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Innovative Management Systems to Cope with Drought: The Case of South-Western France

Yoro Sidibe

Universite Montpellier, sidibey@supagro.inra.fr

Jean-Philippe Terreaux

Mabel Tidball

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Innovative management systems to cope with drought

The case of south-western France

ABSTRACT

Water managers are increasingly aware of the problem of water scarcity and the randomness of rainfalls. This problem is exacerbated by recurrent droughts observed in south-western France. In the given context of climate hazard, some management companies have introduced new water pricing methods with very specific features aiming particularly at a certain anticipation of the demand of irrigation water. The objective of this research is to analyze the effect induced by the application of these different water pricing methods on water demand, especially in case of drought, on farmers' income and on the revenue collected by the management company. To undertake this analysis a stochastic model that simulates farmers' behavior and their response to different water pricing scenarios has been built. Empirical application of the model has been carried out with the help of an agronomic model of plant growth and data collected from Midi-Pyrénées (France). The results show that these pricing policies create a wide range of effects that can be searched by management companies according to their characteristics and their access conditions to the resource. These pricing systems prove to be powerful tools to mitigate the impact of drought.

INTRODUCTION

The balance between supply and demand for food is heavily dependent on irrigated agriculture (FAO, 2004). This will continue to play a fundamental role in the fight against malnutrition and contribute significantly to food security in the world. For most Mediterranean regions, agricultural production depends mainly on water brought in through different irrigation systems especially south-western France where agriculture is the largest water consumption sector with 80% water use in summer. This problem has become much more acute in recent years because of recurrent drought events.

In the face of this situation, traditional economic solutions can't provide satisfactory solutions. Irrigation water management must indeed meet several objectives and satisfy multiple constraints. These objectives include efficiency of water allocation, especially binding in case of scarcity, equity in sharing (between farmers or between farmers and manager) and costs recovery. The major constraints faced by water managers are the climate uncertainties and severe drought episodes leading to water use restrictions. Due to the time delay between the decision to plant and the climatic event (mainly rainfall), the farmer in temperate climates makes planting decisions (especially for seasonal crops) before he knows the amount of rainfall that will come in the summer. He will therefore not be able to adjust the various decisions, either the choice of crops (more or less water consuming crops) or the technical route.

Some water management companies in France developed original water pricing methods to manage the negative impacts of drought episodes. The methods, especially adapted to their operating situation are based on a previous water subscription before the agricultural season which makes it possible to reveal some information about future irrigation water demand. In this study we show that these pricing systems allow forecasting water demand, which leads to a better management of drought. Our purpose is to analyze these unusual pricing methods and to show how their interesting properties can help in managing drought. To do this, a farmer's decision model in uncertain environment is built based on microeconomic theory. This stochastic model is then used with data collected in the south-west France, which allows us to run simulations and determine the effects of the pricing methods.

METHODS AND DATA

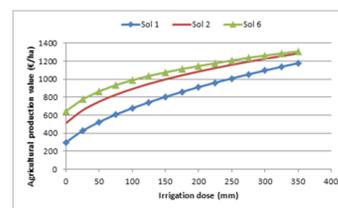
The concerned companies are CAEDS and CACG. We translate their pricing schemes into mathematical formulas. We construct an economic model in uncertain environment representing the rational farmer's water consumption decision problem with different possible states of nature "drought" and "humidity". We then carry out simulations to determine the effects of the pricing methods on farmers' profits and water manager's revenue.

The two pricing systems are compared according to various economic criteria including the profit of farmers, the income of the manager and the total value of agricultural production. These various indicators of performance of the pricing system are compared for identical water consumption (we calibrate the two pricing systems to have the same water consumption for the farmer).

A second comparative method of analyzing water levels is employed. It involves comparing for similar agricultural production levels, the quantity of water consumed in a dry year, in a wet year and the average consumption with the two forms of pricing. This information is very useful because it allows assessing the management capacity of a drought of a pricing system compared to the others for example by limiting the use of the resource in case of water scarcity.

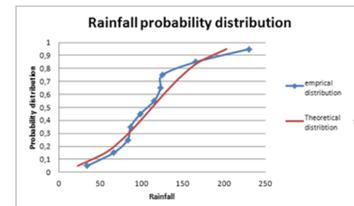
Estimation of production functions

The data we used are related to agricultural and climatic parameters for a period of 10 years (1998 to 2007). The estimation is based on the use of the crop growth model STICS (A model to estimate a production function with the vector of the quantity of water supply at different dates). We then complete with a further step using a maximization program to determine a production function with only one variable corresponding to the total amount of water brought to the cultures during the irrigation season.

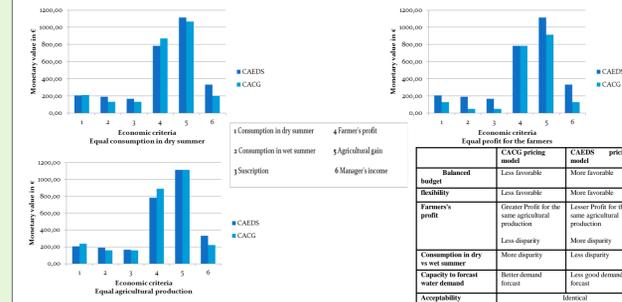


Specification of rain levels

To determine the levels of rain, in dry summer or humid summer, and their probability of occurrence we use rainfall data from 1998 to 2007. We define drought by setting an arbitrary drought probability. The dry year is then defined as any year in which the rainfall is less than the rainfall that has a certain non-exceedance probability. We will then vary the non-exceedance probability in order to check the stability of the results relatively to the chosen value.



RESULTS



The farmer always has a higher consumption of water in a dry summer irrespective of soil type and pricing system in question: In other words, the drought leads the farmer to have a greater reliance on water from irrigation to compensate for the climate deficit.

With the same agricultural production, the CAEDS pricing system is more favorable to the manager in terms of revenue while the CACG pricing is more favorable to the farmer in terms of agricultural profit. Water consumption in the two cases is substantially equal on average. However, CAEDS pricing allows a more balanced distribution between dry summer and wet summer in that it induces lower consumption in the dry summer and increased water consumption in wet summer compared to the CACG pricing system. Water consumption for pricing CAEDS is less variable at a cost of a greater variability in farmers' profits. The results remain consistent if farmers are slightly risk averse.

The economic rationale behind these pricing models can easily be accounted for if we consider the specific context of each water managing company. These pricing policies that are similar in some particular features (priced subscription and consumption) are nevertheless different in regard to their effects on income distribution between farmers and the manager and on the use of water in case of a drought or abundant resource availability. Important and interesting lessons can be deduced from these pricing systems by focusing on specificities of management agencies.

The CAEDS pricing system is effective for reducing the gap between the consumption of water in dry summer and the consumption in humid summer. Note that the CAEDS faces more severe drought conditions than the CACG. The ability to reduce water demand when the resource is less available compensated by an increased demand when there is much water makes it less necessary to forecast water demand. The CACG implemented a pricing method able to predict more correctly the future water demand before the agricultural season. In addition, the CACG has a network of pipes connecting several watercourses across a wide area. Anticipation of demand can then be valorized easily, by for example moving water masses in time from an area of activity where water is less valued to another area where water demand is greater.

Finally, the CAEDS is a smaller company compared to the CACG. The social capital of the CACG is 4 times greater than that of the CAEDS (2.1 106€ vs 0.5 106€). In addition, the CACG operates in a range of activities much broader (regional planning, environment, etc...) while the CAEDS deals only with water management. Therefore, the CAEDS has a budget constraint probably stronger than the CACG. By allowing to collect a greater revenue for the management company (than the pricing system of the CAEDS), their pricing model reduces the important budget constraint they face.

CONCLUSIONS

The studied pricing systems, beyond the traditional objectives of pricing (efficiency, equity, coverage of costs), seek to answer another important dimension which is the search for a certain anticipation of the irrigators water demand. Through previous subscription (reservation of water) in early summer, the manager is able to avoid certain management difficulties due to a sudden discrepancy between supply and demand of water. Our study was conducted in a framework integrating climatic risks, a stochastic context which plays an important role in irrigation water management.

In comparative terms, the results show that the two pricing systems have different strategies to cope with drought. Ultimately the choice of one pricing system or the other will depend strongly on the relative weight that the manager of the resource allocates to each benefit. By adopting innovative pricing models in harmony with their operating environment and technical capabilities, the water companies under consideration have shown how the adaptation of management practices can have significant impact on the management of hazards associated with water resources. These pricing systems prove to be insightful tools to mitigate the impact of drought. This study provides useful lessons for the design of water management policies.

The greater the impacts of climate variability, the more important is the development of innovative tools needed to ensure the survival of farming systems in harmony with both other water consuming sectors and the environment. A fundamental problem that will confront policymakers in the coming years is the management of various risks and uncertainties. The pricing systems analyzed here may help to meet the need to develop appropriate management tools to reduce the vulnerability of farms. It is possible to improve the systems studied here by enhancing positive aspects or to overcome some shortcomings. Finally we can make the two pricing systems more easily interpreted by farmers by summarizing them with a double-entry table (subscription and consumption).

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