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Equity in forecasting climate: can science save the world's poor?

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For the past ten years, the role of seasonal climate forecasting (SCF) in decreasing the vulnerability of poor populations in many countries to climate variability and change has been discussed in the scholarly literature and policy circles. This paper reviews the literature on climate forecasting information and explores three main equity implications of SCF use. First, while investment in SCF as a decision-support tool has been justified in social terms, many examples of application show that the most vulnerable are unable to benefit from SCF information and may be harmed by it. Second, the usability of SCF as a decision-making tool has been constrained by accessibility and communication issues. Third, there may be opportunity costs in the sense that focus on SCF displaces political, human and financial capital from other more effective alternatives for decreasing the vulnerability to disaster among the poor. This review argues that, without attention to specific mechanisms to counter pre-existing inequities, the distribution and use of SCF is not likely to ameliorate the conditions of those most in need.

BETWEEN 1979 AND 1983, a series of devastating climatic events, including severe drought in northeast (NE) Brazil and Australia, flooding in Peru and Ecuador and drought-related famine in southern Africa and India, revealed to the world the harmful effects of El Niño. Although this was not the first global devastation related to El Niño–Southern Oscillation (ENSO),[1] it was the first in which ENSO effects were widely publicized as an interconnected global phenomenon. The ENSO wreaks havoc on many tropical and subtropical regions of the world, disrupting normal patterns of rainfall to cause severe droughts and catastrophic flooding.

To make matters worse, many of the regions most hard hit by ENSO have populations in poverty, already living close to the margin for survival in a 'normal' year. In NE Brazil alone, the four-year drought caused by the 1983 El Niño affected 18 million *nordestinos*,[2] and in response, the Government spent an estimated US$1.8 billion on emergency programs (Magalhães *et al*, 1989: 334). More recently, a multi-year drought has had serious impacts on the livelihood of eastern African populations where pastoralists living close to the margin of poverty have been particularly affected in countries such as Kenya (Reliefweb, 2006).

In the mid-1980s, scientists interested in climate dynamics understood the mechanisms of the ENSO phenomenon well enough to be able to predict with some skill the onset of its warm (El Niño) or cool (La Niña) phase some several months to even a year in advance. Not surprisingly, the possibility that scientists might be able to forecast seasonal climate variations, and anticipate their negative consequences such as drought and flooding, captured the attention of policy-makers seeking to improve the livelihoods of those negatively affected by climate-driven hazards.

Because of ENSO's dominant impact on many vulnerable populations worldwide, research on, and application of, seasonal climate forecasting (SCF) has often been specifically justified in terms of their potential for improving the lot of those most in need (for example, see McPhaden *et al*, 2006). However,

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if the idea of positive societal impact enticed atmospheric scientists, climatologists and funding agencies to improve the science behind forecasting, early optimism has somewhat faded and many challenges remain (Harrison, 2005). The results of the application of the new technology have been mixed, not only in terms of effectiveness,[3] that is, how much SCF has been used successfully to deflect losses, but also in terms of equity, that is, how SCF use has actually benefited those most in need.

While there is considerable focus in the climate impacts and forecasting literature on theorizing about potential benefits and forecast value, especially how SCF application could improve the response to hazards in the short term (Magalhães *et al*, 1988; Glantz, 1996; Nelson *et al*, 2002; Pagano *et al*, 2002; Archer, 2003; Jacobs, 2003; Ziervogel and Calder, 2003; Keogh *et al*, 2004; Sayuti *et al*, 2004), there are relatively few examples of empirical studies evaluating actual forecast use to date. However, what is already available allows us not only to temper some of the more optimistic speculations of forecast value but also, more importantly, to learn from experience to increase opportunities for success.

In the case of SCF, we suggest it is particularly important to evaluate the equity implications of its application both because of its policy justifications and because failures can be especially devastating to those already living at the margin of survival. In this article, we review the literature focusing on the experiences and impacts of SCF and explore three main challenges that can negatively affect equity in its use.

First, while investment in SCF as a decision-support tool has been justified in social terms, that is, as a means to improve the lot of those most vulnerable to climatic variability, many of the examples of application reported in the literature show that this is not always the case. In fact, not only are the most vulnerable, in many cases, unable to benefit from SCF information but may be harmed by it. Here access to resources and to power influence the ability of different users to benefit from SCF use, and previous levels of underlying inequities and differential vulnerabilities also matter.

Second, the usability of SCF as a decision-making tool has been constrained by issues of communication and accessibility. Both the character of information (probabilistic) and its availability (the means of its release, communication and dissemination) shape its access by different groups. Factors such as levels of education, access to electronic media, such as the Internet, and to expert knowledge, critically affect the ability of different groups to take advantage of SCF as a decision tool. Unequal access to technical information can also create power imbalances that negatively affect decision-making processes using SCF. While the adoption of participatory processes of communication and dissemination seem to have a positive effect on the accessibility of SCF by low-income groups, these experiences have so far been limited.

Finally, because resources are spent on SCF projects as a potential solution to climate-related vulnerability, other policies that may be more effective may be precluded from being implemented. To date, the implications of the opportunity cost of the application of SCF are not well understood.

Despite these challenges, the literature also illustrates promising new ways of applying SCF that address equity issues more positively. We review several of these cases, and argue that, without attention to specific mechanisms to counter pre-existing inequities, the distribution and use of SCF is not likely to ameliorate the conditions of those most in need.

In the next sections, we discuss these issues in the light of empirical examples of SCF's application.[4] First, we examine the evolution of SCF as a decision-support tool and discuss its equity implications in the context of resource-poor and resource-rich policy arenas. We also review how institutional and resource constraints shape the ability of populations to rely on these tools over a longer time period. Then we explore how the issue of unequal access to information and barriers to communication affect equity in the application of SCF. Finally, we discuss the opportunity costs of SFC use. We conclude with suggestions for SCF application based on successful examples that might improve the equity of SFC as a decision-support tool.

Forecasting climate and accounting for equity

The ENSO is a well-defined coupled ocean–atmosphere system that influences a wide range of climate-related events around the globe. Although the patterns forming El Niño and their statistical associations with climate-related events have been known for some time, it was not until the late1980s that Zebiak and Cane put together the first model to simulate ENSO (Zebiak and Cane, 1987).[5] This auspicious beginning created great expectation that ENSO modeling and forecasting would quickly generate an array of application activities that could critically affect the ability of different users to mitigate the high risk associated with the effects of climate variability on different systems, especially on agriculture and water management. Funding agencies and forecast producers actively hailed the potential positive societal impact of SCF application, especially to resource poor segments of users whose livelihoods have been historically negatively affected by climate variability (Broad *et al*, 2002).

Advances in SCF over the past few decades have led to its application in experimental settings in many regions around the world. In these experiments, the expectation among SFC producers and policy-makers has been that, if forecasts were available and reasonably accurate, decision-makers at diverse scales and income levels could use advanced information about potential hazard in their planning. In such cases, rather than responding to the hazard reactively and poorly, forecast users could better prepare, recover and cope with its negative consequences.

For example, farmers could tailor their choice of crops and planting calendars to the likelihood of drought. Civil defense officials could adjust their budgets, human resources and disaster preparedness plans to the expectation of an incoming flood-prone rainy season. Water managers could plan water allocation and storage based on an expectation of less or more rainfall in coming months. While some level of loss due to climate variability stress will always be likely to occur, the goal has been to use SCF to aim for outcomes that would be at least comparable with, and hopefully better than, the situation before.

Yet, in contrast to many science-policy processes where policy-makers recruit science to solve specific problems (which by itself is no guarantee of success), the application of SCF has been as motivated by the progress of forecasting science as by the need to reduce risk. To a certain extent, the solution, rather than the problem, has framed the relationship between the production and dissemination of climate forecasting among different users. In consequence, many of the processes of climate forecast use so far documented suffer from "new technology blues" (Lemos *et al*, 2002), and the promise of utility and value of the forecast is constrained by both material and institutional factors ranging from lack of resources, to poor communication, to inequitable distribution of knowledge (Broad *et al*, 2002; Lemos *et al*, 2002; Patt and Gwata, 2002; Lemos, 2003; Rayner *et al*, 2005).

As mentioned above, one equity implication of SFC use has been its limitation in benefiting those most vulnerable to climate variability. In some cases, this vulnerability is critically shaped by

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unequal power and leverage in being able to respond effectively to climate information (Agrawala *et al*, 2001). In these situations, differential levels in the ability to respond can create winners and losers within the same policy context. For example, in Zimbabwe and NE Brazil, news of poor rainfall forecast for the planting season influences bank managers, who systematically deny credit, especially to poor farmers they perceive as high risk (Hammer *et al*, 2001; Lemos *et al*, 2002). In Peru, a forecast of El Niño and the prospect of a weak season gives fishing companies an incentive to accelerate seasonal layoffs of workers (Broad *et al*, 2002).

In each of these cases, some users, such as banks and businesses, benefited from SCFs, because they were able to anticipate some of the outcomes of a poor season ahead and protect themselves. However, the people dependent on them for credit or livelihoods lose.[6]

In other cases, even if access to information and resources is not a critical limitation, individuals or institutions can be constrained in responding effectively to SCF. In the United States, there are several well-documented cases of institutional limitations in responding to improved scientific predictions of stream flow, seasonal weather patterns, and climate in water management (Pulwarty and Redmond, 1997; Callahan *et al*, 1999; Jacobs, 2003; O'Connor *et al*, 2005; Rayner *et al*, 2005). For example, in their study of water managers in three US regions, Rayner *et al* (2005) found that, constrained by the high levels of accountability of their decision environment, water managers prefer to rely on their professional experience rather than on SCF to guide their management decisions. Just having better information available does not mean it can stimulate an improved response.

Among poor farmers in the global south, the general lack of alternatives, both in terms of technology and access to financial and human resources, acts as a critical constraint to their ability to use SCFs. Resource deficiencies among the most climate-vulnerable rain-fed farmers also curbs their ability to respond to forecasts even if they have access to them (Lemos *et al*, 2002). In Zimbabwe, for example, poor farmers' flexibility to adjust their planting to forecasted climate may be limited both because they have to purchase maize seeds before forecasts are released and because there is a low number of seed varieties available (Hammer *et al*, 2001; Patt and Gwata, 2002).

Access to seed is also a problem in NE Brazil, where a poor climate forecast may delay Government-sponsored seed distribution, because local officials wait for the first rains to avoid what they perceive is a 'waste' of seed if farmers plant too soon (Lemos *et al*, 2002; Jacobs, 2003; Lemos, 2003). In Burkina Faso, high levels of indebtedness among poor farmers and out-migration in search of wage labor in the mining sector constrain village farmers' ability to use SCF (Ingram *et al*, 2002).

The opposite situation is also true; for those that are already more resilient, or more resource-rich, SCFs have provided additional benefits in terms of improved ability to cope with hazards and disaster. Among rich agricultural systems, the benefits of SCF use are evident.

For example, in Australia, where forecast information is actively sought both by large agribusiness and Government policy-makers planning for drought, agricultural producers have been able to use SCFs to cope better with swings in their commodity production associated with drought (Hammer *et al*, 2001). One factor helping to explain this positive experience is that in Australia forecast producers' approach to the dissemination of SFCs included close interaction with farmers, use of climate scenarios to discuss the incoming rainfall season and automated dissemination of SCFs through the RAINMAN interactive software. Similarly, in Argentina, resource-rich farmers have been able to take advantage of available SCFs (Letson *et al*, 2001).

Significantly, most reported successes seem to be associated with the presence of resources that are usually not available to the most vulnerable groups — resources whose absence, often, defines their vulnerability to begin with. Thus many of the factors that make these successes possible, such as financial, social and human resources, are frequently out of reach of the poor, who lack education, money and time resources to engage forecast producers.

Yet, poverty and other vulnerabilities can be counteracted in the application of SCF, if attention is paid to maintaining alternative types of resources, such as sustained relationships with information providers or attention to the context of application. Even among farmers with fewer resources, access to climate information through sustained relationship with, and advice from, forecast and agricultural extension experts can result in positive experiences, such as in the case of small farmers in Tamil Nadu, India (Huda *et al*, 2004) and Zimbabwe (Patt and Gwata, 2002). In both cases, forecast 'brokers'[7] made considerable effort to sustain communication and provide expert knowledge to targeted farmers who were able to benefit from the use of SCF.

However, also in both cases, the number of farmers targeted was but a tiny fraction of those that might have needed, and benefited from, this kind of support. In addition, it is unclear whether, once the research project is finished, such interaction will be sustainable or how what has been learned can be 'scaled up' to benefit larger number of farmers in need. In any event, for these interactive approaches to succeed, participants usually have to have not only the financial resources to come to meetings or to access information through the media (at least through the radio) but also to be on the 'radar screen' of organizers of workshops, especially in the case of events where participation is limited. Often the poorest segments of the population lack all these resources.

What we learn from these examples is that underlying inequities and differential vulnerabilities in many cases may impede the ability of SCF alone to alleviate negative climate-related outcomes for some vulnerable groups. Success stories seem to depend largely on the resources available to deploy SFC, both in rich and poor agri-economic systems; whenever adequate resources to customize and use forecasts are present, benefits are more likely to accrue. In contrast, when pre-existing conditions are inequitable and without specific counteracting measures, the application of SFC may exacerbate negative conditions for those who are most vulnerable (see also Woodhouse and Sarewitz, 2007: in this issue).

Impact of inequality on equity

One of the fundamental problems often not anticipated by researchers and producers of SCF is that there is great disparity in the ability of potential users to access information (Agrawala *et al*, 2001). Beyond being available, information has to be accessible, that is, users must be able to understand it in order to use it. For example, better-educated and resource-rich users are more likely to have access to information through different media such as the Internet, television, and newspapers and to make informed use of this information. This is true both in terms of knowledge production (countries and groups within countries with more resources will be able to produce better 'customized' information) and use (better-informed systems and users will be able to use information more efficiently).

For example, in the US south-west, forecast producers organized stakeholder workshops that refined their understanding of potential users and their needs. Because continuous interaction with stakeholders was well-funded and encouraged, producers were able to 'customize' their product, including the design of user-friendly and interactive Internet access to climate information, to local stakeholders with significant success (Hartmann *et al*, 2002; Pagano *et al*, 2002; Lemos and Morehouse, 2005).

In contrast, unequal access to climate information can have negative consequences, when one group of decision-makers acts as a 'gatekeeper' for that information and makes decisions insulated from society at large. When public officials (for instance, water managers, relief planners, agriculture- and fisheries-resource managers) cloaked in technical expertise, insulate their decisions from stakeholders, their decision-making process, lacking in transparency and accountability, not only ignores stakeholders' input but also may affect their interests negatively. In this case, if information is controlled by a few actors seeking to bolster their position *vis-à-vis* other stakeholders, knowledge can insulate decisions and intensify power imbalances between those with access to knowledge and those without. This kind of technocratic insulation can not only alienate participation but also discourage stakeholders from 'buying into' management decisions (Lemos, 2003).

The case of Ceará in NE Brazil, one of the best-studied processes of SFC use to date, offers several illustrations of technocratic insulation in practice. For example, in water management, perceived insulation and lack of participation in reservoir management has led to an overall de-legitimization of the system in the eyes of some users and disregard for management policies (Taddei, 2005). Moreover, the perception of inequality diminishes the potential value of climate information as a decision tool for potential users.

In the Lower Jaguaribe River Basin in Ceará, for example, technical information may have contributed both to better water management and to expanding the power gap between technocrats and stakeholders in the process of water management. It may also have shaped users' perception of the value of SCF as a decision-support tool. Although the majority of river-basin committee members find that climate information is relevant to their decision-making process — 7.8 on a scale of one to ten — only 33% consider it accessible. Moreover, 79.3% of all respondents find that the disparate level of technical knowledge among members is the main source of inequality within the committee, above economic and political power disparities.[8]

Communication seems to be an essential ingredient for the success or failure of people to use of climate knowledge operationally. SCF tools are mostly disseminated in the language of probabilities, which is difficult to assimilate, because non-scientists do not generally think probabilistically, nor do they interpret probabilities easily (Nicholls, 1999). Problems with misinterpretation and miscommunication have negatively affected SCF users, and discredited forecast producers as well as the forecast itself. For example, in Peru, the miscommunication and misinterpretation of climate forecasts in the 1997/98 ENSO not only negatively affected some stakeholders but also discredited the forecast in the eyes of users (Pfaff *et al*, 1999; Broad *et al*, 2002).

Difficulties with language and lack of attention to local institutions create an additional layer of constraint. Hammer *et al* (2001) suggest that poor understanding of local systems may act as a deterrent to the communication and availability of information which ultimately may affect access. Ziervogel and Downing (2004) argue that one way for SCF providers to mitigate such constraints is to understand information networks better in the context of SCF dissemination, especially in less developed countries. Such understanding can "provide(s) a springboard for targeting future forecast dissemination, which is imperative if this information is to be of use, particularly to marginal groups" (Ziervogel and Downing, 2004: 97).

As Rayner and Malone (2001: 176) discuss, "poverty cannot be understood in terms of lack of goods or income, or even basic needs, but must rather be understood in terms of people's ability to participate in the social discourse that shapes their lives." If the goal for SCFs is indeed a focus on equity and improving the livelihoods of the poorest and most vulnerable to climate-related disasters, then improving access to information and the decision-making process is paramount.

One specific way to enhance SCF's impact on equity is to increase the level of inclusion of underrepresented groups even among the overall poor, such as women (Archer, 2003), lower castes (Roncoli *et al*, 2001), the old (Valdivia *et al*, 2001) and the most vulnerable to climatic events (Lemos *et al*, 2002). Archer (2003) argues that the current focus on aggregate categories of users such as farmers masks the inequality in terms of access among subcategories of potential users such as those mentioned above.

Ziervogel and Calder (2003) agree and contend that it is important to understand the vulnerabilities of different users to target SFC dissemination better. They suggest that building a typology of livelihoods would not only improve usability but also avoid negative application. Pfaff *et al* (1999) suggest that the first step in addressing equity issues is to identify the interested parties and delineate their various goals. Obviously, limited resources and time would preclude full inclusion of all potential individual stakeholders. However, there are examples of concrete ways in which organizations are attempting to broaden the scope of who is targeted and involved when SCFs are being disseminated and discussed (Kgakatsi (2001) as cited in Archer (2003)).

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Opportunity cost of SCF use

A third source of inequity in SFC use relates to the opportunity cost of choosing SCF as the focus of policy to address climate-related vulnerabilities over other potentially more effective alternatives. In this sense, investment and reliance on climate technology can result in high opportunity costs for policy systems (Brunner, 2000), especially in less developed countries where resources are limited. Because empirical research increasingly shows that, rather than an environmental hazard, disasters are a combination of such hazards, poverty and other vulnerabilities[9] (Blaikie *et al*, 1994), we argue that in order to provide effective disaster response, governments should address both hazard risk and underlying vulnerabilities.

However, public policy-makers often perceive the complex solution of socioeconomic and political problems underlying disasters as financially impossible and politically unfeasible. In this context, it is not surprising that in the eyes of these policy-makers, the possibility of a technical 'fix', such as the ability to forecast the onset of disasters, offers the promise of an easier path to mitigate their effects (Lemos, 2003).

This does not mean that SCFs have no role in improving vulnerability to climate, but it does suggest that there are opportunity costs to pursuing this strategy over others. Technical fixes may compete for resources with other more effective and equitable, but perhaps less politically viable, policy alternatives (such as income redistribution and institutional reform), to build adaptive capacity to climate variability and change (see also Woodhouse and Sarewitz, 2007: in this issue).

Technical fixes have much appeal from a political perspective as they can be implemented with the authority of science, while avoiding the difficult decisions that decreasing climate and socioeconomic vulnerabilities might entail, especially those that involve any kind of resource redistribution or change in regulations. When such a strategy is implemented with the perceived neutrality of a scientific innovation, it can obscure difficult tradeoffs and exacerbate existing patterns of poverty and inequity.

Another opportunity cost in following the strategy of using SCFs to reduce vulnerability of poor populations is that they are not a foolproof method. Early optimism that the ability to predict El Niño effectively would progress rapidly has somewhat faded and the rate of progress in the skill of climate models to forecast seasonal climate variability with confidence slowed down (Harrison, 2005). Overall, the low skill of current forecasts, that is, "the frequency that a forecast is correct based on historic data" (Ingram *et al*, 2002: 334), has been mentioned in the majority of studies as a serious constraint to operational use.

Perhaps even more importantly for the issue of equity, potential users of SCF who are already at the margins of survival face a much greater risk from betting their meager resources on a forecast that turns out to be wrong (Hulme *et al*, 1992). Thus, subsistence farmers and others who rely on traditional means of coping with climate variability may be justifiably reluctant to abandon those methods, even if SCF may promise more success over the long run (Ingram *et al*, 2002).

Concluding remarks

This essay has explored equity issues related to the use of SCF in different policy arenas around the world. Although scholars have extensively speculated about its potential beneficial impacts, the implications of its use for the distribution of resources and power among resource-poor groups has received relatively less attention. We find that, in the application of SFC, equity can suffer when potential users' underlying vulnerabilities are not also addressed, when access to information and communication is unequal, and when organizations and individuals lack resources and alternatives to adjust to forecasted climate. There may also be significant opportunity costs to the application of SCF.

From an equity perspective, if climate science applications seek to aid and target the vulnerable poor specifically, then policy-makers and SCF producers have to invest time and funds in understanding the process through which decisions are made and resources allocated. First, the dissemination and communication of SCF need to be more inclusive of vulnerable groups, and availability and access to climate information must be improved. Specific training and a concerted effort to 'fit' the available information to local decision-making patterns and culture can be a first step to enhancing its relevance.

Second, SCF producers and policy-makers should be aware of the broader sociopolitical context and the institutional opportunities and constraints presented by SFC use; understanding potential users and their decision environment will not only allow for better fit between product and client but also avoid situations in which SCF use may in fact harm those it is supposed to help.

Finally, as some of the most successful examples show, SCF application should strive to be more transparent, inclusionary, and interactive as a means to counter power imbalances between those with resources and those without (see also Eubanks, 2007: in this issue; Woodhouse and Sarewitz, 2007: in this issue). Unequal distribution of knowledge can insulate decision-making, facilitate elite capture of resources, and alienate disenfranchised groups. In contrast, an approach that is interactive and inclusionary can go a long way to supporting informed decisions that, in turn, can yield better outcomes.

So can science, in the form of SCF, save the poor? From the SCF application experience thus far, we might say no, not by itself. Scientific innovations by themselves are no panacea for the age-old problems of poverty, inequity, and inertia. At the heart of the problem is not equality of outcomes but equality of opportunities to influence the process through which decisions are made. By being mindful of equity issues, we can begin to build a process in which a positive outcome is not a unique contextual experience but an expected result of the application of SCF as a decision-support tool.

Notes

1. For an interesting history of the 19th century drought that may have killed an estimated 60 million people in Africa, India and China, see Davies (2001).
2. As people from northeast Brazil are known.
3. For an early evaluation of SCF use in agriculture, see Hammer *et al* (2001).
4. These empirical examples provide illustration for our arguments throughout this review and are not intended to test formal hypotheses about SCF and equity across different sectors or countries.
5. For a detailed description of the evolution of SCF, see Harrison (2005).
6. Here, rather than equality, the critical issue is the unfair distribution of outcomes (some win, some lose). See Cozzens (2007: in this issue) for a discussion of the distinction between equity and equality.
7. Researchers in the India case and researchers and extension agents in the Zimbabwe case.
8. The Watermark Survey was carried out in the context of the Watermark Project, a broad comparative study of water management in Brazil, of which Lemos is one of the investigators.
9. Among the causes of vulnerability are lack of democracy, unequal power relations and/or poor access to resources.

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