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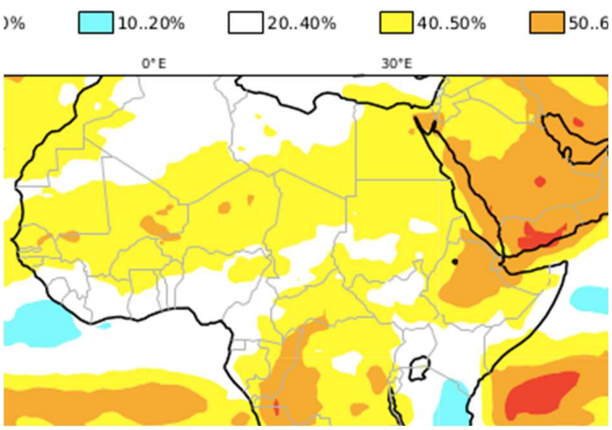

Probabilistic scenario planning in agriculture: balancing risks through data-driven forecasting

Many decisions in the agricultural sector are made under uncertainty. Farmers choose crops and varieties without knowing how much it will rain, or how farmgate prices will develop. Food processors and retailers buy perishable farm produce without knowing if demand will go up or down. Such uncertainty about the future creates economic risk: the decisions made by farmers and other food system stakeholders today can prove suboptimal in the future. Many stakeholders mitigate such risks by choosing a heuristic 'best-bet' strategy: for example, farmers may plant a mix of traditional drought-tolerant varieties and high-yielding hybrids. Applying the same best-bet strategy every year is a reasonable way to deal with risk because many uncertainties affecting agriculture cannot be predicted accurately. For many phenomena, however, it is possible to estimate their probability of occurring. This enables more flexible, anticipatory decision-making that considers how the future is likely to differ from the present or past situation.

What is scenario planning?

In the business world, scenario planning exercises are used to prepare enterprises for different, potential future market developments. In participatory sessions, decision-makers identify key risks and opportunities for their business, assess respective probabilities, and devise a strategy for each positive or negative 'scenario' in advance, to be able to respond immediately.

Probabilistic scenario planning in agriculture uses available data and expert estimates to inform decision-making across the food system in a way that minimizes economic risk. For example, medium-range climate forecasts use meteorological information to indicate how likely it is for a drought to occur. If the forecast shows a high probability for drought, farmers are well-advised to plant a high share of drought-tolerant, but low-yielding crops and varieties. This strategy will minimize overall risk: it mitigates the high risk of crop failure due to drought, but maintains a low risk of a sub-optimal outcome in case no drought occurs eventually.

Probabilistic scenario planning in agriculture does not mean counting on the most likely scenario. Rather, decision-makers design a balanced strategy by weighing in the different probabilities of alternative scenarios. The goal is to optimize outcomes by balancing different risks wisely. Probabilistic scenario planning in agriculture involves two ways of dealing smartly with uncertainty:

First, designing an overall risk-minimizing strategy

Take decisions today that balance the risks of different scenarios based on their expected probabilities.

Second, preparing alternative scenario plans

Despite the balanced strategy, plan ahead future responses to different scenarios to speed up adaptation when scenarios occur.

September 2021

Five steps for scenario planning in agriculture

1. Identify key drivers of uncertainty

Decision-makers define key conditions or events that affect outcomes. Many different factors may be considered, for example:

Biophysical:	seasonal climate, cyclones, locust outbreak
Economic:	development of input and output prices, demand
Political:	provision of government credit, political violence

2. Define a few major scenarios

Based on the triggers identified in the previous step, decision-makers describe plausible, alternative futures. Often, different factors are likely to co-occur. For example:

Scenario	1	2	3	4
Dry spell	no	yes: maize damaged	yes: maize killed	yes: maize killed
Staple prices	stable	stable	increased	increased
Political violence	no	no	no	yes: hinders replanting

3. Assess the probability of each scenario

Using available scientific forecasts, exploration of past frequencies, or just expert heuristics, decision-makers attribute a plausible probability to each scenario. Forecast range will often be weeks or months, but can extend to years for decisions with long-ranging consequences, such as investing into perennial crops.

4. Take overall risk-minimizing decisions

Based on experience or scientific know-ledge, decision-makers specify an optimal strategy for each scenario. Then, the overall balanced strategy can be calculated by considering the different probabilities of the scenarios. For example: a farmer needs to balance the risk of crop failure due to drought (affecting maize more strongly than sorghum) and the risk of too low production (as sorghum is less productive than maize).

Scen.	Probability	Optimal planting strategy (based on scientific knowledge and experience)
1	50 %	2 acres of maize
2	30 %	1 acre of maize, 1 acre of sorghum
3	15 %	2 acres of sorghum
4	5 %	2 acres of sorghum

The overall risk-minimizing planting strategy can be calculated from the individual optimal strategies:

Scen. 1	0 acres sorghum	*	50 % +
Scen. 2	1 acre sorghum	*	30 % +
Scen. 3	2 acres sorghum	*	15 % +
Scen. 4	2 acres sorghum	*	5 % =
	0.7 acres sorghum		

With the given scenario probabilities, the overall risk-minimizing strategy would be to plant 0.7 acres of sorghum and 1.3 acres of maize.

5. Still plan a response for each scenario

Defining and following an overall risk-minimizing strategy lets food system stakeholders enter the future from a position of strength. Nevertheless, depending on how the future unfolds, different economic risks may emerge.

The last stage of scenario planning is to devise, for each explicit scenario, a sequence of actions to take to mitigate the remaining risk of economic losses. For example:

Scen.	Remaining risk	Scenario plan
1	Farm output below potential	Business as usual
2	Maize affected by drought, farm output below potential	Apply chemicals to achieve high market value with remaining maize harvest
3	Maize plot fails, replanting costly	Replant just 1 acre, then business as usual
4	Insufficient farm output to feed family	Sell assets, work as farm laborer

Use case examples

Probabilistic scenario planning in agriculture can potentially be useful to a range of stakeholders. For example: Extension services can set priorities in training and advisory activities by exploring different climatic and market scenarios. Input providers, such as seed and fertilizer dealers, can use it for planning investments into new products or distribution of existing ones. Researchers, including breeders, can anticipate future need for their outputs, in order to prioritize high-impact research activities.

Case study: Matching seed supply and demand in sub-Saharan Africa

Many seed companies offer various varieties of the same crop, targeting different agro-ecologies or market segments. For example, farmers can choose between early-maturing, average, and late-maturing maize varieties. In many years, however, some high-demand varieties sell out, while low-demand varieties are eventually shipped back to seed companies, who need to re-package or destroy the seed.

Because farmers often select which varieties to purchase just before the season, it is hard for seed companies to predict sales. Thus, every year, seed companies supply a similar, long-term average mix of varieties. This can lead to the above-mentioned suboptimal outcomes for both farmers and seed suppliers. Variation in farmers' seed demand between years can, however, be linked to climatic events: in dry years, seed companies typically sell different seed quantities (for example, more early-maturing varieties) than in years with abundant rainfall.

Today, free online seasonal climate forecasts give an indication of total seasonal rainfall abundance with up to six months lead time. These forecasts provide probability estimates for simple seasonal scenarios (dry / average / rainy season). Using such climate forecasts, seed suppliers can anticipate farmers' seed demand and adapt seed distribution accordingly. We collaborated with SeedCo, Ltd. (Zimbabwe) on developing a simple three-step procedure for forecasting next-season seed demand with scenario planning:

1. Analyze data on past seed sales regarding differences in variety demand by scenario (dry / medium / wet year). Calculate 'typical' seed demand pattern by scenario.
2. Retrieve probabilistic seasonal climate forecast, for example, from ECMWF's *Copernicus Climate Change Service*. This will give a probability for each scenario in the upcoming season.
3. Anticipate next season's seed demand by weighing in the probabilities of the three scenarios and their associated 'typical' seed demand.

This procedure has been implemented in an MS Excel workbook with external weblinks embedded. It helps seed companies to adapt their decisions about seed distribution priorities, for example, regarding packaging, cleaning, logistics, and promotion of different varieties.

Funding This work was undertaken by the Alliance of Bioversity International and CIAT as part of Integrated Seed Sector Development in Africa (ISSD Africa), funded by the Swiss Agency for Development and Cooperation (SDC).

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The Alliance is part of CGIAR, the world's largest agricultural research and innovation partnership for a food-secure future dedicated to reducing poverty, enhancing food and nutrition security, and improving natural resources.

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