Dreams beyond DROUGHT

by Adam Barclay

HUMNATH BHANDARI

For the rural poor, drought delivers heartbreak and rips communities apart — but promising new research can help rice farmers and their families avoid devastation

ARIEL JAVELLANA

DROUGHT that causes rice fields like this also forces women to travel long distances to find drinking water (*inset*).

LEHARNE FOUNTAIN

The headlines don't scream at you from the front page. But their effect builds and, if you've followed the news from across Asia this past year or so, you will understand the scale of the problem. Drought doesn't have the immediacy of a tsunami or a flood, but it can kill just as effectively. Its method is slow, insidious and, in the end, more painful, grinding people slowly into the dust that lies where crops once stood.

Essentially, drought is an extended period of substantially lower-than-usual rainfall, leading to a shortage of water for domestic use and agriculture, and ultimately to financial, physical and social hardship. And it happens over and over again in Asia, where around a fifth of all rice area is drought-prone.

The consequences of drought read like a description of the apocalypse: decline in food production, hunger, malnutrition, disease epidemics and other health problems, famine, displacement of people, loss of assets, starvation — the list goes on. Where floods and typhoons inflict instant damage, drought's impact is gradual, so it receives less attention from politicians and policymakers. Nevertheless, prolonged severe drought causes the breakdown of livelihoods and rural economies and the failure of social support systems. The impact is disproportionately high on poor households that are less able to cope because they do not own or have access to the resources they need to escape the worst effects.

The consequences of drought read like a description of the apocalypse

In 2004, widespread severe drought in much of Asia not only resulted in agricultural production losses of hundreds of millions of dollars but also pushed literally millions of people into poverty. In Thailand, drought hit 70 of the country's 76 provinces and affected more than 8 million people. Production loss from major crop failures covering 2 million hectares is estimated at US$326 million, resulting in a 3.9% decline in the 2004 agricultural gross domestic product (GDP). More than half of the rural population of Thailand relies on farm income for their livelihoods. The story is the same all across developing Asia, where well over half the population depends on agriculture.

Reports from numerous countries have a depressing sameness to them. In 2004, the normally lush tropical southern Chinese island of Hainan suffered its worst drought in 50 years, with 12 million hectares of farmland affected. Media reports claimed that more than 9 million Chinese faced drinking-water shortages. Vietnam's eight central highland provinces suffered their worst drought in 28 years, affecting around 1 million people and causing an estimated $80 million worth of crop losses. In March 2005, Cambodian Prime Minister Hun Sen called for international assistance for a national campaign to help farmers who are short of water. Coping with recurrent drought is part of life for millions of Asia's rural poor.

Just over two-thirds of India is susceptible to drought and more than half of Asia's drought-prone rice lands

AS DROUGHT takes its toll, employment for agricultural workers also dries up, forcing them into inactivity or migration to cities in the search for work.

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are located in eastern India alone. Drought is one of India's foremost constraints to increased and stable agricultural production. The last century has seen the country rocked by severe droughts in 1918, 1965, 1972, 1979, 1987 and 2002. With agriculture contributing around a quarter of India's GDP, severe drought directly stifles economic growth.

The 2002 drought ranks as one of the most severe in India's recorded history. More than half the country's area and around 300 million people across 18 states felt its impact. The lack of rain caused a 15% drop in total food grains and a 19% drop in rice production — 31 million tons and 17 million tons, respectively — compared with what was expected based on agricultural trends. The Indian Department of Agriculture estimated that the 2002 drought year resulted in a 3.2% decline in agricultural GDP, a $9-billion loss in agricultural income and the loss of a staggering 1.3 billion person-days in rural employment due to shrinkage of agricultural operations.

The 2002 drought ranks as one of the most severe in memory

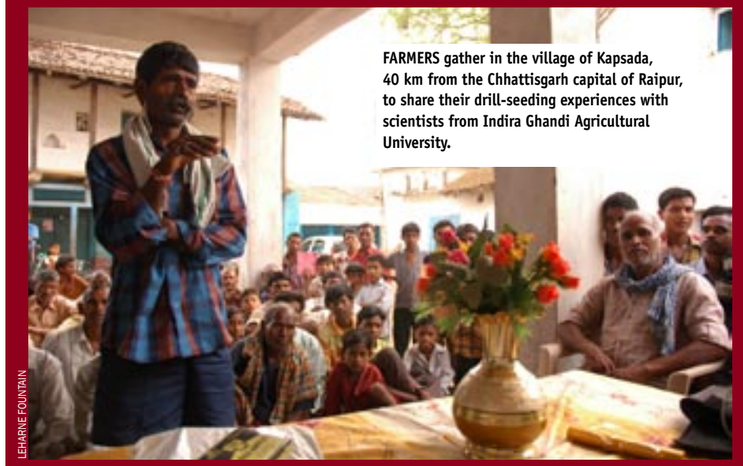
What do these numbers actually mean, though? First, you have to remember that India is home to more than a sixth of the planet's population — almost 1.1 billion, and rising. So a little economic push here or shove there can affect a *lot* of people. In just three states in eastern India, Chhattisgarh, Jharkhand and Orissa, the 2002 drought slashed farm household income by 40-80% and shoved 13 million people below an already-low poverty line. In short, a lot of people who weren't doing too badly became poor and a lot of poor people became a lot poorer.

Sushil Pandey, a senior agricultural economist at the International Rice Research Institute (IRRI), led a recent Rockefeller Foundation-funded study into the impact of drought titled *Economic costs of drought and rainfed rice farmers' coping mechanisms in eastern India*. He points out that the impact at a national level tends to be moderated because a whole country is rarely in drought at once, and areas experiencing a good year will to some extent buffer the hardest hit areas. If you take a look at the effect on localized groups, though, you see a much bleaker picture.

"When you zoom in on specific areas, you see the impact much more," says Dr. Pandey. "It's possible to have very little fluctuation

Community action combats drought

by Leharne Fountain



FARMERS gather in the village of Kapsada, 40 km from the Chhattisgarh capital of Raipur, to share their drill-seeding experiences with scientists from Indira Ghandi Agricultural University.

LEHARNE FOUNTAIN

Drought is a major issue for rainfed rice cultivation in eastern India. In Chhattisgarh state in 2002-03, for example, drought led to a halving of rice production, hampering the rural economy and forcing farmers into debt.

Rice cultivation in this region is often performed by direct seeding, rather than transplanting. One drawback of this technique is that weeds can be a big problem. The chief method of weed control in Chhattisgarh is through the traditional practice of *biasi*, which is heavily dependent on adequate and timely rainfall to impound about 10-15 cm of water. Around 30-50 days after sowing, farmers run a narrow plow through the mix of crop and weeds. Although disruptive for the seedlings, the method keeps weeds under control, and allows farmers to redistribute seedlings and fill any gaps. But a lack of enough rainfall can delay or even prevent *biasi*, and weeds soon out-compete the rice, causing severe declines in yield.

One solution is to sow the rice in lines using a seed drill — a device that opens furrows in the soil and drops seeds into them — with different weed management strategies not dependent on impounded water. The technology is not new but, until recently, has not been adopted in Chhattisgarh due largely to a lack of access to seed drills and tractors. Now, IRRI and the Indira Ghandi Agricultural University, with funding from the International Fund for Agricultural Development, are helping remove barriers to adoption by taking a more community-oriented path. The research team recently helped farming communities set up a hiring system and encouraged local entrepreneurs to purchase drills and tractors that could be hired out to other small farmers.

Importantly, line-sown rice matures up to 10 days earlier than *biasi* rice. Previously, farmers grew varieties of different durations, which were harvested relatively late and at different times, prohibiting a second crop under residual soil moisture conditions during the otherwise fallow period. Cropping intensity has increased because the farmers now sow the same early-maturing rice variety, allowing production of a high-yielding variety of chickpea after the rice harvest.

Line sowing is gaining popularity among farmers and helping them to produce higher yields and income. Managing weeds in line-sown crops is easier too, as it isn't dependent on the high rainfall required for *biasi*. Gaining access to line-sowing technology has helped, but it is the cooperation of local communities that has really made the difference.

FARMERS IN CHHATTISGARH tell IRRI's Humnath Bhandari (*seated at right*) about how drought has affected their lives and what they do to try and cope. A woman checks a public tube well (*below*) for drinking water. In the background is a parched farm pond, which in better years provides water for domestic use and livestock.

IRRI

HUMNATH BHANDARI

Tears in the dust

To get a sense of life during an Indian drought, let us examine the case of one farmer. Nandu Bhoi farms a half-hectare block near Datarengi village in the Raipur district of India's Chhattisgarh state. The area's soil retains very little rainwater; crops here depend on consistent, timely rains. It is an unforgiving place to eke out a farm living.

Despite droughts in 1997, 1998 and 2000, Nandu managed to produce a little rice. Then, in the 2002 monsoon season, the rains dried up completely and he neither planted nor harvested a single grain. Six years earlier, he had bought a bullock to help with land preparation and to hire out to other farmers. In the absence of rain, Nandu simply grazed his bullock in his barren rice field, but by 2002 there were not even enough weeds to feed a single draft animal.

With his family becoming hungrier and his bullock fast losing weight, Nandu decided to sell. Many of his fellow farmers in similarly dire circumstances were doing the same thing, so prices for bullocks had hit rock bottom. He received a paltry sum for the sickly beast but at least it was one less thing to worry about. Unable to produce food himself, though, Nandu became more and more desperate, selling his farm tools and some cooking implements.

When food is in short supply in this part of India, women are given whatever is left over after the men, the children and the elderly have eaten. Nandu's pregnant wife, Sulochana, had thus become weak, barely able to gather the energy to join the other farm wives foraging in the nearby forest for food. Most days, Sulochana was helped by her 12-year-old-son and 10-year-old daughter. Together, they would spend up to 12 hours each day collecting firewood, timber, medicinal plants and food. Keeping a small portion for themselves, they sold the bulk of it at the market, earning around 50 rupees (US$1.15) per day.

The children no longer attended school and although people harvest forest products in nondrought years, the practice increases sharply during drought, contributing to rapid depletion of useful plants and severe deforestation. Foragers also risk an unreliable market, low prices and exploitation by middlemen.

WOMEN FROM POOR, drought-affected households in Chhattisgarh collect kendu leaves from the forest. They can make a little money selling these in the local market, but the practice, which peaks in drought years, contributes to deforestation.

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With his options rapidly dwindling, Nandu moved to Maharashtra, hundreds of kilometers southwest of Raipur, to perform manual labor at a brick-producing kiln. To do this, he borrowed Rs 1000 ($23) from a local money lender, who charged him 40% annual interest. In Maharashtra, he worked a punishing 15-hour day for a paltry Rs 50. Meanwhile, Sulochana gave birth to a 5-week-premature boy who, underweight and underfed, died a week later.

In 2003 the rains finally returned to Raipur and Nandu moved back to Datarengi to re-establish his farm. Already owing money, he had no alternative but to plunge further into debt. Having previously sold his bullock and farm tools, he borrowed enough money to hire what he needed to plant a rice crop. Forced to wait for the equipment until its owners had finished with it, Nandu planted his crop late, resulting in considerable production losses. For the first time in years, though, he was able to provide his family with food that he had grown himself, and so begin the long, hard journey to recovery. But if another drought hits any time soon, Nandu and his family will find themselves rapidly ground into the dust once more.

The story of Nandu Bhoi and his family represents the heartbreaking reality for an enormous number of farm families across India who continue to suffer from recurrent drought. Poverty and debt feed on themselves and, when the rains fail, already-struggling farmers quickly find their circumstances spiraling out of control, unwitting players in a potentially deadly chain reaction.

and loss of production at the national level at the same time as massive production losses — 60-70% — in the affected areas."

Although the direct impact of drought is production loss and consequent income loss, this is only the start of a farmer's problems.

"The local economy in a rural area depends on agriculture," says Dr. Pandey, "and if the local economy isn't functioning well, the other employment disappears. You have a cumulative effect. The total economic cost of drought is several-fold higher than the value of the production loss, and farmers' coping mechanisms are usually inadequate to prevent a shortfall in consumption, particularly among vulnerable groups. When people are unable to pay off their loans, they go deeper and deeper into debt, ultimately losing their land and whatever else they own, and become completely destitute."

Sukraram Dhuru, from Raipur's Kumarkhan village, sums things by saying "a 1-year drought creates a 5-year problem." Imagine, then, the ruin inflicted by 2, or 3, or 5 consecutive years of poor rains. Some farm families are simply pushed so far down they never make their way back up, condemned to a subsistence of monotonous, unskilled labor, drudgery and malnutrition.

What's more, this sort of tragedy happens again and again. It is both encouraging and sobering to realize

Drought – what is IRRI doing?

IRRI is developing a range of strategies to tackle drought. Read on for a summary of some of the institute's key research.

Breeding for drought tolerance

IRRI researchers have demonstrated that some rice varieties (including some hybrids), are much more tolerant than mainstream high-yielding irrigated varieties to periods of soil drying during the critical flowering and early grain-filling stages. Luckily, this characteristic does not seem to undermine yield under favorable conditions. Rice breeders can find the most drought-tolerant varieties through a screening process wherein plants are deprived of water around the flowering period, and then the best-yielding candidates are selected. Since 2004, IRRI has identified many varieties combining high yield when conditions are good with the ability to produce yields of 2-3 tons per hectare under conditions that are so dry that many popular varieties produce less than 1 ton per hectare. IRRI and collaborators are studying the genetic basis for this tolerance.

Aerobic rice

Rice breeders at IRRI are developing new types of rice that combine the ability of some traditional but low-yielding varieties to grow in dry soils with the fertilizer responsiveness and yield potential of modern high-yielding varieties. The first generation of this so-called aerobic rice has been developed by crossing irrigated high-yielding varieties with some of the traditional types and selecting the progeny under dry soil conditions. Researchers in China and at the Brazilian Agricultural Research Corporation pioneered this breeding strategy. The resulting varieties are direct-seeded into dry soil in nonflooded fields and managed like a high-yielding wheat or maize crop. Irrigation is applied if available and needed, but no standing water is held in the fields.

Crop management strategies

IRRI is researching a range of crop management strategies that have the potential to reduce the impact of drought. Dry direct seeding — planting seeds directly into nonflooded fields instead of transplanting seedlings into flooded fields — has the potential to help farmers avoid late season drought, increase rice yield and gain opportunities to grow extra crops. Researchers are also quantifying drought effect on crop development, growth and yield, then using the Oryza2000 crop modeling system (co-developed by IRRI and Wageningen University in The Netherlands) to simulate rice growth under drought conditions. Such modeling has already allowed scientists to analyze yield constraints and explore management options to increase the yield and stability of rainfed lowland rice in Indonesia. Land leveling can help farmers use water more efficiently. Studying how soil and hydrological characteristics vary according to topography — and how this affects soil nutrients, water availability and yield — will help researchers develop improved, site-specific management strategies for drought conditions.

Deletion mutants

Deletion mutants offer an exciting way of exploring the effect of unknown genes on drought tolerance. IRRI scientists have created more than 40,000 deletion mutants where chemicals or radiation were used to "knock out" random segments of the chromosome. The resultant plants — the deletion mutants — are then screened under drought stress in the field, or by applying drought-related plant hormones in the laboratory, to identify drought-tolerant or drought-susceptible mutants. By carefully investigating different physiological characteristics of the tolerant mutants a picture of the mechanisms important for drought tolerance in rice is beginning to emerge. Work is also under way to identify which deleted genes are responsible for this effect.

AEROBIC RICE varieties, like these being trialed at IRRI, can grow in conditions far too dry for commonly grown modern varieties.

GARY ATLIN

Physiological, anatomical and molecular bases of drought sensitivity

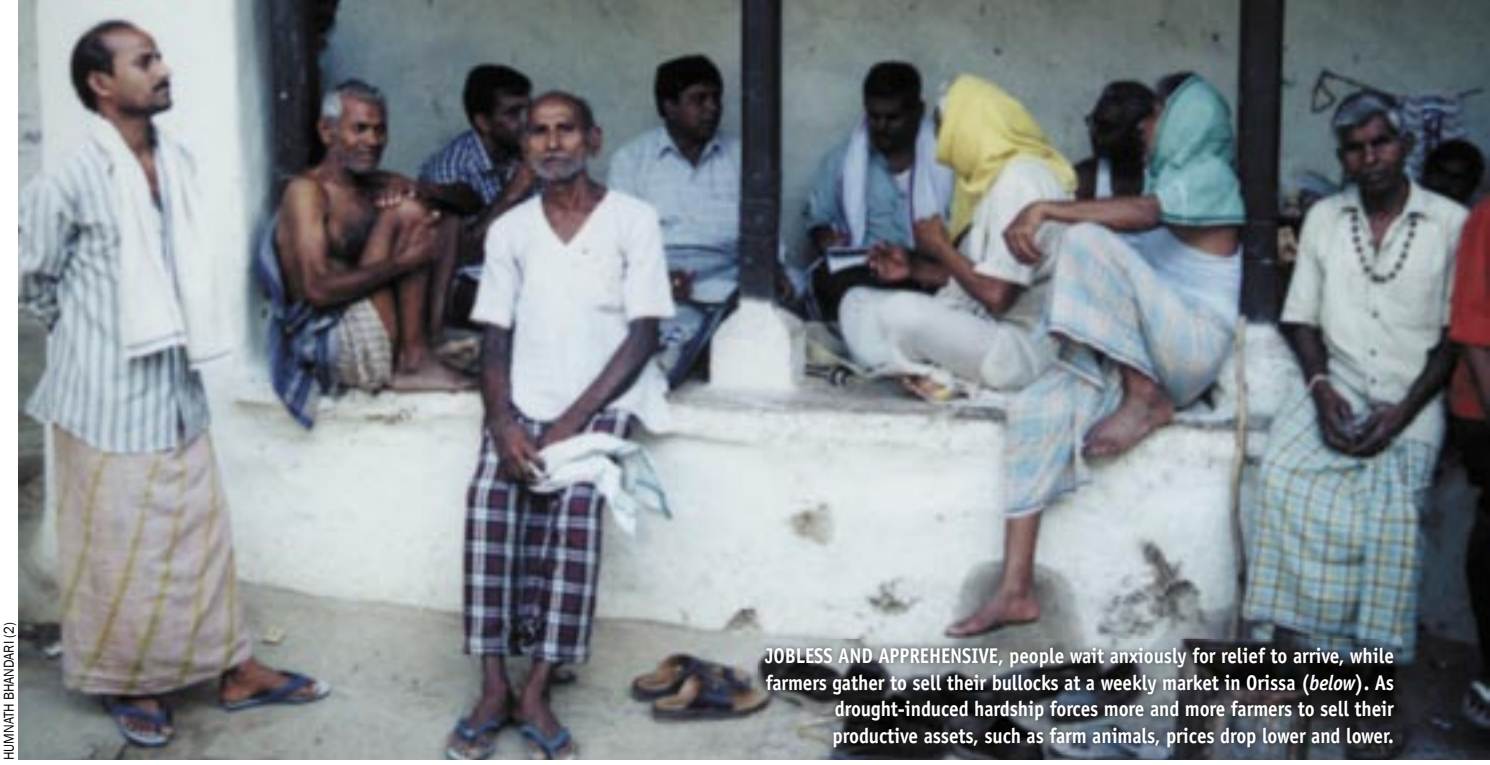
The reproductive stage of rice is the most sensitive to drought stress. Inadequate rainfall during the flowering and grain-filling stages can lead to large yield losses in many leading rice varieties. One of the reasons for reduced yields is that the panicle (the flowering section of the rice plant) does not fully emerge from the leaf sheath. For the panicle to fully emerge, the plant needs to produce a particular hormone (gibberellin). Under drought stress, however, the plant decreases production of gibberellin and increases production of a different hormone (abscisic acid), which works in opposition to gibberellin. This same phenomenon is responsible for poor pollen release under drought conditions, which also inhibits yield. IRRI scientists are examining the genes that control the production and release of these hormones, as well as the corresponding proteins. Ultimately, researchers hope to develop rice plants that maintain reasonable yields under drought conditions.

Molecular breeding

Although drought-resilient rice varieties do exist, it has proved difficult to combine drought tolerance and high yields. To link these two traits, scientists at IRRI and the Chinese Academy of Agricultural Sciences interbred popular high-yielding varieties with more than 100 varieties from diverse origins. This produced a large number of breeding lines, which were then screened for high yield under drought stress. Researchers identified many lines whose physical appearance and performance were similar to the popular varieties they were derived from, but with improved yield in a range of drought environments. These lines are now being field-tested in drought-prone environments in South and Southeast Asia. This approach has also helped scientists identify many genes and parts of the genome that influence drought tolerance.

The Challenge Program on Water and Food

The Challenge Program on Water and Food is one of several high-impact, collaborative research programs that target major global and regional agricultural issues. The Challenge Programs are an initiative of IRRI's parent organization, the Consultative Group on International Agricultural Research (CGIAR). Ultimately, the Water and Food program will help farmers grow more food with less water. IRRI is leading the program's Crop Water Productivity Improvement theme, which seeks to increase crop water productivity to ensure food security and improve farmers' livelihoods without increasing water used for agriculture over the amount used in the year 2000. Researchers from five CGIAR centers and several additional partners aim to achieve this by developing water-efficient crops, improving farming practices to optimize water use, and promoting policies and institutions to help farmers gain access to new technologies.



HUMNATH BHANDARI (2)

JOBLESS AND APPREHENSIVE, people wait anxiously for relief to arrive, while farmers gather to sell their bullocks at a weekly market in Orissa (*below*). As drought-induced hardship forces more and more farmers to sell their productive assets, such as farm animals, prices drop lower and lower.

that the worst consequences can be avoided. We may not have the ability to prevent drought, but we have the chance to soften its effects and give people who depend on agriculture a fighting chance.

The answer lies in three interconnected areas — research, effective long-term drought-mitigation policies and relief strategies. There is an urgent need for policies that give farmers access to markets and affordable credit. Improved irrigation systems and soil and water conservation, through better approaches to managing natural watersheds, can help ease the effects of drought. Access to improved agricultural technologies that increase productivity will help farmers diversify their income sources, giving them opportunities to earn a living from more than just one type of crop and from viable nonfarm activities.

"Farmers need nonagricultural income so even when there is agricultural failure, they can earn money," explains Humnath Bhandari, a visiting research fellow at IRRI who coauthored the India drought report.

"Effective drought relief, such as emergency food supplies, is crucial," says Dr. Bhandari, "but people only receive assistance when a drought actually happens. Millions of relief dollars are spent but with little impact on long-term mitigation. Unless we focus on long-term strategies, we won't find a solution, but governments are now starting to realize how serious this issue really is."

In research, we find the potential for truly sustainable improvements. IRRI has taken on a suite of different approaches, from breeding rice varieties that are better able to tolerate drought conditions, to improved crop and water management strategies that help conserve and reduce the need for water (see *Drought – what is IRRI doing?*, opposite).

In combination with inadequate coping mechanisms, drought not only perpetuates poverty but also deepens it, forcing more people below the poverty line and dragging those already there deeper down. At the same time, improvements borne by research can have the opposite effect, nudging people back up into better circumstances.

"What would happen," asks Dr. Pandey, "if we could halve the rice yield loss suffered during drought years? This alone would prevent about 4 million people in eastern India from falling into poverty."

Combine that with improved policies, effective relief and better infrastructure, and you give farmers and their families a chance to keep water in their fields, their crops above ground and their heads above water.