From water conservation to crop selection, how farmers can take action against drought

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As climate change accelerates, Farmers' vulnerability to drought will depend on his choice of varieties and cropping practices. Credit: Raphael Belmin, Author provided

As climate change accelerates, many countries around the world are increasingly facing the risk of drought. Water scarcity has become one of the major constraints of food production in the 21st century, and a major threat for our current and future food security. In the Horn of Africa, four consecutive rainfall deficit seasons have led to more than 16 million persons facing severe hunger in Somalia, Ethiopia and Kenya. Droughts and other climate shocks like this summer heat wave become more frequent in the current climate crisis.

Because crops' primary source of water is rain, they're highly vulnerable to drought. Even where farmers have underground sources of water available, many are running dry. In Morocco, the water crisis and competition with other sectors may soon make farming in regions such as Agadir difficult or even impossible.

Yet in the next 20 to 30 years, we will need to boost agricultural production by as much as 70%, especially in Africa. Agriculture is the first user of water resources (70% to 80%) and thus needs to radically increase its efficiency to respond to declining resources and a growing demand for drinking water and other uses, including industry, tourism and ecosystem preservation.

Crop selection and farming techniques

So how can we sustainably grow crop production in the context of droughts that are more frequent, more intense and longer lasting? If we look over the science, this largely comes down to crop selection. More specifically, the capacity for a wheat or pea variety to produce more grain with less water is the combination of three phenomenons:

- Plants' ability to **pump soil water at the root level**: this is how they create biomass through photosynthesis without losing too much water through evaporation. Plants have leaf surfaces with microscopic openings called stomata that open or close to allow the exchange of CO_2 and water vapor. Research has shown that by modifying light-sensitive opening mechanisms of the stomata, the plant could save 25% water for the same biomass produced.

- **Increasing the amount of grain produced by each crop**, including by ensuring they use water as efficiently as possible. An innovative lysimetric system weighing individual plants and scanning leaf surface in real time has revealed that transpiration efficacy for plants like sorghum could vary a lot between individual, yet without necessarily yielding any differences. This could be a promising drought-tolerance trait to explore.

- Investigating the optimal combinations of plants—known as **crop diversity**. In drought conditions, pearl millet associated with cowpea, an important legume in West Africa, can produce the same millet yield as millet alone. This means that an additional protein-rich harvest of cowpea can be produced with the same quantity of water. Growing cereals and legumes together in the same field can optimize water resources in the soil, limiting soil evaporation thanks to vegetal cover. This also contributes to food security by adding protein in the diet of farming families.

Another strategy against drought is improving the storage of "green water", which is held in the porous structure of the soil. This can be achieved through soil-conservation practices, landscaping structures such as terracing or contour farming, and other irrigation strategies. For instance, deficit irrigation is the practice of watering plants less frequently but in targeted manner, and it can force the plant to dig their root systems deeper and be less dependent on watering.

Computer-simulated experiments and socioeconomic

tools to guide decision making

Over the years, agricultural research has developed many technological solutions against drought. Giving the increasing risks, however, we need to get better at choosing what works best for each farmer. The choices depend on the specific environment of each farm, where agronomic and climatic conditions vary considerably over space and time. Uncertainties on agro-climatic conditions mean that traditional crop research is not enough to explore and scale up climate adaptation solutions.

Breakthroughs in the past few years have enabled researchers to use low-cost sensors to measure in real-time soil humidity, the hydrological status of the plant, and other parameters. Using drones and other tools, plants can also be scanned directly in the field, harvesting dozens of parameters such as leaf temperatures (a water-stress indicator) and leaf-area indexes, which allow researchers to model how plants respond to drought at the leaf or root level. This data revolution has led the selection of "stay-green" sorghum that can resist even intense drought conditions.

But how to sort out all this complexity? Plant growth modeling combined with statistical models allows researchers to run "virtual" agronomic trials to assess crop combinations and farming practices in different soil, water and climate conditions. This approach allowed sorting more than 150 wheat varieties according to their drought resistance across 13 different environments.

From the farmer's point of view, their vulnerability to drought will depend on the choice of crops and varieties that are cultivated, the sowing time (which can become very difficult to decide when rainfall forecasts are more and more uncertain) and how soils are managed to retain this precious water.

The economic and policy dimension is crucial, as farmers need to maintain a tricky balance between risks, uncertainty and potential benefits. The co-creation of drought index insurance products adapted to small farming in developing countries could transform agriculture in these countries, as farmers could better plan risks and their crop system from one year to another.

Navigating between food-security and food-sovereignty considerations, some African countries such as Senegal will have to invest to produce more food per drop. It may be through radical transformation of their agriculture, from shifting rice investments toward new water-saving rice systems such as revolving wetting and drying rice (AWD) in South Asia, introducing wheat in Senegal or Mauritania to respond to the growing food-import bill or develop traditional drought-resistant crop value chains like fonio, a native millet in West Africa. All these national choices will have implications on farmers' vulnerability to future droughts.

Combining in silico (computer-simulated) experiments and socioeconomic tools could greatly facilitate decision-making toward the most efficient solutions of drought adaptation—at the scale of a plant (varietal selection), the farm or a territory (towards more integrated water management).

From November 28 to December 2, 2022, the seventh Inter Drought conference will take place in Dakar, Senegal. This is the first time it is being held on the continent that is facing the most devastating effects of climate change, and it will be a key moment to imagine the resilient and water-saving agriculture our society so urgently needs.

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