini and Sarah Abdelrahim for their comments and contributions to this preliminary paper.

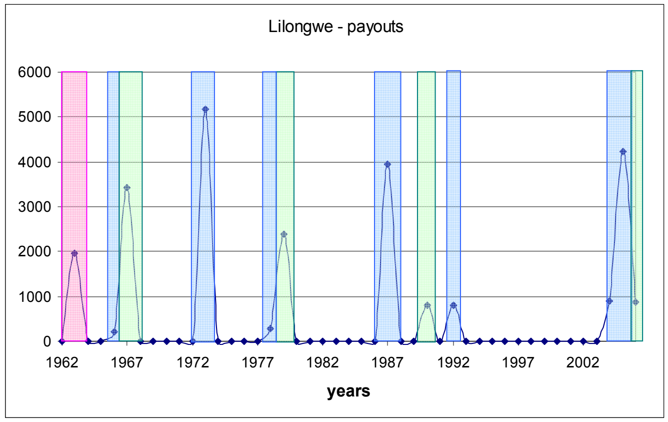
bipolar precipitation pattern is associated to these two regions: la Niña events are associated with dry climate in eastern Africa and wet climate in Southern Africa. In other words, la Niña phase (also called Cold Episode) increases the likelihood for stronger and more frequent storms in Southern Africa, and is thus associated with an increased probability for above normal rainfall in that season. During El Niño (or Warm Episode) the precipitation dipole is inverted (Ropelewski and Halpert, 1989).

As a first step of our experiment we simulated possible payouts using historical precipitations data and analyzed the differences between years with different ENSO states – from 1961 to 2005. The results obtained from historical precipitation data indicate that more abundant rainfalls reduce payouts and the risk of loan default during La Niña in Kenya and Malawi, during El Niño in Tanzania. Figure 1 helps to illustrate our simulation in the case of Malawi. The three graphs report the occurrence and estimated value of simulated payouts (vertical axis – the corresponding unit of measurement is the Malawi currency, Kwacha) over time (horizontal axis) for three villages: Kasungu, Lilongwe and Chitedze. The vertical colored bands indicate the ENSO state associated to each payout with pink, blue and green indicating respectively La Niña, El Niño and neutral years.

Fig 1. Occurrence of payouts (estimated in Malawi currency on the vertical axis) in three Malawi villages, for the period 1962-2005. The vertical colored bands indicate the ENSO state associated to each payout with pink, blue and green indicating respectively La Niña, El Niño and neutral years (Vicarelli, 2007).







As shown by the three graphs, in any of these villages in Malawi by far most payout years are associated with El Nino but not all El Nino years are payout years at any of the villages. In summary, of the 29 payouts for all of the villages in the study, 19 payouts were associated with el Nino, only, roughly, 1/3 as many (7) with neutral conditions and only 1/6 as many (3) with la Nina. Further, payouts are not just more frequent in association to El Nino but the estimated value is also higher. It is also interesting to observe that, despite the proximity between villages, not all payout years occur in association with the same El Nino years. Despite the short historical precipitation record, these results are quite interesting and deserve further analysis from an insurance perspective.

The relatively short precipitation time series available represents the major limitation of this preliminary simulation. So, as a second step, we chose to apply the Monte Carlo method in order to analyze the statistical distribution of payouts using a larger sample of precipitation data. More specifically, we modeled precipitations by a gamma distribution the parameters of which were deducted from the historical precipitations. Then, the Monte Carlo approach allowed us to extract large random samples from the precipitation distribution. Finally, we used the simulated precipitations distributions in each location to calculate the mean and variance of payouts associated to different ENSO states. The results of the Monte Carlo simulations confirm our preliminary findings for Kenya and Tanzania but they are more ambiguous for Malawi (Vicarelli, 2007).

This exploratory study illustrates that despite the technical constraints associated to up-scaling over different regions and over multiple time periods (e.g. taking into considerations interannual climate variability and forecasts) new opportunities emerge.

Let's focus first on the challenges to be faced. A first group of constraints includes limitations related to climate data, simulations and forecasts: (i) larger scales and the use of climate proxies translate into the necessity for reliable climate data distributed over large areas. However, sparse stations and short data series (especially in developing countries) can compromise reliability of rainfall measures. This is an intrinsic limitation in the simulation of rainfall distributions in both space and time; (ii) spatial and temporal scale up is not feasible for heterogeneous regions characterized by several microclimates; (iii) scaling up insurance contracts in time up to 10-30 years allows integrating climate variability in the insurance/reinsurance design, however, the uncertainty related to seasonal forecasts could be a limitation to insurance planning; (iv) longer timescales also require taking into account precipitation and temperature trends associated to our changing climate. However, disagreement between models in simulating local trends represents a further source of uncertainty in insurance planning and contract design; (v) even when the climate data is satisfactory and the forecast is solid, the very timing of the forecast might not be compatible (thus useful) with respect to the agricultural calendars, planning decisions, and thus with the insurance contract calendar.

The second group of limitations is related to the existing economic and institutional framework especially in developing countries where index-insurance projects are currently under implementation. (i) Local commercial banks are not always able to participate as source of funding for large scale microfinance or microinsurance programs (volatility, illiquidity of local currencies). (ii) Linking micro-insurance contracts in different countries in an effort to spread risk geographically might not be feasible because of different currencies in use and/or regulatory systems. Moreover, the very risk of political instability, especially in developing nations, is a further major constraint in the implementation of insurance programs. (iii) Last but not least, institutional mediators for "regional risk-sharing" planning are still missing in the international framework. Another challenge is certainly represented by cultural differences in attitudes towards risk for different peoples when designing and harmonizing risk management strategies at large geographic scales.

Besides these challenges new opportunities for innovative tools and strategies emerge, representing also new directions for research. From a technical point of view, by scaling up insurance programs, the use of climate proxies and remote sensing, for both rainfall and vegetation, might help to overcome the problems related to sparse stations and short data series. The use and applications of such tools is just at a pioneering stage and needs to be refined. From a strategic planning and institutional point of view: (i) while shorter time scale and local spatial scale are difficult to model, timescales of 10-30 years over large areas are more relevant for mitigation planning at a regional level and could increase the ability of insurance markets to intertemporally diversify risk; (ii) geographic and intertemporal risk spreading might translate into a scaling up of the institutions involved; national governments could emerge as public partners of the insurance sector in developing regional strategies to reduce risk exposure; (iii) forms of regional cooperation between neighboring nations could also take shape in an effort to maximize risk spreading; (iv) and finally from a regulatory perspective, new challenges but also new opportunities for micro-insurance regulation and supervision institutions would arise.

References

Cabrera, V.E., Fraisse, C.W., Letson, D., Podestá, G. and Novak, J. (2006). Impact of climate information on reducing farm risk by optimizing crop insurance strategy. *Transactions of the American Society of Agricultural and Biophysical Engineers* 49 (4): 1223-1233.

Glantz, M. H., Katz, R. W. and Nicholls, N. 1991: Teleconnections linking worldwide climate anomalies. Cambridge University Press, 535 pp.

Klein, S. A., Soden, B. and Lau, N.-C. 1999: Remote sea surface temperature variations during ENSO: evidence for a tropical atmospheric bridge. *Journal of Climate*, **12**, 917–932.

Khalil, A. F., H.-H. Kwon, U. Lall, M. J. Miranda, and J. Skees (2007), El Niño–Southern Oscillation–based index insurance for floods: Statistical risk analyses and application to Peru, Water Resour. Res., 43, W10416, doi:10.1029/2006WR005281. http://www.agu.org/pubs/crossref/2007/2006WR005281.shtml

Mjelde, J.W. and Hill, H.S.J. (1999). The effect of the use of improved climate forecasts on variable costs, input usage, and production. *Agricultural Systems* 60 (3): 213- 225.

Ropelewski, C. F., and M. S. Halpert. 1987. 'Global and regional scale precipitation patterns associated with the El Niño Southern Oscillation.' *Monthly Weather Review* 115 pp. 1606-1626.

Ropelewski, C. F., and M. S. Halpert. 1989. 'Precipitation patterns associated with the high index phase of the Southern Oscillation.' *Journal of Climate* pp. 268-284.

Vicarelli, Marta. 2007: Integrating interannual climate variability forecasts into weather-indexed crop insurance: he case of Malawi, Kenya and Tanzania. *International Institute for Applied Systems Analysis (IIASA) - YSSP Report to the Risk and Vulnerability Group*.

Wallace, J. M., Rasmusson, E. M., Mitchell, T. P., Kousky, V. E., Sarachik, E. S. and von Storch, H. 1998: On the structure and evolution of ENSO-related climate variability in the tropical Pacific: lessons from TOGA. *J. Geophys. Res.*, **103(C7)**, 14241–14259.