COMMENT

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Flooding in Pakistan in September 2012 affected millions of people, displacing them and damaging their homes, farms and supplies of food and water.

Improve weather forecasts for the developing world

Global prediction partnerships would cost little and reduce the regional carnage caused by floods, droughts and tropical cyclones, argues **Peter J. Webster**.

Hurricane Sandy hit the northeast coast of the United States in October with ample warning. The storm caused widespread damage, but only around 125 people died in the region, thanks to planning made possible by accurate long-range weather forecasts.

In the developing world, tropical cyclones, floods and droughts arrive with little notice and kill thousands of people each year. Although only 5% of tropical cyclones occur in the north Indian Ocean, they account for 95% of such casualties worldwide[1,2]. In 2007 and 2008, two Very Severe Cyclonic Storms — Sidr and Nargis — caused the deaths of more than 10,000 and around 138,000 people in Bangladesh and Myanmar, respectively.

Flooding in the Ganges and Brahmaputra river basins has displaced more than 40 million people in each of the past few years[3,4]. In 1998, 60% of Bangladesh was inundated with floodwater for almost three months. Pakistan's Indus Valley was devastated by floods in 2010, costing more than 2,000 lives and US$40 billion[5]. Flooding struck the area again in the summers of 2011 and 2012.

Droughts condemn millions to hunger across the developing world. A three-week break in rainfall just after seasonal planting, following what seemed to be a normal monsoon onset, caused a disastrous crop failure in India in 2002 (ref. 6). The unforeseen dry period was tied to a south Asian weather oscillation that occurs every 30–60 days[7].

An individual living in south Asia or Africa can expect to encounter several extreme weather events in his or her lifetime. Because the resilience of poor populations is low and falls with every crisis, the cumulative effects are relentlessly impoverishing. Smallholders often purchase stocks on credit that is repaid at the end of the season, so the loss of a crop or livestock in one bad year can put the farmer into debt for many years, ▶

condemning generations to poverty.

Owing to advances in prediction science, such catastrophes can be forecast anywhere in the world with as long a lead time as Hurricane Sandy. The problem is tailoring complex global forecasts to a country or region and communicating them to local populations so that they can take action.

To lessen the impacts of adverse weather, networks must be established between the forecasters of global weather and climate in the developed world, and research, governmental and non-governmental organizations in the less-developed world. The investment needed is not high and will pay for itself: my research group at the Georgia Institute of Technology estimates that such a network could forecast floods across Asia for as little as $1 million a year, saving billions of dollars and thousands of lives.

NO WARNING

In most developing countries, weather warnings are issued a few days in advance, if at all. Yet, for a flood or cyclone, at least a week of forewarning is needed to allow the slowest members of a society (perhaps a farmer and his cattle) to evacuate. For short droughts, several weeks' notice allow smallholders to adjust planting and harvesting schedules. Long droughts require warnings to be given months ahead, so that farmers can choose resistant crops and store fodder and water.

Although Pakistan's devastating 2010 floods arrived with no warning in the north of the country, the pulses of intense rain responsible could have been forecast 8–10 days ahead if available data had been analysed at the time[5]. In September 2012, my research group used rainfall forecasts and a regional hydrological model to predict flooding ten days in advance, but Pakistan's government didn't implement the warning. Fortunately, the floods were less severe than those in 2010.

Regional forecasts with long lead times must take global atmospheric circulations into account, because local weather is influenced by distant events. The path of Hurricane Sandy, for example, was swayed by a mid-latitude low-pressure system in the Pacific Ocean that moved slowly across Canada, thousands of kilometres to the west.

Global weather-forecast models take decades to develop, are expensive to build and maintain, and are run by only a few national or multinational government organizations, including the European Centre for Medium-Range Weather Forecasts (ECMWF), the UK Met Office and the US National Centers for Environmental Prediction (NCEP).

Each run of a model begins with a huge array of meteorological and oceanographic data from more than 30,000 observations on land, 3,500 floating buoys and drifters, and numerous satellites. Even so, the global data coverage is incomplete (particularly in the Southern Hemisphere), the measurements have errors and the algorithms are imperfect. Global models are thus run many times a day using different initial conditions[8]. The ECMWF, for example, runs its model 51 times twice a day, incorporating new initial data to produce 1–15-day forecasts, and extends its forecasting horizon to 32 days ahead twice a week.

In theory, developing countries can access these data streams. The NCEP forecasts, for example, are posted on the Internet daily. But peeling off regional data from the global deluge is like filling a cup from a fire hose. Internet transmission costs are high, and timely downloading requires a fast data-transfer rate. Less-developed countries have small budgets and slow Internet connections. Paradoxically, as forecasts become better and their resolution grows, it becomes more difficult for developing countries to access them.

Regional forecasting requires calibration with local data, such as geographic contours, and so is beyond the remit of the global weather centres. Intermediaries — research groups, universities or companies — can form a bridge between global-forecast providers and user communities. Partnerships are springing up, but more are needed.

Bangladesh offers a success story that could be emulated elsewhere. Global forecasts produced in Europe are sent to the United States and turned into flood forecasts that, within six hours, can be integrated into Bangladesh's disaster-management protocol by local experts.

The need for a rapid forecasting and warning system in Bangladesh became apparent following the 1998 floods. The ECMWF, the Bangladeshi government and my research group therefore developed a 1–10-day flood-forecasting system and created the Climate Forecast Applications Network (CFAN) to distribute it. This system was first used experimentally in 2004 and became operational in 2007. The basic science was developed with support from the US National Science Foundation, and implementation by the CFAN was funded by the US Agency for International Development (USAID) and the humanitarian agency CARE.

The CFAN has produced daily forecasts of the Brahmaputra and Ganges flows since 2004, sending them to the Bangladesh Flood Forecast and Warning Centre[3,4]. If the probability of flooding exceeds 80%, warnings are issued to government offices across Bangladesh.

Planning and training are essential for effective use of the forecasts. Before the 2007 flood season, village and community leaders in six administrative unions of Bangladesh were trained to interpret the data and to take action if flooding was likely. Local leaders could tell farmers to harvest crops, shelter animals, store clean water and secure food, household and farming effects.

Bangladesh experienced three major floods in 2007 and 2008. Each was forecast successfully ten days in advance and mitigation steps were taken[3,4] (see 'Bangladesh flood alerts'). On the basis of a World Bank report[9], one analysis concluded that about $40 was saved for every dollar invested in the regional forecasting and warning system. Savings at the village level were measured in units of annual income[4].

In 2009, to boost regional capacity-building, the CFAN handed over its flood-forecast modules to the Bangladesh Flood Forecasting and Warning Centre. When the large volume of data proved too difficult for the centre to handle, the responsibility shifted to an international non-government entity, the Regional Integrated and Multi-Hazard Early Warning System (RIMES).

Funded partly by contributions from member states, RIMES works with governments across south and east Asia to incorporate regional forecasts into national disaster-mitigation programmes and provides warnings for a range of natural hazards, including

BANGLADESH FLOOD ALERTS

Bangladesh's floods of July–August 2007 were predicted ten days in advance. Forecasts were communicated to five pilot areas (red), where community leaders directed people to harvest crops, lead cattle to safety and store water, food and personal belongings.

SOURCE: CEGIS/UNOSAT

earthquakes, tsunamis and extreme weather. RIMES is innovative but its funding is limited, making it difficult to maintain the cadre of scientists necessary to tackle specific problems. Inadequate funding also hinders the essential updating of forecast modules as satellite and global forecast systems change.

GLOBAL PARTNERSHIPS

Partnerships that bridge the gap between the global forecasters and the user community need to be established in other regions to address a range of weather hazards. The plan and type of group that forms the bridge will depend on the type of hazard being addressed. But the aim of each team is the same: to produce hazard-forecast modules based on the global forecasts and to use them to provide warnings for the region. The team will also be responsible for updating the modules as systems and technologies change.

Such partnerships can be aided by sustained funding from intergovernmental organizations, such as the United Nations, the World Bank and USAID. My research group estimates that the cost of extended 10–15-day forecasts for south and east Asia for a wide range of hydrometeorological hazards (including slow-rise monsoon floods, droughts and tropical cyclones) is relatively small: perhaps $2 million to $3 million per year.

Asia and Africa stand on the threshold of great economic advancement and can build resilience through the effective use of longer-range weather forecasts[10]. Faced with possible climate change, societies that learn to cope with and mitigate hazards now will be most adept at dealing with more frequent and intense hazards in the future. ■

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