Using model to identify and meet potential challenges in regional development: The ECOWAS T21 case

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ABSTRACT

The ECOWAS region (Economic Community of West African States) has big potential, but it faces major challenges in its development. To help support the decision making of regional and national leaders and bring a wide variety of stakeholders from all member states into policy debates, the ECOWAS T21 model was developed. The initial focus of the model was to test the consequences of regional integration of 1) free movement of people and commodities; 2) integrated energy, transport, and telecommunication infrastructures; and 3) creating a monetary union. When building and calibrating the model, another challenge was identified: fast population growth would make it difficult to improve the well being of the people in the region, even with successful implementation of regional integration. As a result, a family planning scenario was added. Results from the model show that a combination of regional integration and family planning policies generates the best results: smaller population, longer life expectancy, higher GDP, much higher per capita GDP, higher total government revenues, a lower poverty rate, a lower unemployment rate, more forest land, and higher per capita cereal production. However, any good policy could have its costs, such as higher oil demand and lower oil exports in this case.

Key words: ECOWAS region, development planning, T21 model, scenario analysis, regional integration, family planning

I. Introduction

Covering a total area of 5,112,903 square kilometers with a total population of 300 million, the ECOWAS region (Economic Community of West African States) is the most populous regional economic community (REC) in Africa, comprising about 35 percent of sub-Sahara Africa's population (ECOWAS Vision Document 2011). The countries in the region include Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, The Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.

ECOWAS is a highly complex region facing many possibilities and challenges. The regional GDP is estimated at 157 billion in US$2001 in 2010 (ECOWAS statistical data office 2011), with per capita GDP at US$523 (all currency units in this paper are based on constant 2001 values). The majority of ECOWAS countries are classified as Least Developed Countries, and about 60% of population lives in poverty (under US$1.25 per person per day). Continuing fast population growth is expected in the coming years, with a total fertility rate of about 5.

Yet, the fundamentals for a better life abound. The ECOWAS countries are endowed with considerable mineral, land, water, and human resources. There are gold, diamonds, uranium, crude oil, and iron ore; and numerous waterways run across the region. ECOWAS States also produce primary agricultural commodities, a significant amount of which is sold in international markets.

The ECOWAS leaders and policy makers face major policy challenges. The first of these relates to how the massive population will be fed, provided for, and educated; and how their human capital will be utilized to achieve sustainable development of the region. The second relates to a broader goal of how to articulate more coherent economic, social, and environmental policies that foster more sustainable development and improved living standards in all the countries and the region as a whole.

The mission of ECOWAS is to deal with these challenges, and it is believed that the most important is to promote economic integration in all fields of economic activity. In 2007, the Authority of the Heads of State and Government formulated a vision for the region, Vision 2020, which aims at transforming the current "ECOWAS of States" into an "ECOWAS of People", to achieve a region without borders to derive maximum benefits from globalization. To bring regional integration (RI) to fruition, it is essential to strengthen the decision making capacity of the ECOWAS Commission with an advanced analytical tool that adequately captures the socioeconomic dynamics of the region and supports looking into alternative future scenarios resulting from policies focused more on their goals than simply continuing business as usual. Such a tool would also help bring a wide variety of stakeholders, both State and non-State actors, from all member states into policy debates, which will in turn enlist real support for more mutually beneficial policy decisions and actions envisioned by ECOWAS.

The ECOWAS Community Development Program (CDP) team decided to choose the Threshold 21 (T21) Model as the policy tool to formulate a coherent program of actions for RI. The experts in the CDP team worked with the Millennium Institute to identify the four pillars to start modelling for RI. They are:

1. Free movements of people, goods and services, and capital among member states
2. Governance, peace, and security
3. Energy and infrastructure
4. Finance and monetary integration

The T21 model (Qu 2011) integrates a broad range of sectors in economic, environmental, and social areas; and its transparent structure and user-interface enables all stakeholders to engage in constructive dialogue about policy options, which helps achieve consensus. The model has been applied in more than 20 countries and regions, and it has benefited from lessons learned along the line. In a few cases, T21 models were used to identify challenges the countries have to face in

the future (Qu 2005). In addition to building an effective country or regional model, a major goal of every T21 project is to build the local team's technical capacity to a level where they can fully operate, update, and expand the model. They take over full responsibility for the model and assure its continued use.

II. The ECOWAS T21 Model

ECOWAS T21 is similar to most other T21 models except that 1) it is a regional development model and all 15 countries are combined into a single entity; and 2) the main focus to address is the possible consequences of RI.

Based on discussions with local experts, RI in ECOWAS could boost productivity, increase employment, make better use of the potential hydro power, and reduce power transmission loss. It could also have negative effects, such as lowering government tariff revenues, due to free regional trade. However, it is possible to determine how much these losses in revenues would be offset by higher revenues from increased employment and productivity, or other sources. A clear advantage of a coherent dynamic model is its ability to identify these feedbacks and help find ways to mitigate negative effects. Potential causal relationships from RI to these consequences are shown in Figure 1.

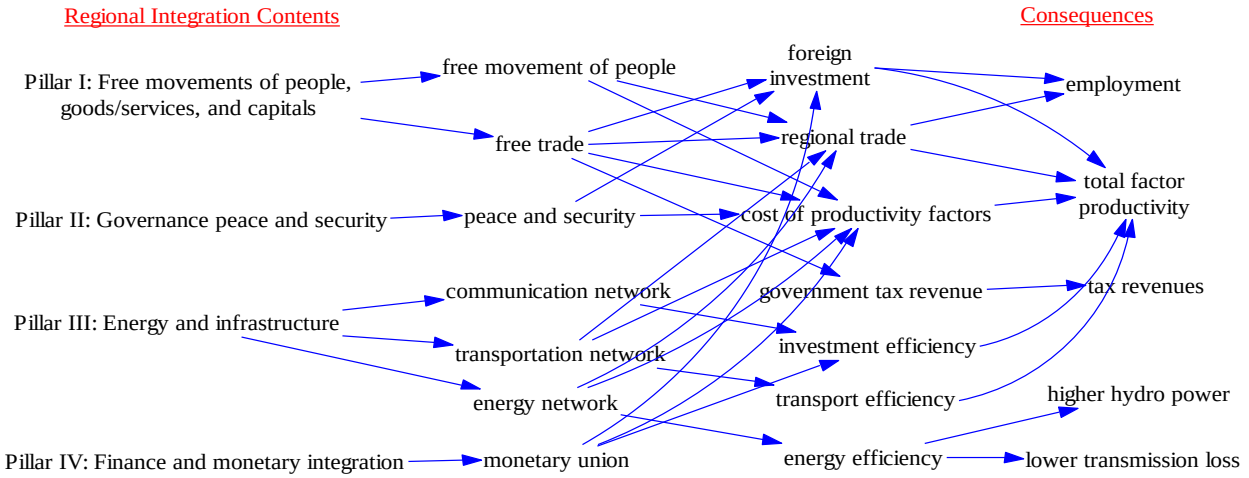

Figure 1: Causal diagram of RI pillars and their consequences

Starting from the first column on the left of Figure 1, the first policy variable "Pillar I: Free movements of people, goods/services, and capitals" will have causal effects on the first two variables in column two, "free movement of people" and "free trade". Variables in column two from left will affect variables in column three, such as "free movement of people" will affect "regional trade" and "cost of productivity factors". Finally, variables in column three will affect the variables in the right column under the red title "Consequences", which include "employment", "total factor productivity", "tax revenues", hydro power, and transmission loss. This diagram shows how the RI policy measures will have causal impacts on these consequences.

The policy variables and the consequences in Figure 1 are built in the ECOWAS T21 model, whose condensed structure is displayed in Figure 2.

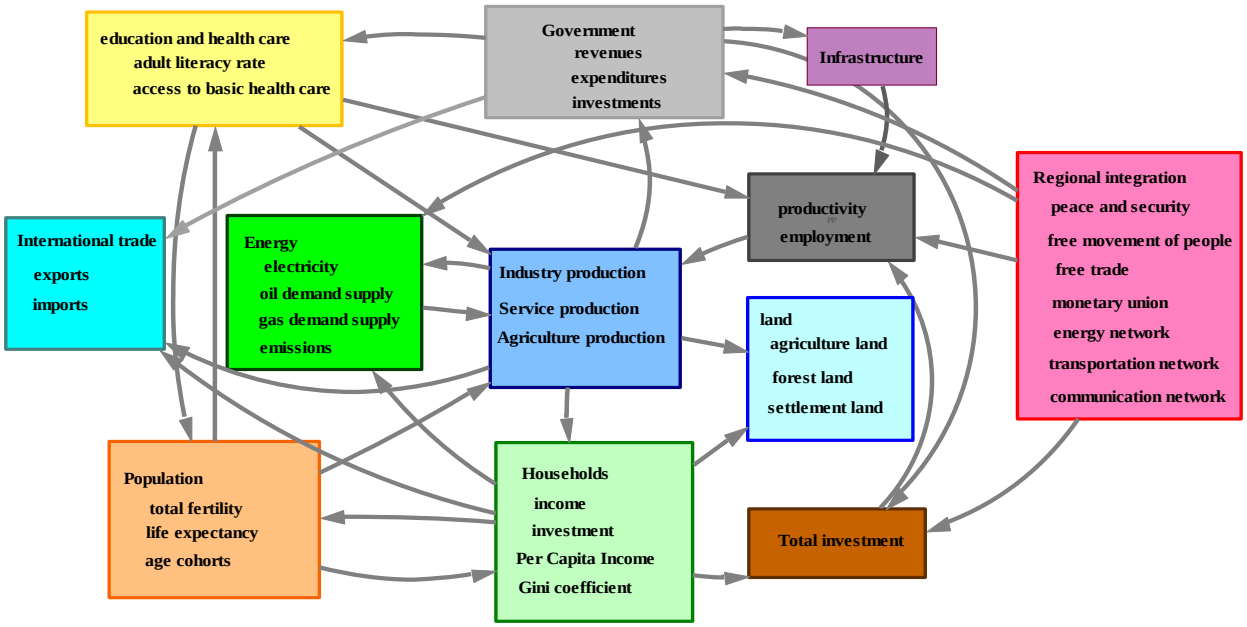

Figure 2: Overview of ECOWAS T21 model

Production of agriculture, industry, and services is at the center of Figure 2. This sector affects 1) government revenues and expenditures above; 2) household income and investment below; 3) energy demand and supply to the left, 4) international trade to the far left, and 5) resource demand of land and water (not shown). Each of these sectors will further affect more sectors, as the arrows show in the figure. From these links, it is possible to see how the increase in industrial production and household income and consumption may increase revenues to offset the losses from trade tariffs. Many feedback loops are formed in the model, such as from production to government and household, then to total investment, then to productivity and employment, and finally back to production.

The main issue of the model, RI, is represented by the pink box in the far right. It can directly affect 4 sectors: government, energy, productivity and employment, and total investment. Indirectly through further linkages and feedback loops, it affects almost all other variables in the model.

Figure 2 is an overview of the model's structure. The actual model is much more detailed to simulate the real world and incorporate the quantitative causal relations among the variables.

Figure 3 is the actual industry sector in the T21 ECOWAS. Industry production is modeled using the Cobb-Douglas production function, with capital, labor and total factor productivity. The variables enclosed by <> are computed from other sectors of the model, and two variables, industry production and capital industry, are computed in this sector and used by other sectors. Total factor productivity is influenced by the effects from the four pillars of RI, as shown in the left of the figure, and by other variables of health (represented by life expectancy), education

(represented by adult literacy rate), and infrastructure (represented by the density of functioning infrastructure).

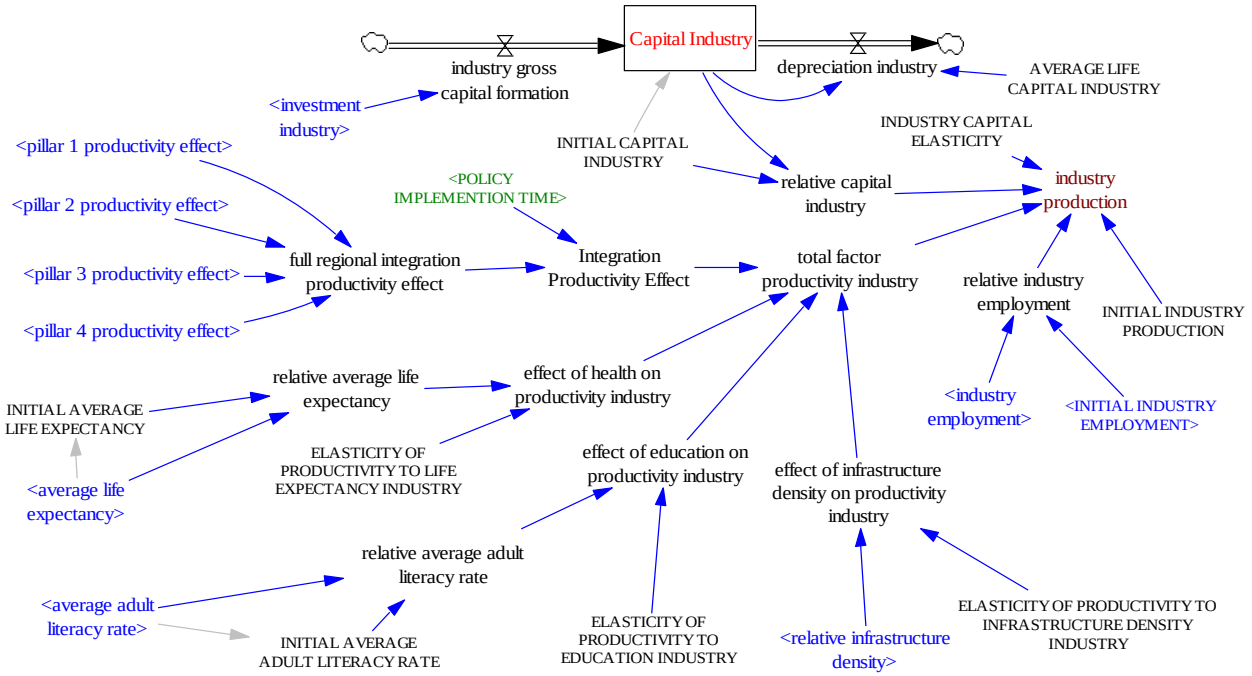

Figure 3: Industry sector of T21 ECOWAS

III. Historical Simulation and Analysis

The ECOWAS T21 model starts its simulation from the year of 1990. Using data, local expert knowledge and literature review for the historical period of 1990 – 2010, equations and parameters in the model were modified and calibrated, and results from the model were compared to historical data. These adjustments improve the realism of the causal relations in the model to assure it provides an accurate representation of the economic, social, and environmental relations. This calibration helps identify where conventional relations need to be modified to better present real ECOWAS relations and improve data collection. After the historical fit is done for all the major indicators whose data are available, the model is then run forward to simulate until 2030 – assuming no major changes in business as usual – to determine how the numerous endogenous variables and indicators will progress. Figure 4 presents the comparison of industry production between simulated results (blue, for the entire period of 1990 - 2030) and actual historical data (red, 1990 – 2010 only).

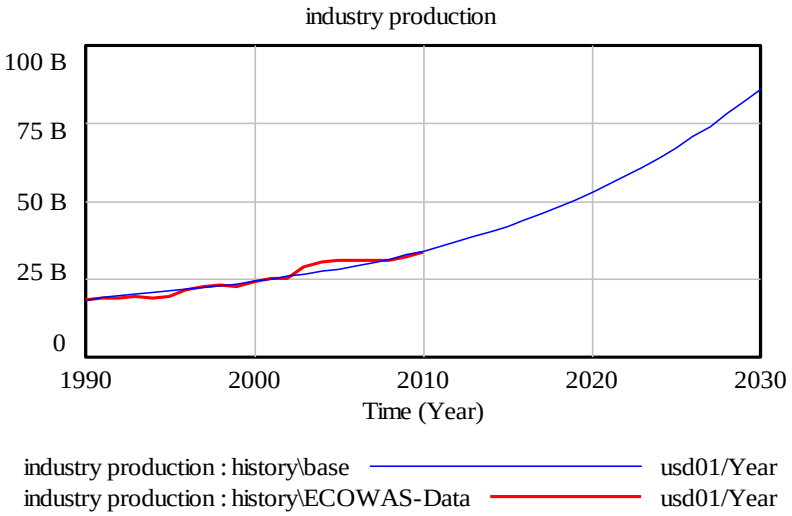

Figure 4: Comparing model behavior with historical data

While working on the historical calibration and simulation of the model, critical economic, social, and environmental characteristics of the region became more apparent, especially the following:

1. Real GDP grew quite fast from US$ 65.1 billion in 1990 to 141 billion in 2008, at an average annual rate of 4.4%. But due to high population growth, average annual per capita GDP growth was only 1.7%.
2. Population grew from 181 million in 1990 to 288 million in 2008, at a high average annual rate of 2.6%. The total fertility rate was high, and declined slowly, from 6.55 in 1990 to 5.5 in 2008. Life expectancy increased, but also at a slow pace, from 48.6 years (female) and 46.3 years (male) in 1990 to 52.2 (female) and 50.5 (male) in 2008. 43% of the population in 2010 was below the age of 15, indicating continuing population growth in the coming decades.
3. The poverty situation is severe. Measured in US$ 1.25 per person per day, in ppp (purchasing power parity), about 60% of the population was living under that rate in 2008.
4. Although government expenditure on education was low, about 2% of GDP, gross enrollment rate (GER) for primary education was good and improving. In 1990 GER was 70% for girls and 90% for boys. In 2008 it increased to 85% for girls and 96% for boys. Adult literacy rate in 2008 was about 50% for female and 70% for male.
5. Productivity (per worker output) growth has been very slow. In the 17 years of 1990 to 2007 (employment data was only available for 1990, 1991, and 2007), productivity in industry and services only increased 8% and 18% respectively, well under 1% per year. Observed GDP growth is thus supported more by the expansion of the workforce, rather than by productivity growth.
6. Unemployment rate has been quite low, such as 8.3% in 2007 (based on data, labor participation rate is 0.63, i.e., 63% of adults with ages 15 and over are or want to be working). This indicates, even with both parents working, the family is very likely living under poverty, as poverty rate is 60%. This could be the consequence of two factors: low salary level, and large family size (since the total fertility rate is over 5 in 2010).
7. Deforestation continues: forest land decreased from 91.6 million hectares in 1990 to 75.0 million hectares in 2008. Agriculture land (arable and pasture land) increased from 212

million hectares in 1990 to 249 million hectares in 2008. It seems that for every hectare increase in agriculture land, half a hectare of forest is lost. Agriculture expansion could be the major cause of deforestation in the region.

8. Even with the expansion of agriculture land, the situation of hunger has not improved much. Per capita cereal production increased from 161 kg/person in 1990 to 192 kg/person in 2008, still much lower than the world average of 352 kg/person in 2007 (FAO 2011). The major indicator for agricultural productivity, cereal yield, increased from about 0.90 tons/hectare in 1990 to 1.27 tons/hectare, still very low compared to world average of 3.38 tons/hectare (FAO 2011).
9. Oil production, which is one of the major drivers of regional economy, seems to have peaked in 2005 at 977 million barrels.

IV. Future Challenges of the Business as Usual (BAU) Scenario

With the BAU scenario, the following challenges were identified for the long term (2010 – 2030). The numeric values of the relevant indicators are presented in the scenario comparison tables in Section VI.

1. Population will continue to grow fast, partly due to high total fertility rate, and partly due to a high proportion of population under 15 at present. Total population of the region could reach 480 million in 2030, 60% more than the current number of 300 million.
2. Fast population growth will continue to slow per capita GDP growth. As a result, 39% of population could still be living under the poverty line in 2030.
3. Due to population pressure, agriculture land and settlement land will continue to grow, taking away land from forest and all other types of land. Forest land could decrease to 50 million hectares in 2030, from over 70 million hectares at present.
4. Agriculture yield has been growing and is still quite low. Even if yield continues to grow at about the same rate in the past, food production, measured on per capita basis, would only grow marginally. This means that feeding the population would remain a big challenge.
5. Educating the young would be challenging as well, as population growth will put lots of pressure on government social services of education and health care. This pressure could extend to other services provided by the government in areas like water, energy, and transportation. Services in these areas are vital to the productivity growth.
6. Annual crude oil production would decrease from about 800 million barrels at present to 650 million barrels in 2030, while annual regional demand could increase from about 200 million barrels at present to over 300 million barrels in 2030. This means that the region would have less oil to export (350 million barrels in 2030 compared to 600 million now.).

Primarily due to population growth, the governments of the region will have a challenging task to feed the people, alleviate poverty, provide education and other social services, and promote productivity in the competitive global market. The task would become especially tough when natural resources of the region, represented by oil reserves and forest land, are being depleted.

V. Assumptions of Regional Integration (RI) and Family Planning (FP) Scenarios

To help meet these challenges, three scenarios were developed with the T21 ECOWAS model. They are: RI, FP, and RI&FP.

For the RI scenario, it is assumed that successful RI implementation will start in 2012 and the four pillars will have the following consequences:

1. Pillar I: Free movements of people, goods, services, and capital will result in larger markets, more competition, and better allocation of human and other resources. These will increase productivity by 5% over the BAU Scenario. This increase will happen gradually over a period of five years. All the productivity and foreign investment increases in the following pillars will happen in the same pattern. Free regional trade will reduce government revenues by 5% of inter regional import values, and the reduction will happen as soon as the policy is implemented.
2. Pillar II: Governance, peace, and security mean that better governance and better use of existing resources will increase productivity by 5% over the BAU Scenario; and it will encourage more foreign investment, and as a result foreign investment will be 5% higher than the BAU Scenario.
3. Pillar III: Energy and infrastructure of transport and telecom improvements will lead to the construction and coordinated operations of regional integrated infrastructure networks of energy, transport, and telecommunications, which will bring more reliability at a reduced cost to the services from this infrastructure. As a result, productivity will increase 10% over the BAU Scenario. These infrastructure networks will take five years to build with an employment of 50,000 people. Power transmission loss will be gradually reduced by 50% over the BAU Scenario in five years, and more hydropower will be tapped (such as in Guinea) so that less oil will be used for electricity generation and more oil will be available for export. Hydropower capacity will increase by 2% annually over the BAU Scenario.
4. Pillar IV: Finance and monetary integration will bring more macro stability, and as a result, both foreign investment and productivity will increase. It is assumed that they will both be 5% higher than the BAU Scenario.

With the FP scenario, it is assumed that improved education and family planning programs will help families make better decisions about the number of children they will have. As a result of this program, it is assumed that the total fertility rate will decline from 5.38 in 2010 to 2.0 in 2030 in a straight line. In the BAU scenario, the total fertility rate in 2030 only declines to 4.12.

The scenario of RI&FP is simply the combination of all the assumptions in the RI and FP Scenarios.

VI. Comparison of Scenarios

The model is built with the Vensim software, and all indicators from these four scenarios can be examined either in graphical form or in tabular form. For instance, the indicator of per capita real GDP, "real pc gdp", from these scenarios is shown in Figure 5 in graphical form. The blue line is from the BAU Scenario. The red line is from the RI Scenario. The green line is from the FP Scenario, and the grey line is from the RI&FP Scenario.

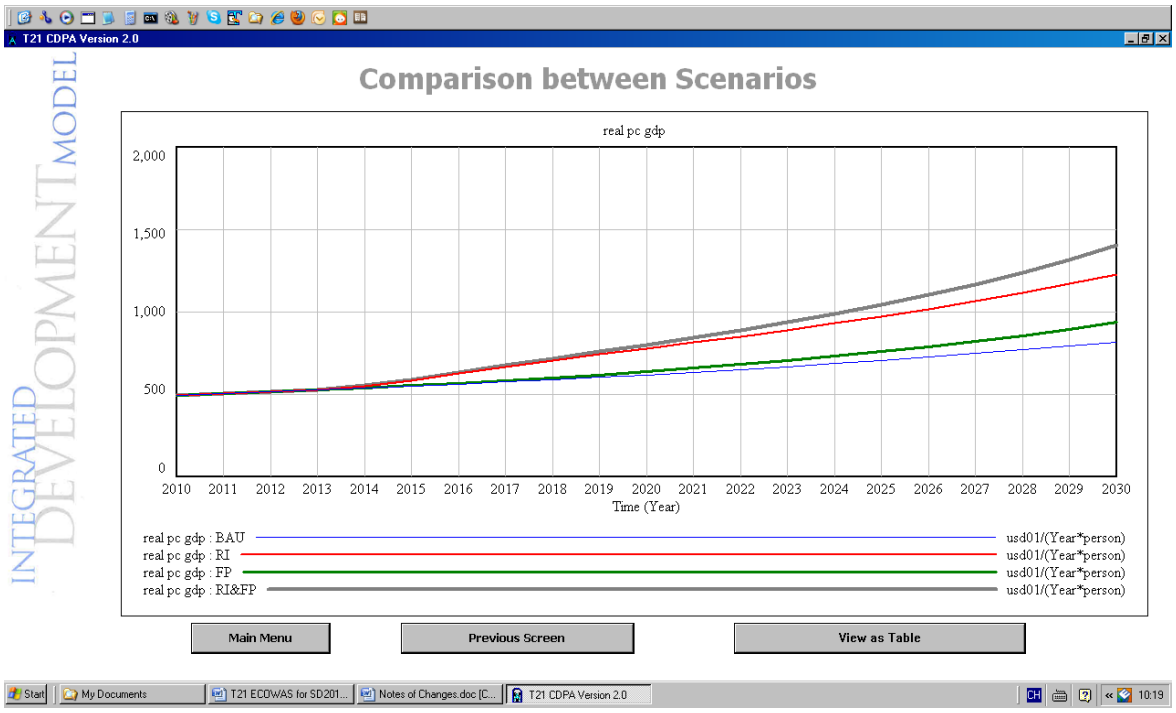

Figure 5: Per capita GDP comparison of the four scenarios

A summary table comparing the results of major indicators for the years of 2030 is presented below.

Table 1: Scenario comparison for 2030

	Unit	BAU	RI	FP	RI&FP
Population:					
Total population	Millions	480	481	423	425
Average life expectancy	years	56.31	58.07	57.03	58.76
Total fertility rate		4.12	4.05	2.00	2.00
Economy:					
Real GDP	Billion US$2001	391	589	395	596
Per capita GDP	US$2001/P	815	1,226	934	1,400
Government revenues	Billion US$2001	70.3	93.7	71.1	94.7
Social:					
Poverty rate		39.09%	21.29%	32.95%	16.91%
Unemployment rate		7.55%	3.79%	6.86%	3.02%
Land:					
Agriculture land	Million Hectare	299	299	287	288
Forest land	Million Hectare	50.1	50	55.6	55.4
Food and energy:					
Per capita cereal production	Kg/P	248	313	280	353
Oil demand	Million Barrels/Y	318	380	318	380
Oil export	Million Barrels/Y	330	268	329	267

From the table we can see the differences among the scenarios in 2030. The RI&FP Scenario generates the best results: smaller population, longer life expectancy, higher GDP, much higher per capita GDP, higher total government revenues, a lower poverty rate, a lower unemployment rate, more forest land, and higher per capita cereal production. However, any good policy could have its costs, such as higher internal oil demand and lower oil export for the RI&FP Scenario in the table.

People who are looking only from their specific positions could be concerned about short-term losses from these alternative scenarios. For instance, due to free trade, government domestic revenues from intra-regional import tariffs could decline. But in the long run, total government domestic revenues will grow faster due to a larger tax base (GDP) and more imports from outside the region, as Figure 6 shows.

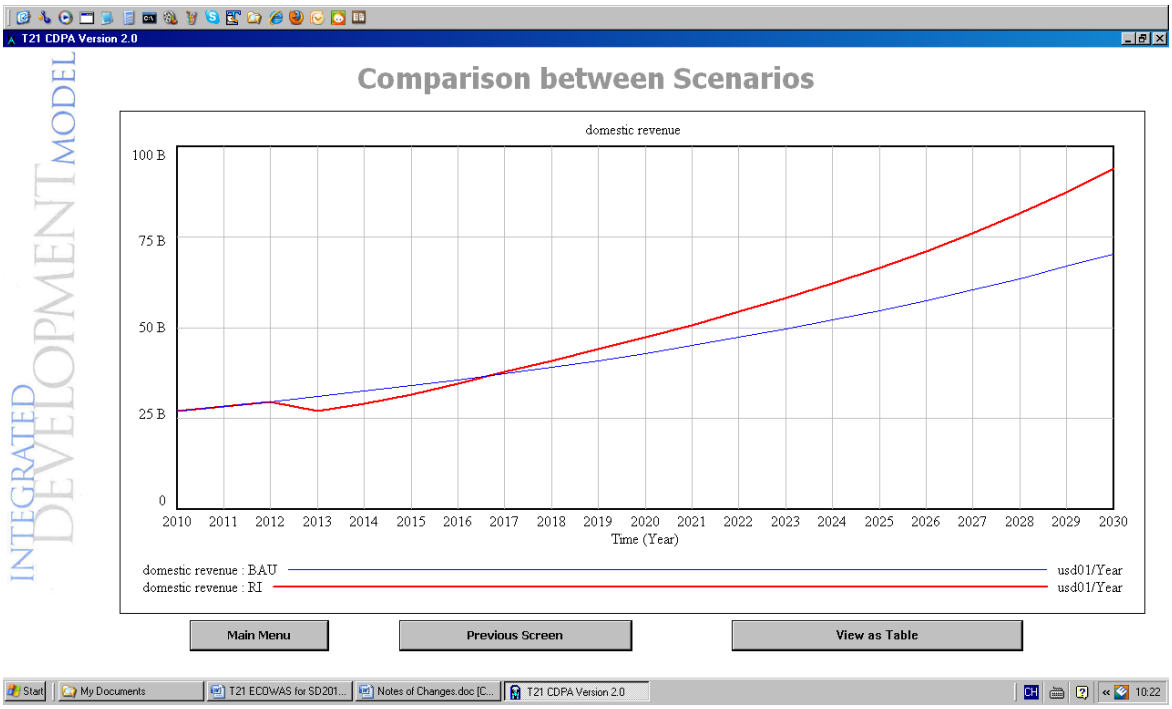

Figure 6: Comparison of government domestic revenues between BAU and RI

Beyond 2030, the differences among the scenarios could become even greater, as the total population of the FP and RI&FP scenarios begin to stabilize, while it will continue to grow for the BAU and RI scenarios with a strong inertia. The comparison of the population pyramids in Figure 7 between the BAU and RI&FP scenarios in 2030 can show that in the next 20 years beyond 2030, the RI&FP scenario will have a much smaller population of fertile women. With a lower total fertility and a smaller fertile women population, the RI&FP will continue to generate lower population growth. The higher per capita income achieved in the BAU and RI scenarios lead to a very modest decline in the fertility rate, which is taken into account. But the differences in total population and its growth are still quite significant between BAU and RI, and the FP scenarios.

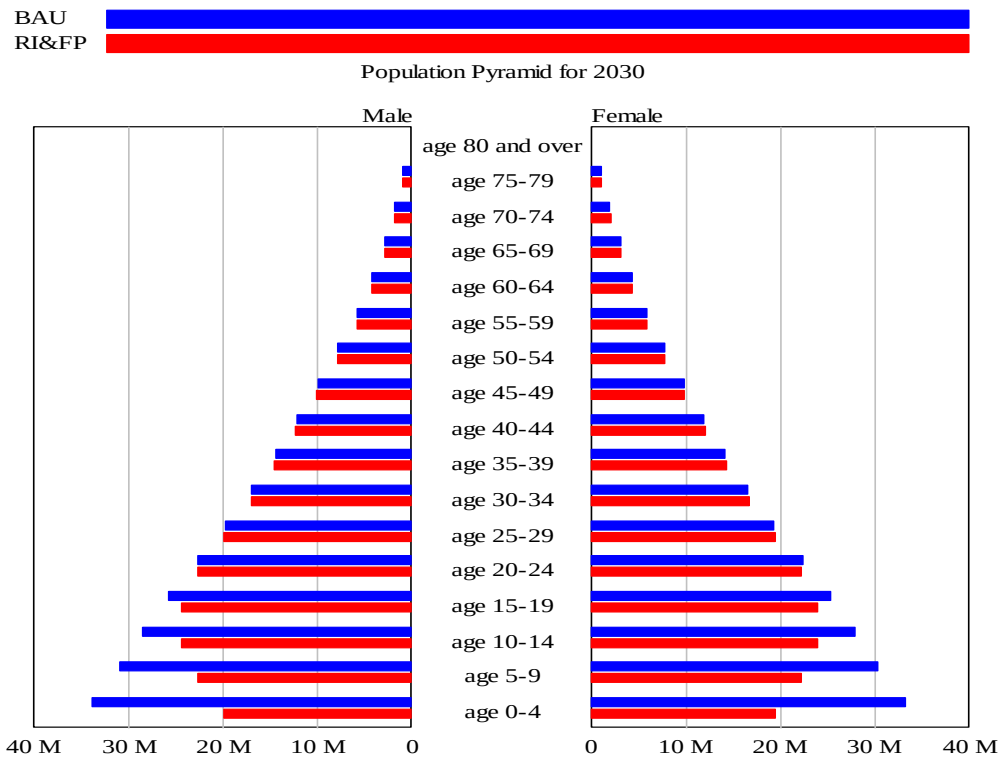

Figure 7: Comparison of population pyramids between BAU and RI&FP

VII. Summary and Further Work

It is shown in this paper that a good use of development models is to identify potential challenges before they emerge or before they get worse. It shows how potential challenges, like lower tariff revenues, will be overcome within the system over a longer term due to the effects of other beneficial policies. It is also good, using the model, to test the results of alternative policies to reverse or mitigate the undesired consequences of the BAU scenario and to mitigate possible negative effects of the desirable policies. These are essential for long-term decision making of development policies.

RI was first suggested by CDP experts to meet these challenges. When building and calibrating the ECOWAS T21 model, it gradually became clear that continued fast population growth due to the high total fertility rate, would make it difficult to improve the well being of the people in the region, even with successful implementation of RI. As a result, the FP and RI&FP scenarios were added.

Are these policy assumptions with numeric values realistic? We are not sure, as no model projections are by any means certain. But the calibration of the T21 model with the historic scenario provides a certain confidence that key causal relations are plausible. At present, the model is being studied and discussed by experts from ECOWAS and its member countries to see what further refinements and modifications would make the model more representative and accurate. It is very likely that RI and FP will have effects of varying magnitudes in different countries.

When using the model, the quantities in the above assumptions of the RI scenario, and the future total fertility rates of the FP scenario, can all be modified by the user. Simulation results of the different rates will be generated immediately, and they can be easily compared, as was done in Figure 5.

How should ECOWAS implement these policies and achieve the desired results? This is the question primarily for humans, including decision makers and all stakeholders. Humans have the intellect and are creative to discover and invent policies, but when situations get complex, they are often unable to keep track of all the factors, causal linkages, and feedback loops. Machines and models are mechanical, but they follow certain rules consistently, even when these rules become very complex, so they are good for keeping tract of these complex relations to fully test different policies, see the results, and thus help decision makers reach agreement on more effectives sets of policies.

Historical data for the ECOWAS T21 model was from multiple sources, including the ECOSTAT database from ECOWAS, WDI from the World Bank, Population data from UN Population Division, energy data from EIA (US Energy Information Agency), and land, water, and agriculture data from FAO.

Our next step is to build T21 national models for all the 15 member countries, and in the process, major challenges for each country will be identified, and alternative policies be tested. Based on our learning from the country models, as well as feedback from the current review of ECOWAS T21, we may re-visit the ECOWAS T21 model and update it accordingly.

The ECOWAS T21 model discussed here is an aggregate model, in which all the 15 countries are combined into a single entity. Another ECOWAS T21 model, called ECOWAS T21 Integrated model, will be developed after the 15 country models are completed. That integrated model will link all the 15 country models, or the major country models, in a single framework to simulate and test the consequences of RI for long-term development based on the activities and progress achieved in each country and their interaction within the region. This will take account of developments at both the country and regional level, until ECOWAS achieves its goal of full regional integration.

References

1. ECOWAS Vision Document, March 1, 2011, http://ecowasvision2020.org
2. ECOWAS statistical data office, ECOSTAT, March 1, 2011, http://www.ecostat.org/
3. Weishuang Qu, Hugh Morris and Jed Shilling, "T21 Jamaica: A tool for long term sustainable Development Planning", accepted by the International Journal of Sustainable Development and Planning, to be published in Volume 6, Number 2 in May/June 2011.
4. Weishuang Qu, Ted Chu, Gerald Barney and Jed Shilling, "Challenges Facing China in the Next 15 Years", Proceedings of the International Systems Dynamics Conference, Shanghai, China, 2005.
5. FAO, March 1, 2011, http://www.areppim.com/stats/stats_cerealsxworldxyield.ht