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Original article

Management of water resources sector to face climatic shocks in Algieria: A dynamic CGE model analysis

Mohammed Touitou[1]*, Yacine Laib[1], Ahmed Boudeghdegh[2]

[1] Faculty of Economics and Business, University of Algiers 3, Road Ahmed Oueked, Dely Brahim, Algiers, Algeria
[2]Faculty of Economics and Business, University of Jijel, Jijel, Algeria
*E–mail address (*corresponding author): touitoutouitou@yahoo.fr; touitou.mohammed@univ-alger3.dz*
ORCID iD: Mohammed Touitou: https://orcid.org/0000-0002-4442-7888

ABSTRACT

Climate change is a major global issue, which is becoming increasingly important on the international scene. As it has a direct impact on ecosystems and societies. Water is at the heart of these changes. The aim of this article was to capture all the microeconomic and macroeconomic effects of resource availability, and to propose a sequential dynamic computable general equilibrium (CGE) model that takes into account long-term changes in the availability of the primary resource (water supply) with regard to population growth (demand). The results show that the very negative effects on the economy of water shortages could be counteracted by the introduction of a marginal cost demand management policy. This makes it possible to better manage the scarcity of this resource. In fact, the model shows that when Algeria is facing water deficits, the marginal cost tariff policy reverses the trends of an economy that would maintain a tariff policy at average cost. Total investment increases, and total welfare deteriorates less. The drop in the price of water (input and final good), generated by the transition from an average cost pricing to a marginal cost pricing, generates an expansion of many sectors, and stimulates economic activity which reduces the rate of unemployment.

KEY WORDS: water resources, climate change, CGEM, SAM, Algeria

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1. Introduction

Water is a vital resource for the demographic and economic development of the planet and its problem does not arise in the same terms according to the level of economic development social and political reach of different countries. The imbalance between an ever-increasing demand and a reduced supply poses the problem of managing the scarcity of water. The uneven distribution of this resource across countries creates tensions and creates a source of conflict.

With a strong growth in demand for water, the Algerian government first tried to cope with its scarcity by engaging, in the 20 last years, in many investment programs, to increase production capacity. At the same time, the idea of rationalizing the use of water through better demand management has developed. Moreover, despite a proactive policy to combat supply/demand mismatches, Algeria is likely to experience significant water deficits, taking into account the evolution of demand (economic growth) and population growth. These water deficits could be worse if climatic hazards lead to a decrease in rainfall (and thus drought).

To capture all the microeconomic and macroeconomic effects of resource availability, on the one hand, and water pricing policy, on the other hand, we proposed a sequential dynamic computable general equilibrium (CGE) model to take into account long-term changes in the

availability of the primary resource (supply) with regard to population growth (demand). The model shows how the economy faces the future risks of water shortages, amortizes the long-term shock according to whether it maintains its current pricing policy at the average costs (sector's budget balance) or whether it introduces pricing at marginal cost (via the granting of a State subsidy for the survival of the sector). The originality of the model is based on the modelling of a potable water production sector in a natural monopoly as well as a fine disaggregation of the distribution market (private connection, standpipe and informal) and water uses.

More precisely, the model simulates in the short term a phase of increasing the availability of the resource (justified by the policies of increasing supply and the current rather favourable rainfall context) followed by a phase of deficits in anticipation of future demand trends and the risks of new droughts in Algeria. These climate shocks are simulated in combination with two tariff policies for water demand management: average cost pricing versus marginal cost pricing.

The first section of the article presents the basic data on water resources in Algeria to combat the risks of supply/demand mismatches. The second section presents, in the light of the literature, the originality of the CGE model and the simulations developed. Finally, the last section presents the results of climate shocks combined with the two-demand management and scarcity policies (average cost pricing versus marginal cost pricing).

2. Basic data on water resources in Algeria

As one of the 17 African countries affected by water stress, Algeria ranks among the poorest countries in terms of water potential, which is below the theoretical scarcity threshold set by the World Bank at 1,000 m^3 per capita per year. In 1962 the theoretical water availability per inhabitant per year was 1500 m^3, it was only 720 m^3 in 1990, 680 m^3 in 1995, 630 m^3 in 1998, 500 m^3 and in 2020 it will be only 430 m^3. The availability of potable water in Algeria in m^3/inhabitant will slightly exceed the threshold of 400 m^3/ha (WHO standard).

The issue of water is inseparable from sustainable development in that water must meet the needs of current generations without preventing, the ability of future generations to satisfy theirs. It should be dispose between 15 and 20 billion m^3 per year, with 70% reserved for agriculture, to achieve satisfactory food security. This is a huge challenge when we know that we mobilize barely 5 billion cubic meters of water per year. The pressure exerted on these resources will continue to grow under the combined effects of population growth and policies applied to water-consuming activities.

This situation, linked to the weakness of the resource, aggravated by drought, will imply ipso facto between the different users of the serious conflicts which will inevitably require difficult arbitrations for the public authorities, and this especially as the needs of the potable water supply (AEP) will be multiplied by 2,5 approximately in twenty five years and that they will represent practically 40% of the mobilizable resources towards the year 2025. The 21st century promises to be marked by worsening water shortages. Particularly in the western parts of Algeria despite the use of other forms of water mobilization.

2.1. Water resources

Algeria is divided into 5 river basins grouping 17 watersheds. Water resources are not distributed equitably, either in terms of their geographical distribution, quantity or nature (surface or groundwater).

The overall water potential. The overall water potential is estimated at 19.4 billion m^3/year. The resources contained in the groundwater of the north of the country (renewable resources) are estimated at nearly 2 billion m^3/year. The surface water resources are estimated at 12 billion m^3/year. The southern part of the country is characterized by the existence of considerable groundwater resources from the Continental Intercalary (CI) and Terminal Complex (TC) aquifers. These water reserves are very important and are of the order of 60 000 billion m^3 of which 40 000 billion $m^3$are located in Algeria. This resource is not renewable.

Mobilization capacities. Total mobilization capacity is 12 billion m^3/year including: (i) a volume of 6.8 billion m^3 in the north (5 billion m^3/year of surface water, 1.8 billion m^3/year of groundwater) and (ii) a volume of 5.2 billion m^3/year in the Saharan regions, which equates to exploitable reserves without risk of hydrodynamic imbalance. These resources are mainly mobilized by:

(i) dams: the total capacity of the 59 dams in the 5 river basins is 6 billion m^3 in 2008 and a regularizable volume of 3 billion m^3. On the basis of the projects carried out, Algeria currently has a large mobilisable resource, consisting of 72 dams increasing the mobilization capacity to 7.40 billion m^3;

(ii) groundwater exploitation currently reaches 1.6 billion m^3 by drilling and 85 million m^3 by foggaras;

(iii) desalination of seawater is practiced in 23 stations with a capacity of 347 000 m^3/day including three large stations.

2.2. Water problems related to climate change

Climate change: an aggravating factor. The climatic data recorded in the Maghreb region during the 20th century indicate a warming during this century estimated at more than 1°C which has been accentuated over the last thirty years. General circulation models converge to estimate a probable warming of the region in the order of 2° to 4° during the 21st century (HARTMANN ET AL., 2013). Due to its geographical position in the arid and semi-arid zone, Algeria is subject to unfavourable physical and hydro-climatic conditions, accentuated by periods of chronic drought. It has a high sensitivity to climate, especially in the highlands and steppe regions, which cover about 60% of the viable land in the North. The effects of climate change are therefore unavoidable and will result in significant impacts, linked, among other things, to increased temperatures and precipitation, the scarcity of water resources and an increase in the frequency of storms. Other impacts are being studied: such as biodiversity loss and ecosystem degradation, increased risk of famine, population movements, and health impacts.

Changes affecting dam water. Changes in surface water retention are due to siltation and reduced runoff. *Siltation*: The nature and morphology of sloping land, the fragility of vegetation cover, the lack of afforestation and urbanization upstream of the dams cause a strong erosion effect (MANDANA ET AL., 2012) which reduces the storage capacity of dams by 2 to 3% each year due to siltation because of transport and deposition of sediment by rainwater. Currently, 14 dams out of the existing sixty are silted. *Decrease in runoff*: The contribution of runoff to surface water has systematically decreased. Flows that are too weak do not sufficiently fill existing dams.

The impact of climate change on irrigation. Recent climatic fluctuations and droughts, which have been more frequent over the last three decades, have exacerbated the phenomenon of soil degradation, resulting in the desertification of vulnerable areas such as steppes and high plains. The current trend towards more intense floods could lead to greater erosion and soil degradation. These lands have real agricultural potential and could ensure the country's food security and the protection of the coastal fringe.

3. The originality of the CGE model in the light of the literature

3.1. Literature

In the CGE models applied to Algeria, there is no work integrating water resources. Several studies consider it as a factor of production used by agriculture (BERCK ET AL., 1991; ROBINSON & GEHLAR, 1995; GOODMAN, 2000; GOMEZ ET AL., 2004; THABET, 2003). We retain this hypothesis. However, in our model, the primary resource is a factor of production used, on the one hand, by agriculture but also by the potable water production sector whose role it is to transform this primary water into potable water.

First and foremost, CGE models were built to simulate potable water supply policies. These models address the issue of water using an approach by quantities. Some highlight the impacts of policies aimed at increasing the availability of the resource or analyzing the consequences of a decline in the water supply (BERCK ET AL., 1991; ROBINSON & GEHLAR, 1995; LÖFGREN & ROBINSON, 1997). The limit of these models is that water is consumed only by agriculture and not by other sectors and households. This is why other models have focused on the question of the reallocation of water between different uses (SEUNG ET AL., 2000; GOODMAN, 2000; GOMEZ ET AL., 2004). It is interesting to note that the models developed by BERCK ET AL. (1991), ROBINSON & GEHLAR (1995), LÖFGREN & ROBINSON (1997) and GOMEZ ET AL. (2004) are all based on the assumption of water supply exogenous. In that of GOMEZ ET AL. (2004), applied in the Balearic Islands, the water supply (which depends on the level of supply of the primary resource) is determined by the degree of drought. We retain in our model this hypothesis of a stock of exogenous supply of the primary resource. Finally, GOODMAN (2000) introduces into the agricultural production function a substitution between land and water, an assumption that we retain in our model.

The second category of CGE models explicitly addresses the issue of pricing tools as a demand management policy. These models, are much rarer, and address the issue of water in a price approach. In fact, it is in a context of increasing scarcity of resources that the latter seeks to simulate tariff policies for managing the demand of potable water (HORRIDGE ET AL., 1993; DECALUWÉ ET AL., 1998, 1999, 2001; THABET, 2003). In the last two articles, their first contribution is to have introduced a demand

for potable water from the agricultural, and industrial, services (as intermediate good) and household sectors (as final goods), thus generating real conflicts from the use of the resource, in particular following the price shocks that they operate. Their second contribution is to have explicitly modelled a potable water production sector, which is very rare in the literature. THABET (2003) modelled a potable water production and distribution sector by adopting the following assumptions: first, he considers that this sector buys primary water from the State (an assumption that we retain in our model). This water is then transformed into potable water according to a conventional production process: the primary water is combined in fixed proportions with the aggregate resulting from a CES function between capital and wage labour to form the value added of the sector. The latter is used in fixed proportions with other intermediate inputs to produce potable water. DECALUWE ET AL., (1998, 1999, 2001), through the Weibull function, developed an original water production technology that accounts for the exploitation of groundwater. Potable water is produced from two technologies: the first provides users with water from dams while the second relies on water from pumping and digging wells. However, neither of the two models takes into account the peculiarity of the structure of the water market (natural monopoly with increasing returns to scale). In addition, these studies focused only on the issue of the pricing of water for agricultural use. Moreover, the models developed by these authors are only static models.

In the light of this literature, in order to deal with the issue of managing the increasing scarcity of water in Algeria, we propose a CGE model that presents three originalities: (i) a representation of the specificities of the potable water distribution market; (ii) a sequential dynamic recursive approach taking into account the future evolution of demand (population growth) and the availability of water resources; (iii) modelization of the potable water production sector in a situation of natural monopoly (increasing returns to scale) in order to compare, in the short and long term, the effects of the average cost and marginal cost pricing of potable water.

3.2. The originality of the CGE model

A climate scenario developed through a recursive sequential dynamic approach. The interest of the dynamic model is to simulate a more sophisticated climate scenario than with a static model. It makes it possible to take into account the dynamics of the evolution of the availability of the water resource in order to give a better account of the reality. In fact, we simulate on a horizon of 20 years:

(i) a first phase of increasing the availability of the resource. This is justified both by the policies of increased supply which allow a greater mobilization of the primary resource but also, by the recent tendency towards an increase in rainfall (the rains of these last years are more abundant than the average);

(ii) a second phase characterized by a stability in the availability of the resource;

(iii) a third phase marked by the appearance of water deficits. This is justified both by forecasts of future demand that exceed supply capacities (taking into account demographic trends and economic development) but also by future risks of drought.

4. The model

The model is based on the Exter neoclassical static model developed by DECALUWÉ ET AL. (2001) but differs from it in many respects. First, the model has four production factors (labour, capital, land, and primary water), while Exter has two (labour and capital). The typology of the households differs. The model incorporates a linear expenditure function (LES) with a minimum basket of consumption for each household category, while in the Exter model consumption is a fixed proportion of disposable income. Inter-household transfers and between these and the rest of the world are explicitly taken into account. Given the characteristics of the potable water production sector, we model a natural monopoly with increasing returns to scale. We introduce an efficiency wage and an endogenous involuntary unemployment function. Finally, it is a recursive sequential dynamic model.

The model comprises ten blocks of equations: the production of potable water at increasing returns of scale, the production of the other sectors (in pure and perfect competition), the incomes and savings, taxes, demand, foreign trade, prices, equilibrium conditions in the labour market (with unemployment), other equilibrium conditions and dynamic equations.

The model solved on 20 periods and includes a total of 13,306 equations for 13,306 endogenous variables and 2,255 exogenous variables (resolved under Gams). Under the small country assumption, world prices for imports and exports assumed to be given. We assumed a fixed public consumption. The total supply of land factor is assumed exogenous. Demand for primary water factor by the irrigated crops sectors and the production of

potable water is fixed. Finally, dividends and transfers between different agents are exogenous.

5. Results of simulations of average and marginal cost policies associated with the climate scenario

Both simulations relate to the same climate scenario. This one allows a representation of the dynamic and long-term evolution of the availability of water resources in Algeria. We simulate a 25% increase in the availability of the amount of primary water used for irrigatation of crops and potable water sectors over the first three periods (1, 2 and 3); then we simulate a 25% drop in the amount of primary water used by the irrigated crops sectors and the production of potable water in periods 7, 8 and 9. All other periods are characterized by climatic stability in terms of the availability of water resources. What distinguishes the two simulations is the tariff policy for managing the water demand that accompanies these climate shocks. The first scenario is that of a tariff policy at average cost, and the second is the introduction of marginal cost pricing with a subsidy from the state to the potable water production sector. We compare the short-term (2009) and long-run (2028) effects of these two policies associated with climate shocks on the Algerian economy.

5.1. Average cost pricing in the face of climate shocks

In the short term (2009). Increase in the availability of the primary resource in the short term directly benefits the potable water production sector and irrigated crops. First, it causes a decrease in the average cost, the marginal cost and the price of production and consumption by 35.1%. This drop in the cost of potable water input directly benefits the potable water distribution sectors. In fact, the prices of production and consumption of water at the private branch and at the standpipe decrease respectively by 10.77% and 9.19%. The increase in the quantity of available primary water then generates an increase in production of the irrigated crops sectors (+7.98%), potable water production (+2.44%), distribution at the private branch sector (+1.71%) and the standpipe (+9.29%).

Given to the Leontief's production function in these sectors, their respective intermediate inputs increase in the same proportions. There is therefore a ripple effect on other sectors whose production is also increasing but to a lesser extent (except fishing and the intensive water industry). There is therefore an overall expansion of sectors that also responds to an increase in demand via its three components: intermediate demand, final consumption of households and investment requests. This increase in demand is illustrated by an increase in imports (except for irrigated crops, the local production of which is sufficient to meet the demand). This can be explained firstly by the increase in intermediate demand linked to the expansion of the sectors and the fall in the price of potable water, but also to a rise in agents' incomes. The income of the agents has indeed increased due to the increase in the factorial remuneration. In fact, wages and the yield of the land increase respectively by 0.62% and 0.47%, the remuneration of the capital having also increased in all sectors (except that of irrigated crops and the production of potable water).

In fact, in these last two sectors, primary water substituted for other factors (labour, capital and land) could therefore be absorbed by the other sectors that must ensure their expansion. In particular, the potable water distribution sectors benefit largely from the release of the labour force, in particular the work-intensive fire hydrants sector. Other agricultural sectors also benefit from the land liberation of the irrigated crops sector. It is horticulture (the most expanding agricultural sector after irrigated crops given the lower cost of water input) which takes up most of the land (+1.15%, and +0.26% respectively for horticulture and other agriculture).

At the household level, the shock combined with maintaining the current policy at average cost generates in the short term an increase in the welfare of all households except those in the river (down 0.06%). Increase in the welfare of urban households is greater (+0.53% for Algiers and + 0.25% for other urban centres) than for rural people (+0.03% on average).

At the macroeconomic level, although government savings are falling (due to the falling of primary water payments), total investment is increasing by 1.01%. This is explained by an increase in the savings of other agents (households and businesses) related to an increase in their income from other factors whose remuneration has increased. Thus, total welfare increases by 0.79% (taking into account rising incomes and consumption) and the unemployment rate decreases by 0.7% due to the expansion of the Algerian economy. Finally, in terms of potable water distribution, the policy of increasing supply generates in the short term a substitution of the standpipe (+9.42%) for private connection (+1.81%) and the formal in the informal (+0.58%).

In the long term (2028). Ten years after the water deficit shock experienced over three periods, the average cost, marginal cost, and production and consumption prices of potable water increased by 17.77%. This results in an increase in the cost of potable water input by the other user sectors. This decline in the availability of the resource generated a drop in potable water production by 3.61% and irrigated crops by 13.7%. The drop in production of potable water combined with the rise in the price of potable water has led to a fall in production of the water-intensive sectors (-0.55%, -0.59%, -0.77%; -0.78%, -0.99%, -2.46% and -10.14% respectively for industry and commercial services intensive water, energy, informal distribution of water, horticulture, private connection and the fire hydrant). The distribution of potable water is therefore very affected. Given to the fall in the same proportions of their intermediate consumption, the other sectors by training effect also contract.

The fall in production of irrigated crops is partly offset by the rise in imports (+6.65%), but this is not the case for other goods and services whose imports are falling. This reflects a contraction in domestic demand that we must then explain. In the irrigated crops sector, the decline in the availability of primary water resources is offset by an increase in the demand for other factors. Labour, capital and land are substitutes for primary water. Their respective demands increase by 0.85%, 0.47% and 0.63%. The increase in demand for land by irrigated crops is to the detriment of other agricultural sectors, especially horticulture since it is highly water-intensive (and this is very much affected by an increase in the price of water), it is the agricultural sector after irrigated crops which contracts the most. Similarly, in the potable water production sector, the decline in the availability of primary water resources is offset by an increase in the demand for labour and capital factors (+24.43% and +23.49%) to the detriment of other sectors. This decline in factor demands by other sectors is due to their contraction.

At the household level, in the long term, given the water deficit, there is a deterioration in household welfare. The welfare loss of urban households (-0.46% for Algiers and -0.22% for other urban centres) is stronger than that of rural people (-0.04% on average).

At the macroeconomic level in the long term, there is a general contraction of the sectors. Despite an increase in primary water wages, which leads to an increase in government savings, the fall in wages of other factors (wages and return on capital) generates a decline in the income of other agents and therefore their savings. Thus, investment and total welfare deteriorate by 1.02% and 0.73% respectively and the unemployment rate increases by 0.89%. In terms of potable water distribution, the water deficit affects in the long term the distribution via the standpipes more (-10.14%) than that via the private connection (-2.51%). Informal distribution is the least affected (-0.82%) since it plays a regulatory role in the face of scarcity.

5.2. Marginal cost pricing in the face of climate shocks

It is assumed that the State decides to implement a pricing policy for potable water at marginal cost. A potable water production price is then set such that is no longer equal to its average cost (1 to the base year) but equal to its marginal cost (0.771). To maintain the survival of the sector, the State pays a subsidy to offset the loss.

In the short term (2009). The increase in the availability of resources allowed by the policies of increased water supply combined with the implementation of a policy of marginal cost pricing leads in the short term to a fall in the average and marginal costs of potable water production by 32.32%, the prices of production and consumption of potable water decrease more than in the first scenario (-46.86% against -35.1%). This follows a stronger decline in the cost of potable water input for the user sectors. In fact, the prices of potable water distributed by private branches and at the standpipe are lower than in the first scenario (respectively -12% against -10.77% and -10% against -9.19%).

Thus, the increase in production of the potable water sectors is also accentuated (+4.03% against +2.87% for the production of potable water, +2.47% against +1.81% for the distribution at the private branch, +14% against +9.96% for distribution at the standpipe). This means that the increase in their intermediate consumption is also evolving in stronger proportions than in the first scenario with a ripple effect on other sectors also being stronger. This is why increases in production from other sectors are also in stronger proportions. This increase in supply responds to a short-term demand that is itself rising. In fact, the expansion of water-intensive sectors, via the increase in intermediate demand and the fall in the price of potable water, explains this upward trend in total demand.

The latter is ensured by the increase in agents' incomes caused by an increase in factorial remuneration, which is greater than in the first scenario: the wage rate and the return on the

land increases respectively by 1.09% against 0.62% and 0.82% against 0.47%. Similarly, the return on capital increases more in all sectors except irrigated crops and the production of potable water where it decreases according to the first scenario. These changes in factor pay are explained by the fact that in the irrigated crops and potable water sectors, primary water replaces other factors absorbed by other expanding sectors. Increases in the demand for labour in the private branch and the standpipe sector are stronger (respectively +14.07% and +36.64% against +9.98% and +25.73%). In the agricultural sectors, land released by irrigated crops (-1.42% against -1.33% in the first scenario) is dominated by horticulture even more (+ 1.5% vs. +1.2%).

At the household level, the shock combined with implementation of a marginal cost pricing policy generates in the short term an improvement in the well-being of all households. This rise in well-being is, as in the first scenario, higher for urban dwellers (+0.71% for Algiers and +0.34% for other urban centres) than for rural dwellers (+0.5% on average) but in further proportions. This means that the introduction of marginal cost pricing accentuates the beneficial effects of the shock on household welfare.

At the macroeconomic level, the introduction of marginal cost pricing reduces primary water wages less. The State's payment of a subsidy to fill the budget deficit of the potable water production sector results in the deterioration of the government savings of 5.77% against 1.84% when the State does not intervene in the first scenario, but this does not hinder the level of total investment quite the contrary. The latter increases by 1.80% against 1.01%. This is explained by an increase in the savings of other agents that more than compensate for the decline of the State. In the end, the stronger expansion of the economy with the introduction of marginal cost pricing generates a greater increase in total welfare (+1.08% vs. +0.79%) and a decrease in unemployment rate (-1.3% vs. -0.7%). In terms of distribution of potable water, we observe the same results as in the first scenario even if they are more accentuated. That is, a substitution of the standpipe (+13%) for a private connection (+2.47%), which means a strong development of the park of the standpipes following the policies of increase in the supply, and a substitution from formal to informal (+0.77%).

In the long term (2028). We observe that the implementation of a marginal cost pricing policy in the long term counterbalances the negative effects on the economy of the water deficit shock. In the long term, the average and marginal costs of potable water production increase by 19.48%. But the price of production and consumption of potable water decreases by 7.82% while it increases by 17.77% in the first scenario. Long-term trends are completely reversed depending on whether the government is pursuing a pricing policy at average cost or marginal cost. This result shows that in the long term, a marginal cost pricing policy is even more beneficial than in the short term. The analysis of the evolution of the other aggregates we demonstrate it.

Despite the resource scarcity shock, the price of produced potable water decreases, which translates to a drop in the cost of potable water input for the other water-intensive sectors. In fact, the prices of potable water distributed at the private branch and at the standpipe decreased respectively by 2.92% and 2.88% while in the first scenario (average cost pricing), they increased respectively by 7, 28% and 7.35%.

To understand the financing of total investment, it should be emphasized that business savings increases by 2.8% and foreign savings by 14.94% with the marginal cost pricing policy while decreasing respectively by 3.22% and 5.03% with the average cost pricing policy.

Finally, with the introduction of marginal cost pricing, as a result of the scarcity of the resource, total welfare deteriorates less than in the case of average cost pricing (-0.15% against -0,73%). The expansion of most sectors enabled by the fall in the price of water boosted economic activity and reduced the unemployment rate by -0.47% while the latter increased by 0.89% in the first scenario. In terms of potable water distribution, we observe a reverse trend in the first scenario since the water deficit accompanied by a marginal cost pricing policy still allows in the long term, an expansion of the distribution with a substitution of the standpipe (+4.72%) at the private connection (+0.78%). This is explained by the investment dynamics. In fact, investments in the water sectors all increase, contrary to the first scenario. (respectively +34%, +2.43% and +7.84% for the production of potable water, the distribution at the private branch and the standpipe against +23.86%, -2.35% and -10,66%). Thus, unlike the first simulation, the informal sector no longer plays the role of regulator of the shortage since it decreases (-0.07%).

6. Conclusion

The model developed here makes it possible to simulate, in the short term, a phase of increasing the

availability of the water resource, (linked to policies to increase supply and the current favourable rainfall context) followed by a phase of future water deficits in line with forecasts for the evolution of demand and the risks of a new drought in Algeria. These climatic shocks are simulated in combination with two tariff policies for water demand management: average cost pricing versus marginal cost pricing. The results show that the very negative effects on the economy of water shortages could be counteracted by the introduction of a marginal cost demand management policy. This would makes it possible to better manage the scarcity of the resource. In fact, the model shows that when Algeria is facing water deficits, the marginal cost tariff policy reverses the trends of an economy that would maintain a tariff policy at average costs. When total investment increases, total welfare deteriorates less. The drop in the price of water (input and final goods), generated by the transition from an average cost pricing to a marginal cost pricing, generates an expansion of many sectors, stimulates economic activity which reduces the rate of unemployment. The agricultural production of cereals and horticulture is increasing while all agricultural sectors are contracting with average cost pricing. This tariff scenario appears to be beneficial in the fight against food insecurity, since, despite water deficits, agricultural production of irrigated crops and horticulture increase. Finally, the distribution of potable water at the private branch and the standpipes is growing grace to the dynamics of the investment, which increases the access of households to the improved services. The informal water sector is declining with the introduction of a marginal cost pricing policy while it is developing by fully playing its role of regulating the shortage with an average cost tariff policy.

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