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Agricultural reforms, jobs and poverty reduction: A dynamic CGE analysis

Soumana Harouna Idé
Saadatou Alkassoum Sangaré
Fatimata Ousseini
Bibata Mahamadou

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Résumé

Le Niger ambitionne de mobiliser et valoriser ses ressources en eau pour satisfaire ses besoins d'irrigation. La présente étude évalue l'impact d'une plus grande mobilisation de ces eaux sur les agrégats macroéconomiques : la production agricole, l'emploi, le revenu des ménages et la pauvreté. Le Modèle d'Equilibre Général Calculable (MEGC) dynamique est utilisé pour mettre en œuvre un premier scénario examinant les répercussions d'une augmentation de la production des eaux souterraines puis un autre portant sur les effets d'un accroissement de l'offre des eaux de surface. Les résultats estimés sur une période de 15 ans illustrent les mécanismes de transmission selon les types d'investissements privilégiés. Dans les deux scénarios, on observe une amélioration significative de la production agricole, la croissance économique et le revenu des ménages agricoles. Toutefois, les effets sont nettement plus importants lorsque des efforts sont fournis pour mobiliser les eaux de surface.

Mots clés : mobilisation de l'eau, eaux de surface, eaux souterraines, MEGC, réformes agricoles

Code Jel : C68 ; I38 ; Q18

Abstract

Niger aims to mobilize and leverage water resources to meet its irrigation water needs. This study evaluates the impact of large-scale water mobilization on macroeconomic aggregates: agricultural production, employment, household income, and poverty. The Dynamic Computable General Equilibrium (CGE) model was used to simulate a first scenario to examine the effects of an increase of ground water production and another scenario on the effects of the growth of surface water supplies. The results, estimated over a period of 15 years, show transmission mechanisms according to the preferred types of investments. In both scenarios, we observe a significant improvement of agricultural production, economic growth, and agricultural household income. However, the effects are obviously more important with greater efforts to mobilize surface waters.

Key words: water mobilization, surface waters, ground waters, CGE, agricultural reforms

JEL Classification: C68 ; I38 ; Q18

Authors

Mr. Soumana Harouna Idé
Doctor of Economics, Head of Research Unit to the Public Policy Analysis Unit and Evaluation of Government Action-Niger
soumharid@gmail.com

Ms. Saadatou Alkassoum Sangaré
Economist, Head of the Division Macroeconomic forecasting and modelling
Ministry of Planning-Niger
saadalk@gmail.com

Ms. Fatimata Ousseini
Economist, Director of Studies and Forecasting
Ministry of Planning-Niger
ousfa2002@gmail.com

Ms. Bibata Mahamadou
Economist, Human Resources Manager
African-Niger Handling
bibata1437h@gmail.com

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Acronyms and abbreviations

CES	Constant Elasticity of Substitution
CILSS	Permanent Inter-State Committee for Drought Control in the Sahel
ECVMA	Survey on Household and Agricultural Living Conditions
i3N	Initiative, Nigeriens Feed Nigeriens
INS	National Statistical Institute
LES	Linear Expenditure System
SAM	Social Accounting Matrix
CGEM	Computable General Equilibrium Model
MH/A	Ministry of Hydraulics and Sanitation
MP	Ministry of Planning
PANGIRE	National Action Plan for Integrated Water Resources Management
PDES	Economic and Social Development Plan
GDP	Gross Domestic Product
SEEN	Société d'Exploitation des Eaux du Niger
SNDI/CER	National Strategy for the Development of Irrigation and Consumption of Rice in Niger
TIEA	Table of Integrated Economic Accounts
SUT	Supply and Use table

I. Introduction

Niger is one of the Sahelian countries most affected by food crises. From 1970 to 2016, it recorded six major severe food crises[1], including three in the last 15 years (World Bank, 2013). In 2017, 47.6% of its population did not have a secure food supply (INS, 2017)[2]. The recurrence of food crises in Niger (Michiels et al., 2012) can be explained by the high vulnerability of the agricultural sector to climate variations linked to its predominantly rain fed productive structure. In fact, agricultural production is more than 74% rain fed despite the country's potential for irrigable land (270,000 ha) (Ministries of Agriculture, 2014) and large water resources (32.5 billion m^3/year) (Ministry of Hydraulics and Sanitation, 2017). Various agricultural reforms have been implemented since independence. Their mixed results cast doubt over the capacity of the "Nigeriens Nourishing Nigeriens" initiative (i3N, the nutrition strategy and sustainable agricultural development since 2011) to reverse the trend.

The objective of the i3N strategy is to reinforce food security and sustainable agricultural employment by developing irrigation (Office of the High Commissioner for the 3N Initiative, 2016). The mobilization and development of agricultural water resources are thus at the centre of the reforms undertaken by this program and during the second phase (2017- 2030) of the National Integrated Water Resources Management Plan (PANGIRE).

Would the increase in the availability of agricultural water, particularly from surface and ground water sources as targeted by the i3N initiative and PANGIRE, be able to improve the local supply (availability) of agricultural products? Would the impact on household income be big enough to guarantee people access to these products? What would be the best choice between increasing the availability of surface and ground water for the public authorities? The answers to these questions addressed in this paper are important for the government as part of the reorientation of i3N program's actions in order to achieve the targets set for 2035.

The study proposes to make an empirical contribution to the already existing economic literature on the issues of agricultural production, food security and agricultural water

[1] The periods : 1973/1974, 1984/1985, 1997/1998, 2004/2005, 2009/2010 et 2011/2012

[2] Food insecurity is determined in the survey based on the analysis of 5 indicators: the duration of available food stocks, food consumption knowing that a minimum standard of 2,200 cal/day is required for Niger (CILSS, 2004), the number of tropical livestock units, the share of food expenditures in total expenditures and adaptation strategies.

management in the Sahelian countries. Furthermore, it also carries out an impact evaluation of the strategic actions of agricultural reform programs in Niger, starting with a dynamic general equilibrium approach.

After the introduction, the second section of the study reviews the literature on irrigation and water management as part of a CGEM. The third section is devoted to the description of the methodology and the data used. The results are analysed in the section 4 and policy recommendations are presented in section 5.

II. Literature review

The rich existing literature on agriculture is clear on the decisive role of water in the development of agricultural activity. This factor is increasingly important, especially in the current context of climate change (Molden et al., 2007). In the Sahelian countries, the agricultural reforms undertaken by the public authorities aim, among other things, to increase the production of agricultural water in order to cope with the unpredictability of rainfall and the strong demographic pressure weighing on water resources. The decline in rainfall is most often characterized in these countries by a decline in agricultural production or an increase in food insecurity (Cabral, 2011).

Montaud et al. (2017) point out that the development of irrigation is one of the strategies that can reduce the vulnerability of the agricultural sector to rain and climatic change, thus improving food security. However, the development of irrigation requires the setting up of support schemes for farmers (training for example) so that the effects on poverty and the well-being of the populations are more significant (Beyene and Engida , 2016). Although irrigation is considered an effective strategy for developing agricultural production and enhancing the food security of countries vulnerable to climate change such as Niger, its implementation requires the rational exploitation of water resources. This requirement could lead to the authorities making compromises in the exploitation of ground and surface waters for agricultural purposes.

Indeed, Diao et al. (2008) have shown that the use of ground water reduces the negative impact of drought, and the redistribution of rural (agricultural) water to urban (domestic) water. However, according to Elame and Doukkali (2017) "the intensive use of irrigation decreases ground water resources making the commodity more scarce and therefore more expensive to extract". Declining agricultural water resources have negative impacts on GDP, agricultural production and employment (Berck et al., 1991), while population growth contributes to it (Watson and Davies, 2011).

Decaluwé et al. (1998) examined the effects of pricing policies on the economy. They show that an increase in agricultural water prices and a decrease in subsidies reduce agricultural production and gross domestic product, while the Government's income and savings increase. Although this study does not directly address agricultural water prices, it presupposes the application of a better pricing policy. With this in mind the i3N initiative plans for the setting up of decentralised agricultural water management units (Ministry of Agriculture, 2017).

Apart from the study by Montaud et al. (2017) which uses CGE analysis to analyse the effects of change on agricultural production in Niger, the work that uses this technique in the study of agricultural development issues related to water production are quite rare. Thus, the present study aims to complement that of Montaud et al. characterizing climate change with agricultural water through the modelling of water production, with a distinction between surface and ground waters, in order to analyse their impact on agricultural production and consequently on the welfare of households. It builds on the work of Decaluwé et al. (1998) taken up by Gosselin (2010). Water will not be considered as a production factor for the agricultural sector (like e.g. in Watson and Davies (2011) but rather as an intermediate demand. The Computable General Equilibrium (CGE) model allows, on the one hand, an adjustment of the market equilibrium by prices, and on the other hand, an introduction of the possibilities of substitution.

III. Data and methodology

3.1. Data

The Social Accounting Matrix (SAM) used is built using the 2014 National Institute of Statistics (INS) SAM macro which does not include any disaggregation of accounts (factors, institutions, activities, products, capital and the rest of the world). The main changes were to adapt this matrix to the needs and requirements of the study by disaggregating the accounts, especially agricultural activities, products, production factors and integrating into it an agricultural water production sector. These changes were made with data from the INS's 2012 disaggregated SAM, the Supply and Use Table (SUT) 2014, the Table of Integrated Economic Accounts (TIEA) 2014 and the results of the Survey of Conditions of Employment, Household Living and Agriculture (ECVMA) 2014)

Firstly, the 2014 agricultural sectors were disaggregated according to the structure of the 2012 INS's disaggregated matrix. Then, the disaggregation of factor and institutional accounts was based on information from the TIEA in 2014, while the break-up of the household accounts into 6 groups (public, private, informal, agricultural, non-agricultural and unemployed) is carried out based on the results of the 2014 Household Living and Agriculture Survey (ECVMA). On this basis, households allocate, on average, 24% of their income to the consumption of agricultural products, 10% to livestock products, fishing, timber and forestry, 17% to industrial products and 35% to services.

Finally, the water sector could be isolated from the production and distribution of electricity, water and gas account thanks to the additional information collected from the national accounts. This water corresponds to the domestic water produced by the Société des Exploitation des Eaux du Niger (SEEN), which is generally intended for use by households and firms. Agricultural water introduced into the SAM is used only by the various sectors of agriculture. It takes into account the fact that 74% of agricultural production is rain fed and that three crops share more than 76% of the rainwater, namely: millet (36.5%), cowpea (25%) and sorghum (14.9%).

Irrigated crops are grown on both large and small areas. Large-scale irrigation, particularly for rice (6.5% of irrigated production in 2014), is practiced using hydro-agricultural facilities on the banks of the Niger River or from surface watercourses (rivers, lakes, ponds, streams, koris, etc.); while small scale irrigation uses both surface and ground waters (wells, boreholes, etc.). The dominant crops are onion (24% of irrigated production in 2014) and peppers (21.1% of irrigated production in 2014) which are exported to the sub-region countries (Nigeria, Ghana and the Ivory Coast). In 2015, the demand for agricultural water is estimated at 4.1 billion cubic meters, while takings (surface and ground water) are estimated to be 1.2 billion cubic meters (Ministry of Hydraulics and Sanitation, 2017) [3]. Surface water is generally used for rain fed production and its flow is dependent on rainfall while ground water is preferred for cash crops.

Table 1 : Structure of agricultural products by production type and use of surface and ground waters by product type (%)

	RAIN FED PRODUCTION	IRRIGATED PRODUCTION	SURFACE WATER	GROUND WATER
MILLET	100	0	100	0
SORGHO	99,8	0,2	80,2	19,8
RICE	11,7	88,3	49,8	50,2
NIEBE	99,6	0,4	89,4	10,6
PEANUT	100	0	100	0
PEPPER	0	100	4,4	95,6
ONION	5,8	94,2	12,8	87,2
OTHER PRODUCTS	12,1	87,9	9	91

Source: Calculation by the authors.

Thus, the final SAM produced, includes six categories of production factors (agricultural and non-agricultural labour, public capital, private capital, agricultural capital and land), 35 sectors of activity, 35 products of which eight are agricultural. Institutional accounts are represented by public employees, private employees, farmers, informal households, non-agricultural households, the unemployed, firms, the government and the rest of the world.

[3] Surface and ground waters are exploited in 2015 at less than 3 billion m^3 / year and 0.5 billion m^3 / year respectively (Ministry of Hydraulics and Sanitation, 2017).

3.2. Characteristics of the model

The model used in the study is the recursive-dynamic model PEP 1-t (Single-Country, multi-period) from Decaluwé et al. (2013). Changes have been made in particular with the disaggregation of the agricultural sectors, the introduction of the land factor and the production of agricultural water, particularly surface and ground waters. Following the works of Decaluwé et al. (1998) and Gosselin (2010), labour is partially mobile across sectors. This choice reflects the fact that unskilled workers cannot easily change their sector of activity in the short term. In other words, a farmer cannot be employed in industry or services but can move from one agricultural sector to another. Unskilled labour is growing at the demographic rate of 3.9%) while skilled labour at a slower rate (2% corresponding to the recent rate of wage growth in the general government sector, and taking into account the employment problem).

In addition, as with the land factor, capital is assumed to be fixed to reflect the difficulty of converting capital in the short and medium term in developing countries like Niger. Agricultural capital is distinguished from non-agricultural capital. The land factor, used only by agricultural sectors, is exogenous. For institutional agents, household consumption behaviour is represented by an LES-type utility function that provides the minimum consumption required for subsistence. The dynamics of the model is done through a mechanism of adjustment of capital and growth. The capital stock for each period is defined by the stock of the previous period, less the depreciation of the available capital stock and the increase in investment in the previous period.

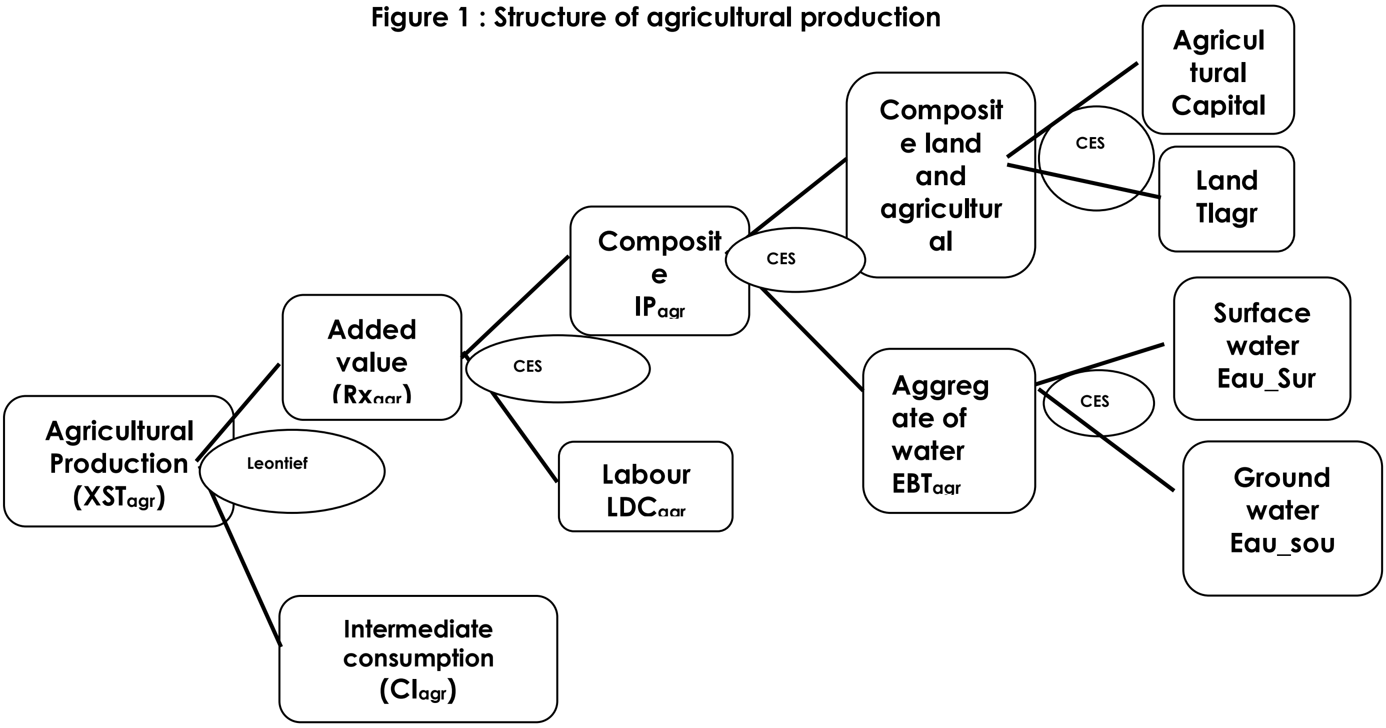
For the closure of the model, we assume that the fiscal deficit is endogenous while the exchange rate and public expenditures are fixed. This implies that financing the reform is supposed to come from public savings and external aid. This choice of closure takes into account the fact that Niger belongs to a monetary union in which the nominal exchange rate against the euro is fixed. We hypothesize that the level of external savings can cover the investment needs of the economy.

The supply of agricultural water is endogenous and it should satisfy domestic, agricultural and primary demand. To meet budget constraints, the Government's income is endogenised to meet the financing needs of the reforms in the agricultural water area. Factor supply (labour, agricultural capital and industrial capital are fixed.)The average annual growth rate of the population is 3.9%, but the amount of available land is growing at a lower rate (1.39%) corresponding to the data from the last decade (FAO, 2016).

3.3. Specifications of agricultural technology

The agricultural production system in Niger is characterized by a variety of crops, mixed soil fertility levels and high sensitivity to rainfall shocks. Most farmers use rudimentary agricultural techniques based on archaic production methods and face high transaction costs due to the inadequacy or even the lack of certain infrastructures. The resulting low productivity leads to the level of remuneration and the instability of employment. Agricultural production, modelled following Gosselin (2010) highlights the relationships between used agricultural water (surface and ground), production factors and intermediate consumption. It is represented by a function with constant elasticity of substitution inserted. Such a specification allows for substitution between the different factors of production and the intermediate consumption at different stages in the production.

Figure 1 : Structure of agricultural production



Source: The authors.

Agricultural capital is defined as a composite factor between capital and land, while aggregated water is equal to the sum of intermediate water demands. The combination of agricultural aggregated water and agricultural capital aggregate gives the composite aggregate (IP). Agricultural added value is derived from the association between the IP composite and agricultural labour allocation behaviours in the context of a CES. Finally, total agricultural production is a Leontief function of this added value and intermediate consumption. The elasticity values were taken from Decaluwé, Patry and Savard (1998)[4].

3.4. Modelling of the water sector

In the economic literature, the most recent analyses of CGEM dealing with water resources distinguish between agricultural and domestic water (Thabet et al. 2005). Agricultural water is used exclusively by the agricultural sector and domestic water is used by industries and households. The supply of agricultural aggregate water is schematized according to a system in which two sources of water remain: surface and ground water. These two types of water are

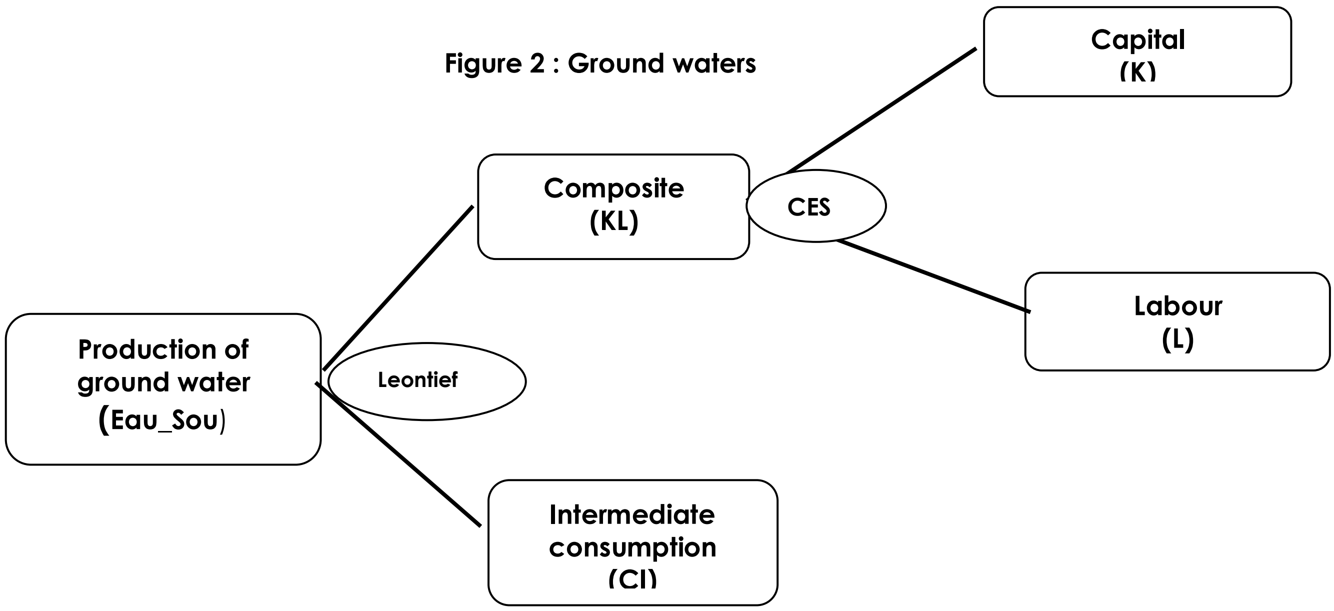
[4] These authors had adopted these elasticities following a review of the literature (Ali and Parikh (1992), Binswanger (1974), Debertin et al (1990) and Ray (1982)).

perfectly substitutable and constitute the intermediate water demand of the agricultural sectors. When surface water production decreases, agricultural sectors use more ground water.

The capital used in the water production functions represents the infrastructures built for their mobilization, namely the wells and pumping systems for the ground water and the hydro-agricultural installations, the dams for the surface water. Surface water production is represented by a CES function using only fixed capital representing the dams existing at the reference period.

Ground water production is a Leontief function linking intermediate consumption and the labour-capital composite. Ground water is drawn from the ground using electric pumps or wells. Its marginal output is decreasing and marginal costs are increasing, reflecting the fact that the more water is drawn, the deeper one needs to go to reach it. It is assumed that the use of the capital factor and the land factor in a fixed proportion, combined with intermediate usage, makes it possible to provide additional water.

Figure 2 : Ground waters



Source: The authors

3.5. The micro-simulation model

The micro-simulation introduced into the macro model aims to take into account the structural heterogeneity of individuals. It allows us to observe the effects of exogenous shocks on the way incomes are redistributed and, consequently, on the well-being of populations. It is based on the 2014 ECVMA survey data that has been combined with macroeconomic data to seize variability across household income groups.

The objective of the micro-simulation is to measure the impact of changes in agricultural productivity on growth, poverty and inequality. The analysis is based on the most common poverty and inequality indicators: the poverty indices of Foster, Greer, and Thorbecke (1986), which allows to derive the headcount, severity and depth of poverty, on the one hand, and the Gini inequality indicators, on the other.

IV. Application and results

4.1. Description of the reference situation

The purpose of this research is to analyse the effects of the choice of water production on agricultural productivity and the fight against food supply insecurity. The baseline situation reproduces steady growth in which most variables (labour supply, current account, minimum consumption of goods, government current expenditure, investment) increase at a rate of 3.9%[5] which corresponds to the rate of population growth. It also takes into account the 2018-2020 economic growth projections from the Ministry of Planning.

Total surface and ground water extractions are estimated at 1200 million m^3/year for 2015 and may increase to 1700 million m^3/year by 2025.[6] Improved water mobilization for irrigation needs will boost the demand for irrigation water, which could reach 6105 million m^3 as expected in the PANGIRE by 2030.

In addition, the high poverty rate in Niger in 2014 (44.9%) affects 8.8 million people, while the level of inequality is 0.347. The number of poor people is higher in rural areas (52.4%). The

[5] The average rate estimated during the 2012 General Population and Housing Census (RGPH)

[6] MH/A, 2015, Diagnostic study of the current situation of water resources within the framework of the PANGIRE project

contribution of the latter to national poverty is about 95%. The predominance of poverty in rural households is explained by the fact that 84% of the population lives mainly from agriculture.

The analysis of the baseline situation shows, slow agricultural production growth levels that do not halve the current number of people living in poverty by 2029, or significantly improve food supply security or halve poverty. By this target date, the average annual increase in final household consumption expenditure of 5.1% will only result in poverty reduction of less than 20%.

4.2. Simulated scenarios

Two scenarios (Table 2) were simulated taking into account the actions planned during the second phase of implementation of the i3N initiative and those of the PANGIRE. In particular the validation of the demand of irrigation water estimated at 6105 million m^3 by the year 2030.

Table 2: Summary of the simulated scenarios

Description of the scenario		Impacted variable
SIM1	Increase in the availability of ground water for irrigation	100% increase in public investment
SIM 2	Increase in government investments in the construction of dams, reservoirs and hydro-agricultural facilities	100% increase in investment

Source : The authors.

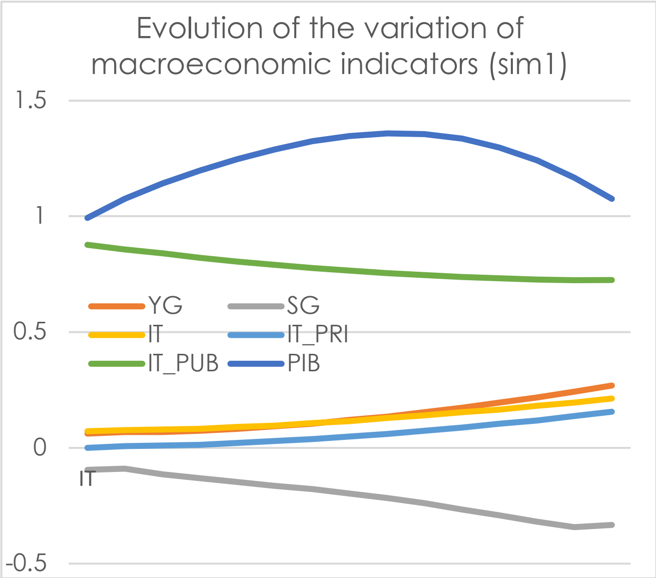
4.3. Analysis of simulation results

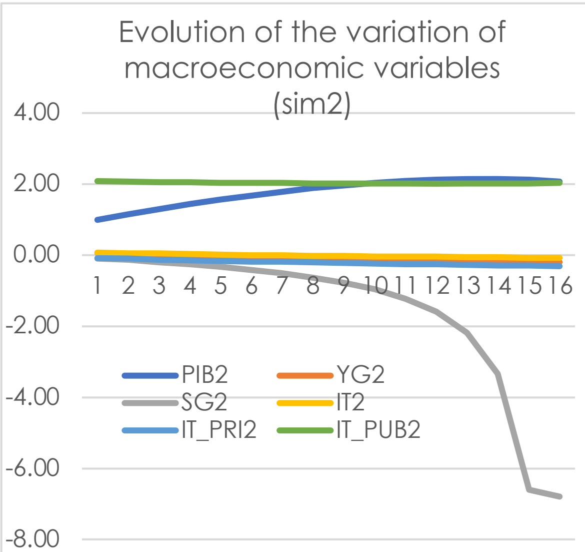
Analysis of the simulation results is based on variables of interest for the study of agricultural production, household income and GDP. It is based on comparisons of results between the different scenarios.

4.3.1. Effects on growth and government income

The increase in the mobilization of water for agriculture through investment is favourable for the economy of Niger. Gross domestic product (GDP) progresses more rapidly in both simulations but much more with the mobilization of surface water. The same applies to the Government's income. In 2029, the GDP variation reaches 2% in the second simulation. It is not surprising that the Government's savings are falling, but this decline will only occur from 2020 onwards. Moreover, following the new investments associated with the increase in the mobilization of water for irrigation, the results show a crowding out effect of public investments compared to private investments from the year 2020 onwards. Overall, even if the observed effects are small, they make it possible to assess the impacts of shocks on the variables. The policy of mobilizing surface water seems to have a more significant impact.

Figure 3 : Effects on macroeconomic variables (% change from BAU)





NB: YG=Government Revenue; IT=Investment; SG=Government Savings; IT_PUB=Public Investment; IT_PRI=Private Investment

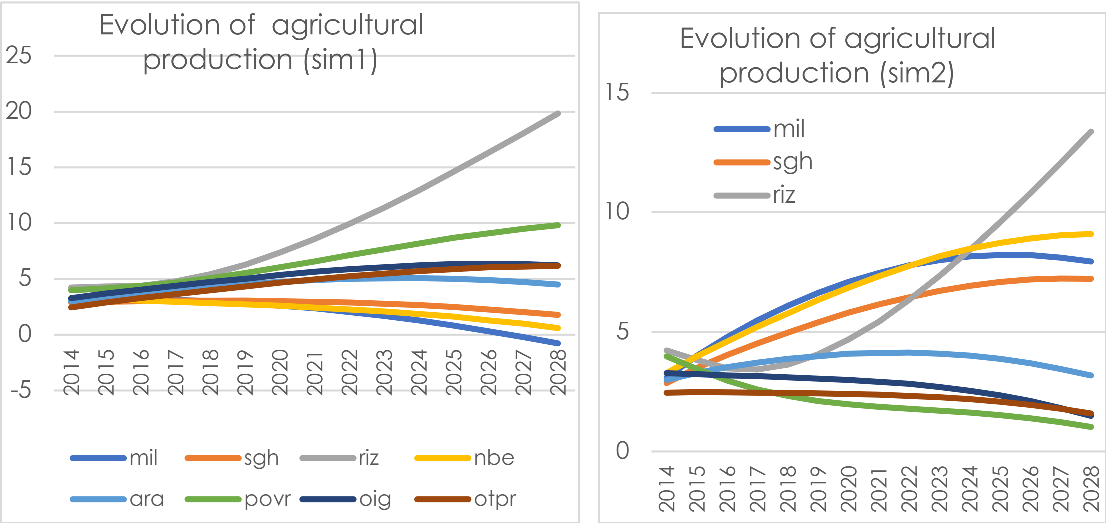
Source: The authors, simulation results.

4.3.2. The effects on agricultural production

The increase in investments in the mobilization of surface water (sim2) has a positive impact on the production of all the agricultural sectors in the long term. The figure below shows that the effects appear from the third year onwards and this delay is justified by the fact that investments take time to produce effects. The amplitudes of variations are greater for food crops that use more surface water or ground water (millet, rice, cowpea). By 2029, increases reach 9% for cowpeas, 8% for millet, 13% for rice and 7% for sorghum.

In addition, the implementation of ground water mobilization policies is more conducive to the development of market and cash crops. These are mainly pepper (+10% in 2029), onion (+7%) and groundnut (+4.9%).

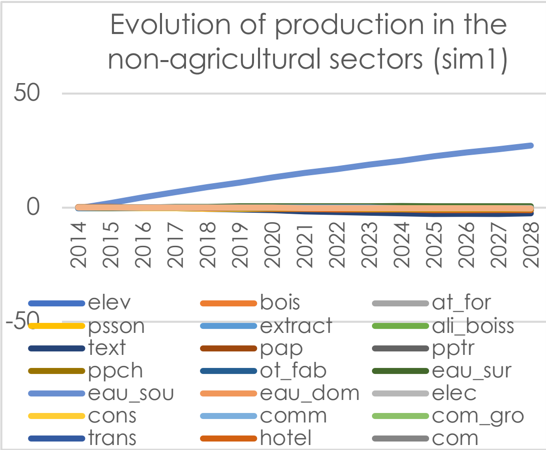
Figure 4 : Evolution of production in the different agricultural sectors (%)

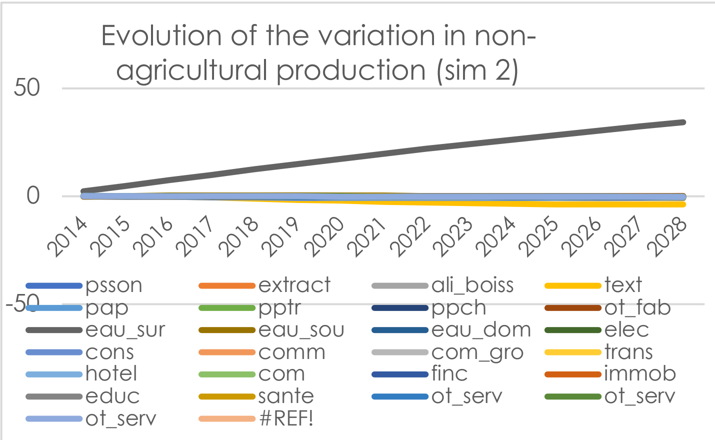


Source: The authors, simulation results.

The impact of the shocks had a positive impact on the non-agricultural sectors, mainly on the livestock sector in both simulations.

Figure 5 : Evolution of production in the non-agricultural sectors (%)



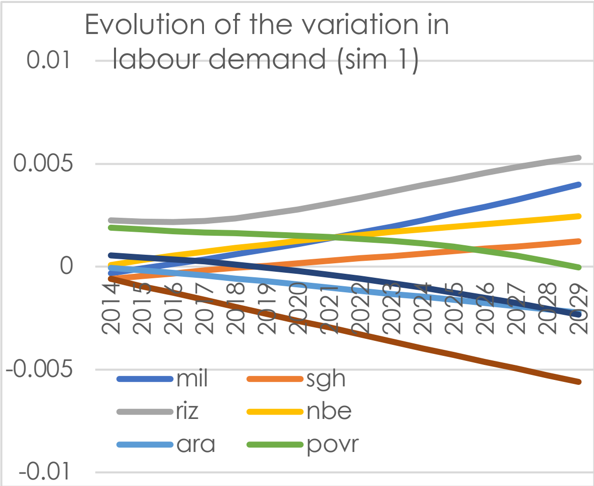


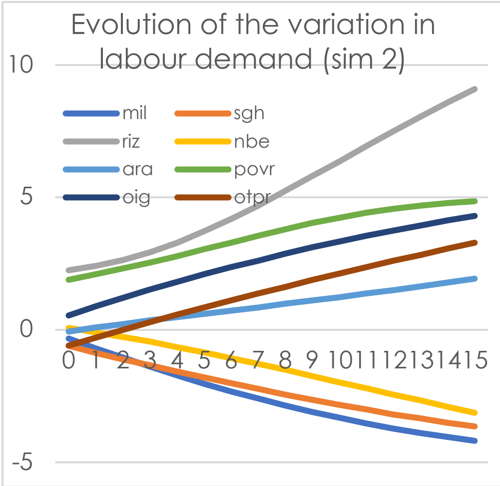
Source: The authors, simulation results.

4.3.3. The effects on employment

Significant investments in the water sector are increasing the mobilization of agricultural water. However, the simulation results show an increase in labour demand mainly in the most intensive sectors and depending on the type of water taken into consideration. Indeed, since water production is increasing, the resulting increase in agricultural production is only possible with additional capital and labour. Variations are more pronounced when surface water availability is increased. Workers losing their jobs will move to sectors where demand is increasing.

Figure 6 : Effects on employment (%)





Source: The authors, Simulation results.

The increase in employment will finally result in a decrease in the wage rates by the law of supply and demand, mainly in the agricultural sectors. In the non-agricultural sectors, wage rates are rising slightly due to the scarcity of workers whom are more oriented towards the agricultural sectors.

Table 3: Evolution of wage rates (%)

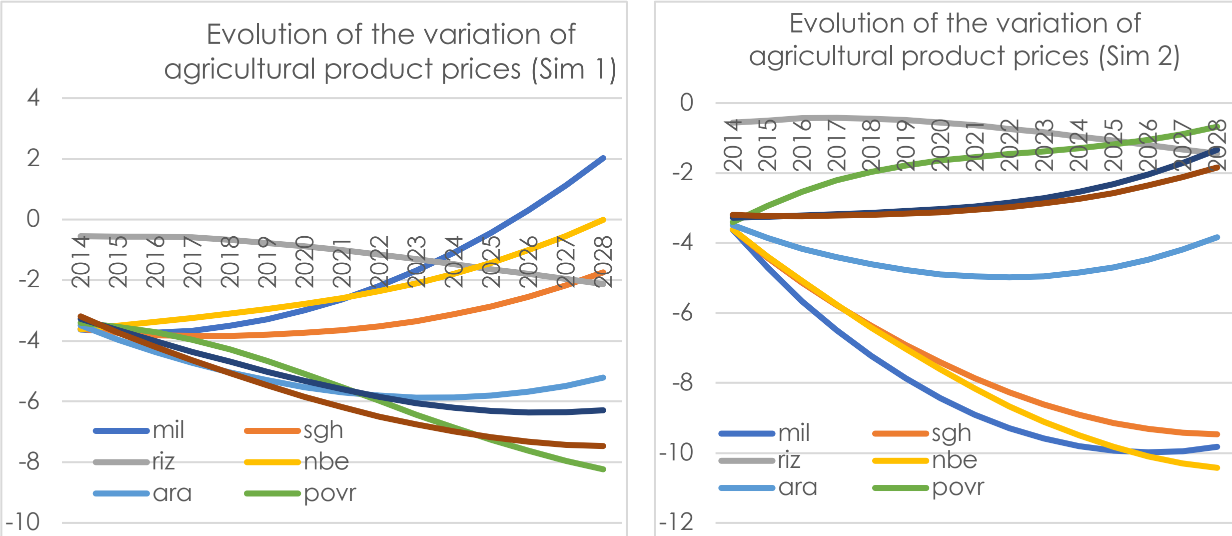
	Sim 1		Sim 2	
	Agricultural workers	Non agricultural workers	Agricultural workers	Non agricultural workers
2015	-0,7	0,3	-0,8	0,3
2016	-0,8	0,3	-1,1	0,3
2017	-0,9	0,3	-1,3	0,3
2018	-1,1	0,4	-1,6	0,3
2019	-1,2	0,4	-1,8	0,3
2020	-1,3	0,4	-2,0	0,3
2021	-1,3	0,4	-2,3	0,3
2022	-1,4	0,4	-2,5	0,2
2023	-1,4	0,4	-2,6	0,2
2024	-1,5	0,5	-2,8	0,2
2025	-1,5	0,5	-3,0	0,2
2026	-1,5	0,5	-3,1	0,2
2027	-1,4	0,5	-3,2	0,2
2028	-1,4	0,5	-3,3	0,2
2029	-1,3	0,5	-3,4	0,2

Source: The authors, Simulation results

4.3.4. The effect on prices

In both simulations, we observe a decrease in agricultural commodity prices. When surface water increases, food crops prices fall the most, while with more ground water, market and cash crops become cheaper.

Figure 7 : Evolution of the prices of agricultural goods (%)



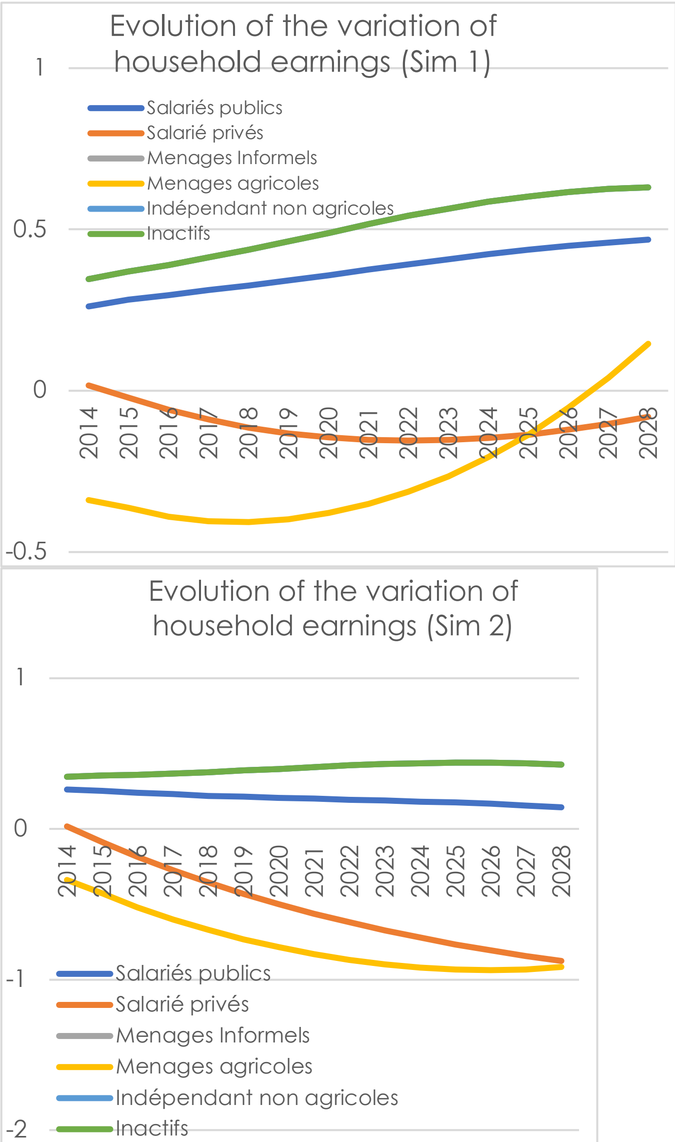
Source: The authors, Simulation results.

4.3.5. The effects on household income

The results of the simulations in the 2 scenarios show a decrease in the incomes of farmers and private employees. This can be explained by the decline in demand for labour in the agricultural sectors to the benefit of other sectors as a result of new investments. Indeed, we observe that the income of the self-employed non-agricultural workers, informal households and the unemployed is on the rise. This contributes to improving the well-being of these households, which constitute an equally important part of the Nigerien population.

In addition, the improvement in the purchasing power of these households, induced by the fall in agricultural commodity prices has had positive impacts. For agricultural households, the magnitude of the decline in household savings is lower, while non-agricultural households increase their savings. Bear in mind that households allocate on average 24% of their resources to the consumption of goods.

Figure 8 : Evolution of household income (%)



Source: The authors, Simulation results.

4.3.6. The effects on household poverty

The simulation results in both scenarios show an increase in per capita consumption expenditure of 1.7% in 2029 compared to the baseline, mainly due to the change in household incomes. Consequently, the increase in productivity induced by the increased mobilization of water for irrigation has a low impact on the reduction of poverty. The rate of decline is less than 1% for the occurrence of poverty and 0.002 for its severity.

On the other hand, the most significant effects are recorded in terms of food poverty. The number of people living below the food poverty line is increasing by 6%. The increase in the production of agricultural goods allows the households to allocate much more resources to self-use. The share of the poorest quintile in final household consumption expenditure rose from 7.8% to 8.1%. This result supports the idea that other mechanisms are essential to help achieve significant poverty reduction. It is all the more justified since agriculture in Niger is mostly subsistence.

V. Conclusion and political information

This study assessed the impact of the increase in available agricultural water on agricultural production and employment in Niger. The analytical approach is a dynamic computable general equilibrium model calibrated using the SAM of 2014. The sectoral analysis of the different scenarios made it possible to highlight the differentiated effects according to the type of water used.

The results of the simulations show an improvement in macroeconomic aggregates, notably in investment, government revenue and economic growth. The objective of developing irrigated agricultural production has been achieved, but the overall impacts appear to be greater with the mobilization of surface water.

An important result to be highlighted is that, by securing ground or surface water supplies for crops, farm household's incomes increase due to the resulting increase in demand for labour. Households, now protected from climatic uncertainties, will be able to increase their purchasing power and consequently fight food insecurity. The results show, on the one hand, that the effects on food poverty are stronger, and on the other hand, that the ripple effect observed on the livestock sector strengthens the beneficial nature of the reform. Furthermore, the CGE analysis highlighted the price effects that reduced the negative impacts on the economy.

Thus, it appears from this study that the Nigerien authorities would benefit from prioritizing policies that mobilize surface water, making it possible to increase the usage rate (less than 1%) of these resources for which Niger has a very high potential. However, this option will only be viable if funding is available to cover investment needs. For this purpose, the construction of dams and reservoirs must be prioritized to allow large-scale irrigation and reverse the current trend of being subject to climate uncertainties, shocks and food crises. To achieve this specific studies must be carried out, as in some African countries (Libya), to identify the land to be developed and the required investments.

This research has focused mainly on the benefit of mobilizing water for agriculture while involving effective water management. Future research on the effectiveness of water management could be carried out to help encourage the reforms foreseen in this area. Rainfall specifically in agricultural waters could be focused upon, to simulate droughts and distinguish agricultural land (dry and irrigated) in the production factors, in order to assess the impact of policies affecting their development.

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