EVALUATION OF ALTERNATIVE DEVELOPMENT STRATEGIES FOR PAPUA, INDONESIA: A REGIONAL APPLICATION OF T21

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Abstract

Irian Jaya, the Western part of the island of Papua-Indonesia, is a region characterised by a huge territory, a small population and an incredible abundance of natural resources. Precious metals, natural gas, oil and rich primary forest make this area a potential thriving ground for many production activities.

After a period of transition from a centralised to a decentralised form of government, the region is now facing a delicate moment in its growth, as the choices and the politics of the local government will dramatically influence Papuan's development chances.

The danger is that the expanding economic activities will be conducted with little regard for the precious, and largely undisturbed, natural environment that still exists in Papua. The biggest challenge faced is how to manage the production of resource based products while protecting the environment.

The objective of the work described in this paper is to identify a developmental path for Papua that would generate a real increase in local people's quality of life and guarantee a proper use of natural resources. In other words, we searched for a more long-term sustainable alternative to the development plan than the one that the Government of Papua is actually undertaking.

Given the multisectoral and multidisciplinary nature of the issue investigated, (our client and) we decided to use a System Dynamics model, the Threshold21 (T21), to support our analysis. A special version of T21 has been created, portraying the specific characteristics of the socio-economic-environmental system of Papua.

In order to demonstrate that, under certain conditions, a development plan that can generate better results in terms of local people's income and resources conservation was possible, we ran, analysed and compared four different scenarios.

From the analysis carried out on the results produced by the model for the various scenarios, we concluded that a more long-term sustainable alternative to the present regional development plan exists, and we recommended in particular one of the strategic plans analysed.

1. Introduction

Papua, Indonesia covers the Western part of the island of Papua, and encompasses the second bigger primary forest in the world. It is a region characterized by an incredible abundance of natural resources -- precious metals, natural gas and oil, and especially rich primary forest. The huge potential profits from extracting these resources create strong incentives to exploit them.

After a period of transition from a centralised to a decentralised form of government, the region is now facing a delicate moment in its growth, as the choices and the politics of the local government will dramatically influence Papuan's development chances.

The way the new government will manage and regulate the inflow of foreign capital, local investment, available resources and the capacity to provide the necessary infrastructures and services will make the difference between mere economic growth in a few profitable sectors and a sustainable development of the region.

Different large-scale investment projects are currently under examination, which mainly concern infrastructure interventions, as the construction of a trans-regional highway network and a series of gigantic hydropower plants. An increase in land concessions for mining, agriculture (palm oil production in particular), and timber production seems to be also among the most likely policies on the government's agenda.

A traditional economic short-term cost-benefit analysis of the actual possibilities would most likely support opening the country to foreign capital and fully exploiting the resources made available by the government, to sustain the economic growth in those sectors that have a comparative advantage with respect to other regions of Indonesia or neighbour nations.

The risks in which the region can easily occur following this kind of policies are numerous, as we learn from many other developing countries experiences. Detrimental outcomes possibly include a huge environmental impact, the appropriation of natural resources by foreign companies with little benefit for local people, the disruption of indigenous cultures and traditional socio-economic activities, among many others.

Actually, Irian Jaya is already partly facing these problems. The resource exploitation policies that characterised the past regimes, in fact, had a dramatic effect in eroding the forest cover on the island and left Papuans with the highest rate of poverty and the lowest levels of Human Development Indicators (HDI) in the whole country. Minerals, oil and gas resources have also been fully exploited, but very little of the production's value has stayed in Papua to benefit local people.

Conservation International (CI), an American NGO involved in conserving the Earth's living natural heritage and its biodiversity which already has been operating in Indonesia since 1990, is particularly interested in the social and environmental aspects of the development of this region. Faced with a lack of adequate tools and perspectives to address the problems described above and fearing that policy decisions under consideration would likely worsen the situation in Indonesia, CI contacted the Millennium Institute (MI) for support in conducting a more comprehensive analysis of these issues. The ultimate purpose of such study is to reach out to decision makers and parliamentarians in Papua and to evaluate jointly various possible development strategies' impacts on the socio-economic-environmental system of the region.

The question we (MI) have been asked by our clients (CI) may be summarized as the following:

How can we identify a developmental path for Papua that would not only generate a real increase in local people's quality of life, but would also guarantee a proper use of natural resources and guarantee the conservation of flora, fauna and ancient civilisations which comprise the rainforest ecosystem?

In order to consider these critical aspects, which cannot be addressed by the traditional macroeconomic analysis, in the planning process for the future of the country another kind of approach to the analysis of the problem is required. A framework becomes necessary that can incorporate the economic, social and environmental analysis of the country's situation and its possible developmental paths. Such a tool would demonstrate to decision makers the impacts of a specific policy, for example, on forests, education levels, access to clean water or real economic benefits to local inhabitants. The Millennium Institute's T21 framework has been found to be a rigorous tool for conducting such analysis and was therefore adopted as the reference modelling structure in the study.
Using this approach we were able to create a series of policy scenarios, following the suggestions of our clients and their skilled and experienced staff working in Papua. These scenarios represented some of the most likely strategies the local government might follow in the next few years. We then simulated them and compared the results to a base case scenario in which all the current policies and ongoing projects were projected into the future. From these comparisons and from an analysis of the determinants of the observed behaviours we finally derived some important policy recommendations.

2. The Model

The model, built to represent the dynamic behaviour of the critical issues addressed by our clients and to give them a variety of policy options, is based on the T21 framework, originally developed by the Millennium Institute.
Threshold 21 (T21) is a system dynamics national model specifically developed to support policy design that addresses economic, social, and environmental issues.
As portrayed in Figure 1, the model addresses three interrelated aspects of a nation, respectively, the society, the environment and the economy. Each application of the model is built around a Core model, a set of general structures that represent the socio-economic and environmental characteristics of most countries. This core may be tailored, parameterized, and initialized to any particular country for which an analysis and policy design is being conducted.

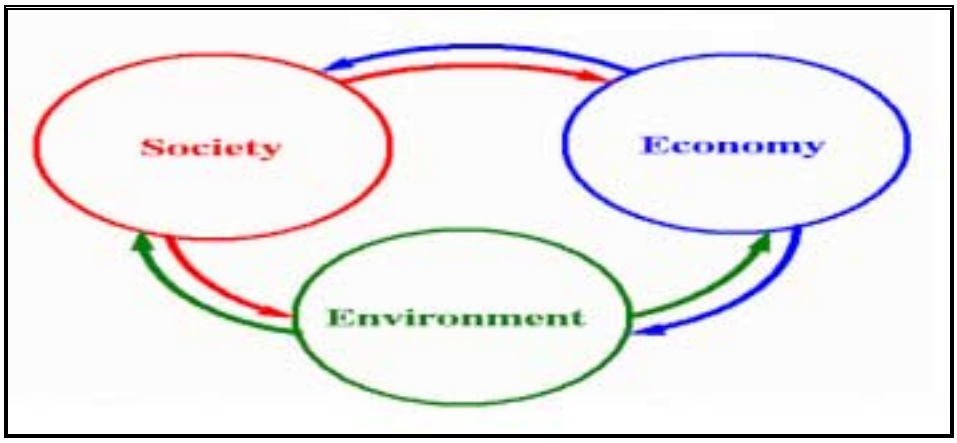


Figure 1

This thesis, consequently, does not constitute the typical T21 application. This is the first time that the model is being applied to a single province in a country. For this purpose, it has been necessary to introduce a variety of new model components and modifications of existing ones that we believe constitutes a strengthening of T21 at large.

2.1 Model Boundaries

There are a number of factors that lead us to model Papua as a province separate from the rest of the country. First, there is the regional character of the issues analysed. Though the challenges Irian Jaya currently faces are certainly affected by some elements outside the province boundaries (such as national policies, political stability of the area, etc.) they are mainly related to the use of local resources and to the quality of life of local people.
The mechanisms we traced out to be the key factors underlying the problem behaviour of critical variables were all identified to be associated with the regional level. Policy choices at the regional level, moreover, are supposed not to have any particular effect on the central government's decisions or on the national economy that could substantially affect the problem behaviour under analysis.

Moreover, Irian Jaya is a world apart from Indonesia. Most of the characteristics observed in the Papuan society, economy, and environment are substantially different from what may be observed in other Indonesian islands, and given the fact that the model uses aggregated data for most of the critical variables, it would have made little sense to make a whole of many different realities that prevail in different parts of Indonesia.
Note also that Papua gradually moves towards becoming a completely independent region with his own administrative structures and autonomy over many critical policies to be implemented. The population belongs to a different ethnic group from those of populations of other provinces. They have their own languages and national identity. Immigrants from the rest of the country are considered foreigners and mainly behave as such. They do not tend to integrate in the local society. They typically do not establish a family there, but remit to their original province most of their incomes and leave the island as soon as their economic conditions would allow it, indicating that visitors also consider Irian Jaya as an entity in part separate from Indonesia. For our purpose, therefore, we find it appropriate to consider Papua as such and to apply T21 accordingly for the purpose of analysis and policy design.

The boundary chart presented in Table 1 illustrates the scope of the model by indicating what key variables are endogenously represented, which are endogenous, which have been excluded, and which are considered policy variables.
As a general rule, we decided to exclude the variables that are not indispensable to endogenously represent the issues under analysis. Furthermore, we represent as exogenous the variables that are determined by causes originating outside the region and that the local government (our client) could not expect to influence.

Endogenous	Exogenous	Excluded	Policy Variables
GDrP	Prices	Indonesian GDP	Education Expenditure
GNrP	Tax Rates	World Economic Trends	Health Care Expenditure
Investment	Foreign Investment	Cross Border Pollution	Infrastructures Expenditure
Sectors' production	Exchange Rate	HIV/Aids	Micro Credit Expenditure
Income distribution	Government Special Allocations	Corruption	Prof. Training Expenditure
Employment	Foreign Aid Grants	People's Political Feelings	Energy Prices
Interests Rates	Routine Expenditure	World's Climate Change	Land Use
Debt	Fishery Production	Mineral Resources Limitation	Logging Control Expenditure
Technological Change		Aggregated Demand	
Land			
Education Level			
Energy Cost			
Transportation Cost			
Logging			
Pollution			
Migrations			
Population			

Table 1

For a complete and detailed explanation of how the model's boundaries have been chosen, please see Pedercini 2004.

2.2 Overview of Model's Characteristics

The model addresses three different aspects of a nation or, as here, one of its regions; the economy, the society, and the environment, as well as the interaction between them. In reality, the model is composed by many different sectors, and each of them typically refers to economic, social and environmental factors. They are normally adapted (or created when not existing beforehand) to a specific country, and subsequently interrelated to make up the entire national structure.
What follows in Table 2 is the list of the sectors used for the Papuan application of T21.
As one may easily guess looking at this table, the sectors are differentiated and named considering what are the key aspects of the region they represent.

Each of these sectors can be described and analysed separately. They are, however, interrelated, - depending on input produced by other sectors and (most of them) producing input to other sectors.

Core Part	Special Sectors
Population	Dam Physical Structure and Demand
Life Expectancy	Dam Impact on Production Activities
Births	Dam Economic Costs and Revenues
Investment	Dam impacts on Labour Force and Forest
Industry	Highway Physical Structure
Agriculture	Highway Impact on Prod. Activities
Services	Highway and Logging
Technology	Highway related Employment
Mining	Highway Economic Costs
Employment	Pollution
Government	Small Credit and Government Borrowing
Forestry and Fishery	Workers Migration and GNrP
Income Distribution	Effects on Life Expectancy
Education	Training
Land	Indicators

Table 2

As seen in Table 2, we differentiate between the Core and the Special sectors. We consider Core sectors those that are normally implemented in every application of T21, as they portray some common characteristics of the national system of most of countries across the world. These sectors describe the generic structure of the population, that of the economic, the land and the education systems as well as the governmental financial structures. They are normally implemented without substantial changes from one application to another, with the exception of the parameter values and the initial conditions. However, since this application of Threshold21 has been the first one applying the model at a regional level, many modifications have turned out to be necessary or useful also in the Core part.

On the other hand, we consider Special sectors all the structures created by the author for this specific application, in order to portray some peculiar aspects of the Papuan system or to introduce some additional policy option for the clients.

Belonging to this category is the group of Dam sectors, built with the aim of describing the actual dynamics of the Papuan electricity market and its influence on economic activities, employment and pollution, as well as to simulate one of the most likely policies of the local government: an increase in the regional hydropower capacity.

Also, the group of Highway sectors have been created to represent Irian Jaya's road transportation infrastructure dynamics and their importance to production activities, environment, and employment. This group of sectors allows the clients to test out strategies for road construction.

To introduce more realistic options for policy makers, a government borrowing and small credit sectors have also been created. By employing these sectors, the clients can introduce increases in the public expenditure exceeding the funds currently available or finance small local businesses, and observe the effects of such policies on the overall behaviour of the system.

The pollution sector has been remodelled in line with similar sectors in other applications of T21, yet modified substantially, to consider in particular the effects of

the different energetic and transportation policies that the Papuan government contemplate implementing.
The workers migration and GNrP sector describes the mechanisms underlying the movement of labour force from and to other provinces or countries. In this sector the GNrP is also determined, representing the part of GDrP beneficing to the local population. GNrP (Gross National regional Product) is in contraposition to GDrP, as it does not consider all the economic production generated inside Papua that is transferred abroad in the form of remuneration of foreign capitals invested there or of remittances from immigrated workers to their original country. In other words, the GNrP equals the GDrP less the net current transfers beyond Papua, including interest payments, profit remittances and workers remittances. This indicator represents therefore the part of GDrP that remains within the province to be shared by the residents.
The effects on the life expectancy sector simply considers how elements as pollution and health care expenditure affect death rates, and the training sector has the only aim of introducing an additional policy option: training workers for specific activities.
Additional technical details of all sectors are reported in the T21 Papua Documentation (Barney, Qu, Pedercini, 2003).

The structure that generates the model behaviour is typically one that traverses a number of sectors of the model offering each of these sector structures to contribute to the creation of that behaviour. Therefore, when analysing the causes underlying the behaviour of the model we will use a holistic approach. In particular, we will describe with the use of causal loop diagrams those feedback loops that play a central role in generating the model behaviour.
In Figure 2 is portrayed a simple subsystem diagram of the model, exhibiting its overall architecture and offering a qualitative idea about how the different sectors of the model interact. Each sector has been given a specific colour to identify what kind of variable its key variable(s) are: grey for economic variables, pink for social variables and green for environmental variables. Moreover, blue colour has been used to indicate the government sectors and the yellow for two important indicators: GNrP and Income Distribution.
Starting from the left hand side of the diagram, we see that the population is affected by births, life expectancy and migrations, mainly consisting of foreign workers immigrating with their families to find a job in Papua. The population provides labour force, and constitutes a key resource for all production activities, just as capital and land. Capital is increased through the investment flow, - local and foreign investments, that in turn is strongly dependent on the production levels. Land is used for different production activities and is a key resource in agriculture and logging. Land use can change depending both on governmental policies and internal circumstances such as food scarcity or illegal logging. Production activities, moreover, affect the land quality (through soil erosion and degradation) and produce pollution dissipated in the water, in the air, and in the soil.

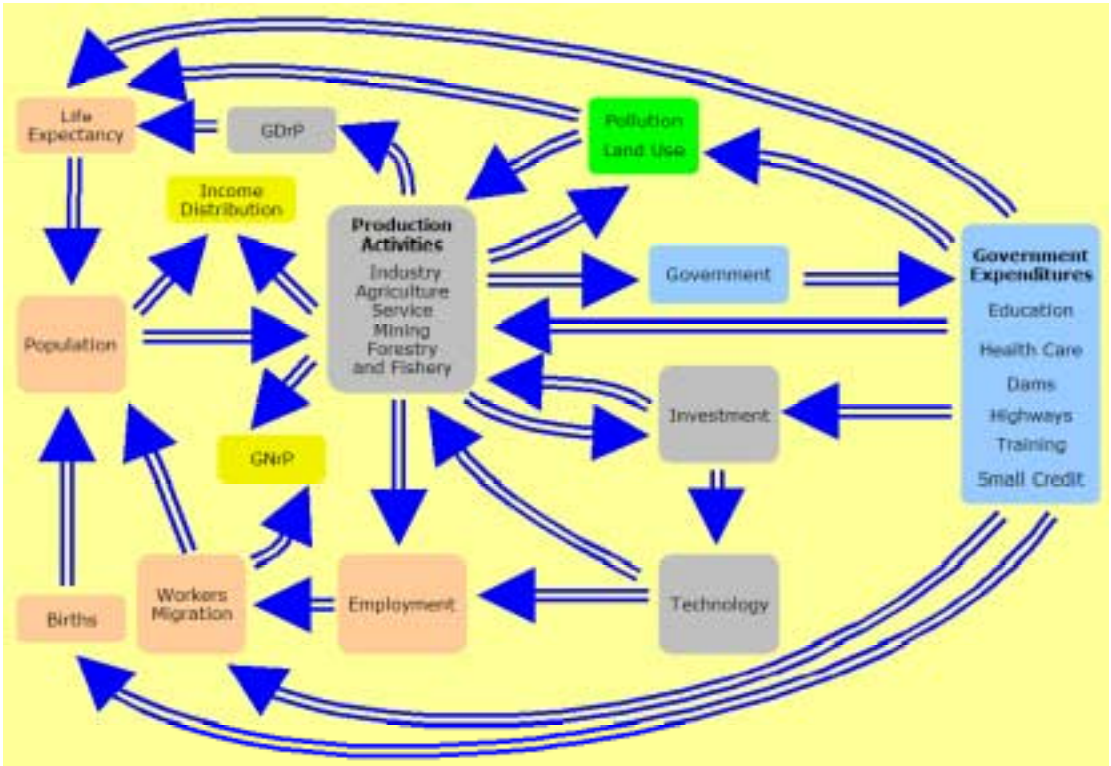


Figure 2

The total economic benefit generated by production activities is summed up in the GDrP (the Gross Domestic regional Product)[1] that has a key role in the determination of, among many other important variables, the life expectancy. The production sectors, together with technology, also define the desired level of employment, which in turn determines the workers migration flow (when labour force demand exceeds supply, there will be immigration and when supply exceeds demand there will be emigration). Technology also affects the production levels and is mainly determined by the investments introduced in each production sector.

Through a flow of taxes (direct from producers to the local government, or indirect passing through the central government), production activities influence the government budget and define what is level of public expenditures that can be sustained. The government can apply a number of different policies and distribute the available resources across a variety of activities. These will consequently affect a number of key economic, social and environmental variables, such as investment and productivity, birth rates and life expectancy, pollution and land use, in the other sectors.

Two central indicators are also portrayed in the diagram, as they are of great importance for our clients to evaluate the different policies that are tested using T21. Income distribution and GNrP (Gross National regional Product), in fact, offer synthetic measurements of how the economic benefit is distributed across the different layers of the society and how much of the benefit produced is targeted local people only.

[1] . In this study we often refer to the GDrP as the aggregate level of production in terms of value added. We use as indicator the GDrP instead of the GDP because we intend to measure only the value added produced in the region of Papua and not in the whole Indonesia

3. Policy Analysis

In order to demonstrate that, under certain conditions, a development plan that can generate better results in terms of local people's income and resources conservation was possible, we ran, analysed and compared four different scenarios. The first three scenarios represent some of the policy interventions under discussion that are more likely to be implemented in the near future. The last scenario was created by our client with the principle of sustaining the economic activities directly benefiting local people and preserving the natural resources.
In the following paragraphs a brief description of each scenario and the results of the policy analysis conduced are reported.

Indicators

To evaluate the results of each scenario with respect to the base case, we chose a set of indicators consistent with the characteristics of the issues analysed. In the original full analysis developed, we used seven indicators representing what our clients considered the most significant economic, social and environmental aspects of the system under study.
For the sake of synthesis, in the following analysis of the scenarios' results we will focus only on 3 of them: the Gross National regional Product (GNrP), the Public Debt and the Forest Land. The three indicators chosen are sufficient to give a complete idea of the outcomes from each scenario. Moreover, the recommendations emerging by monitoring these three variables are perfectly in line with those obtained with the wider spectrum of indicators used in the original work.
The GNrP represents the part of Gross Domestic regional Product (GDrP) that is actually benefiting local people, and excludes all the revenues remitted abroad by foreign workers or used to remunerate foreign investors. This key indicator is necessary to understand to what extent the economic growth effectively improves local people's wealth.
The Public Debt measures the total amount of money the government owes to foreign financial sources. This variable is extremely useful to keep track of the actual cost sustained by the government to implement a certain set of policies. In other words, it measures the economic inheritance left to Papuan future generations.
Forest Land represents the total number of hectares of land in the region that are covered by forest. The Papuan forest is the world's second biggest primary forest and represents probably the most precious resource in the region. The flora and fauna's biodiversity are impressive and could be easily compromised by the poor land management. Monitoring the state of the forest is therefore a key factor to avoid the destruction of an ecosystem of extreme value not just for Papua, but also for the entire world.
Forest Land is not only a very important environmental indicator, but also allows us to evaluate some critical aspects of social change in the country. As mentioned in the introductory chapter, a relevant part of the population lives in remote villages dispersed in the forest, each with its own particular culture, traditions and language. These people live off of the flora and fauna offered by the forest, and its destruction would probably mean the end of their civilisations.

In the following sections each scenario will be briefly described in terms of the set of policies introduced and their significance. The results generated in each case will be analysed and compared, and some policy recommendations proposed.

3.1 Base Case Scenario

3.1.1 Description

Of the four scenarios analysed, the first is called “Base Case” and represents the term of comparison for the results observed in the other cases. This scenario simply projects in the future the actual policy lines followed by the local government in the last years, and assumes the completion of the ongoing infrastructure projects.
To have an overview of the actual policies implemented in this scenario, we could qualitatively describe them as following:

- A small investment in Hydropower, financed by the government, but not directed specifically to support mining or industrial activities
- A relatively small investment direct to improve the existing road system based on extending ongoing projects, also financed by the government
- An increase in expenditure on Education as recently introduced by the Papuan government
- A continuation of the other government expenditures on the current relative levels

Although it does not consider very innovative policy plans, this scenario constitutes an important factor for the analysis conducted, as it represents the reference with respect to which other scenarios are evaluated.

3.1.2 Results

In the Base Case scenario we observe a general growth in the economy mainly driven by foreign investments, which is only moderately beneficial to local people. This is well represented in
, where the model’s generated behaviour for the variables GDrP and GNrP is portrayed.
The unit for the X scale is time, from the year 1995 until 2020, while the scale on the ordinate axis measures the values assumed by the variables. Units of measure are reported in the legend at the bottom of the graph, where a colour is also assigned to each variable and the name of the run, Base Case in this case, specified.
As it appears from the above Figure, though the GDrP growth at a sustained rate, the GNrP, representing the flow of value added actually benefiting to local people, grows at a much slower rate. In particular, the ratio between GDrP and GNrP increases over time.

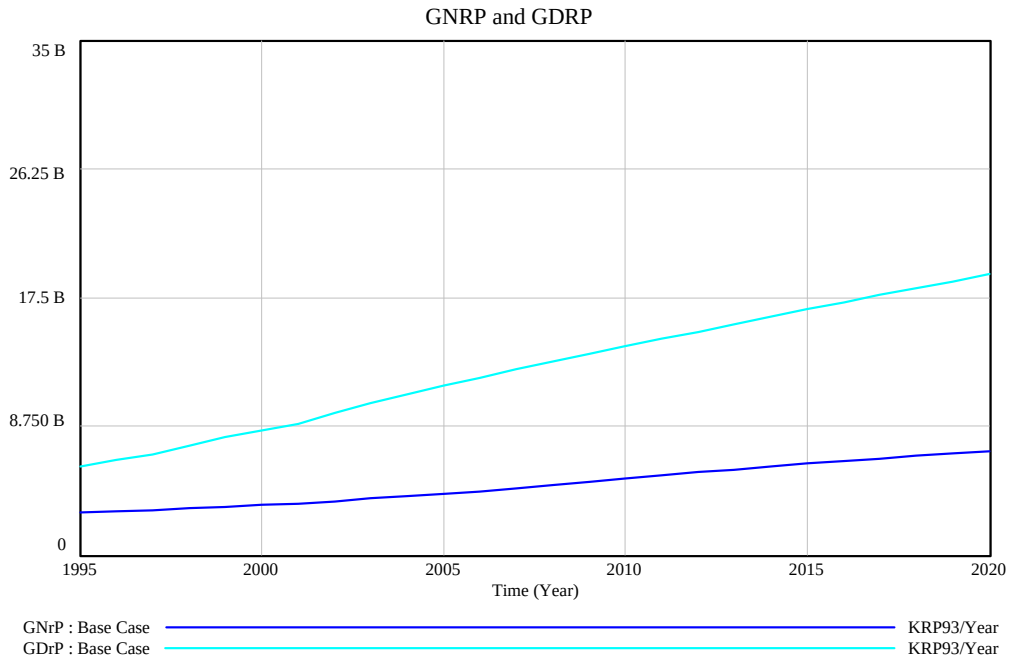
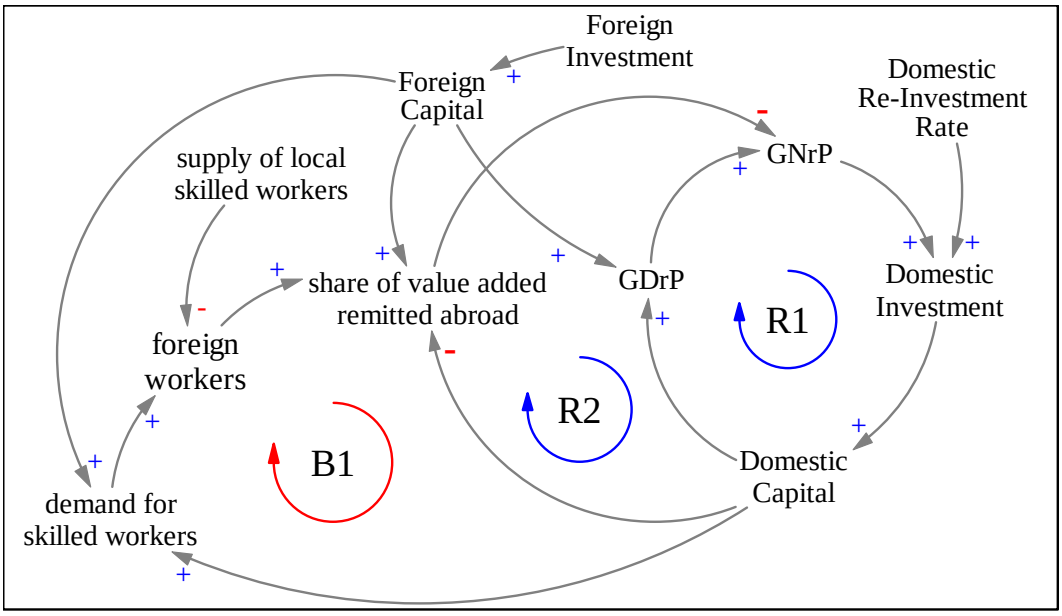


Figure 3

The huge shares of foreign capital and workers over the total productive factors available actually causes the biggest portion of surplus value, generated from the exploitation of the existing natural resources, to be remitted abroad. A dynamic explanation of this phenomenon is offered in Causal Loop Diagram 1.



Causal Loop Diagram 1

The above causal loop diagram (CLD) illustrates three feedback loops: the reinforcing loops R1 and R2 and the balancing loop B1.

The reinforcing loop R1 is a common investment acceleration loop, with one important peculiarity: we consider the GNrP as determinant for the flow of domestic investment, and not the whole GDrP. This is based on the observation that the GNrP is a more accurate representation of the value added benefiting to local investors than the GDrP.

The reinforcing loop R2 extends the R1 loop including an additional variable: the share of value added remitted abroad. This is directly influenced by two factors: the ratio between local and foreign capital; the ratio between local and foreign workers. According to this view of the local economic system, in fact, a lower amount of local capital and local workers implies a bigger share of value added remitted abroad, a lower (ceteris paribus) GNrP and therefore a smaller flow of local investment.
The balancing loop B1 has the effect of counterbalancing the growth generated by the R1 and R2 loops. As domestic capital increases, in fact, the demand for skilled labour force increases. Given the limited amount of skilled local labour force available, the demand for foreign workers also increases. This leads to a bigger share of foreign workers over the total, a bigger share of salaries remitted abroad and ultimately to a smaller GNrP.
In Causal Loop Diagram 1, we identified three main variables on which the government could directly or indirectly intervene: the foreign investment, the supply of local skilled workers and the domestic re-investment rate.
Stimulating foreign investment is actually one of the main targets of the actual government. We observed, however, that if on one hand foreign investment has the effect of strengthening the R1 loop, on the other hand it has a weakening effect of comparable intensity on the R2 loop. Changes in foreign investment have overall a very small effect on the GNrP, and this variable does not represent a strong leverage point.
The domestic re-investment rate, on the contrary, represents a very strong leverage point, as it directly strengthens both reinforcing loops R1 and R2, with a strong impact on the GNrP.
Eventually, the supply of local skilled workers is an even more important leverage point. Increasing the amount of local skilled workers directly weakens the balancing loop B1, which represents one of the principal constraints to the growth of the regional economy.
The identification of such leverage points not only improved our understanding of the behaviour generated by the model, but also gave us solid bases to create a more efficient and effective development plan (tested in the Urban Development scenario).

Continuing in the analysis of the results produced in the Base Case, we can focus on the development of the public debt.
The public debt in this scenario grows at an impressive rate until 2010, before being reabsorbed around 2020 (Figure 4). The growth of debt is mainly driven by the increasing expenditure to finish the ongoing infrastructure projects and by the consequent maintenance costs.
Such high levels of public debt have a profound consequence on the budget allocation. Typically, as interests and repayment rates increase, the government has to cut other type of expenditure, including development expenditure. This in turn may have, on the long run, a negative impact on labour productivity and on GDP.
A dynamic representation of this phenomenon is offered in Causal Loop Diagram 2. The reinforcing loop R3 represents a typical debt accumulation loop: as debt increases, interest payments increase, boosting the deficit and therefore augmenting the debt even more.

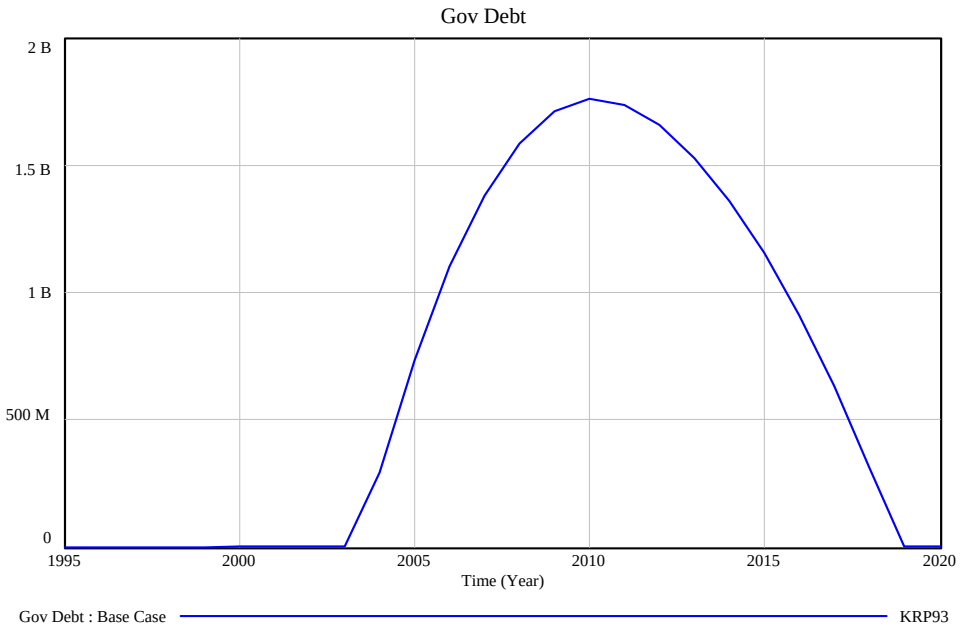
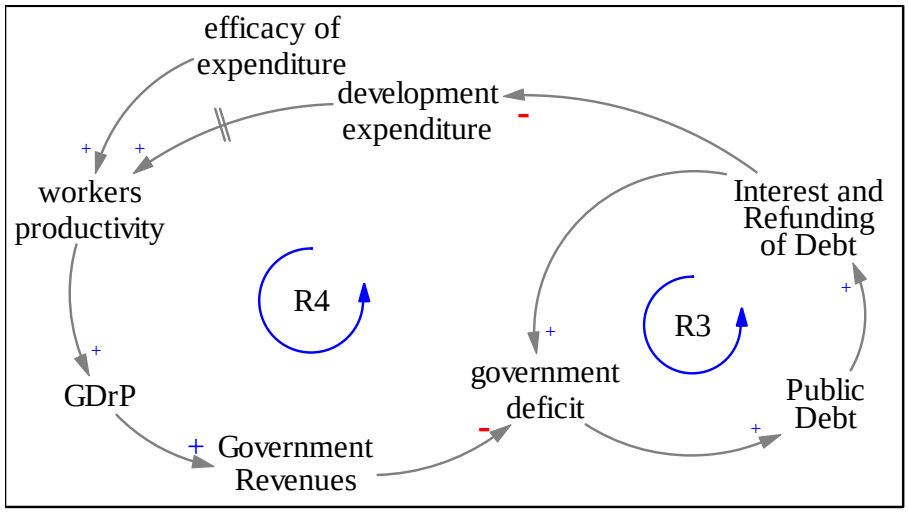


Figure 4

The reinforcing loop R4 extends the R3 loop to consider the effect of the expanding debt on development expenditures. Based on what observed in many developing countries, we assumed that the government will try to keep the deficit at reasonable levels by cutting development expenditures (which include education and health care expenditure). This type of intervention may seem to be effective in the short run, but in the long run may generate serious problems for the government and the local population. As development expenditures are decreased, health and education services are compromised, impacting with a long delay on workers' productivity. As a consequence the GDrP decreases and government revenues, which strongly depend on GDrP, are also reduced.



Causal Loop Diagram 2

Therefore, while the R3 loop have a very important role in driving the public economy in the short-term, the R4 loop becomes crucial on a longer time horizon, and should not be undertaken. The long delays involved in this loop, in fact, also imply a strong "inertia" in changes of workers' productivity.

In Causal Loop Diagram 2 we identified one important policy variable: the efficacy of expenditure. Concentrating the expenditure on the projects that promise the strongest

impact on workers productivity is the key to assure that government investments are paid back by increases in revenue on the long run. A higher efficacy of expenditure makes therefore the action of the R4 loop more favourable under any circumstances.

Looking at the environmental impact of the development plan implanted in the Base Case, we can observe in Figure 5 the development of forest land over time. Forest land decreases rapidly, but at a decreasing rate, apparently following a goal seeking behaviour. The amount of forest loss is, however, impressive and at the end of the simulation only about 2/3 of the initial forest land is left. Causal Loop Diagram 3 shows the main elements affecting forest land as well as the basic structure responsible for the goal seeking behaviour observed.

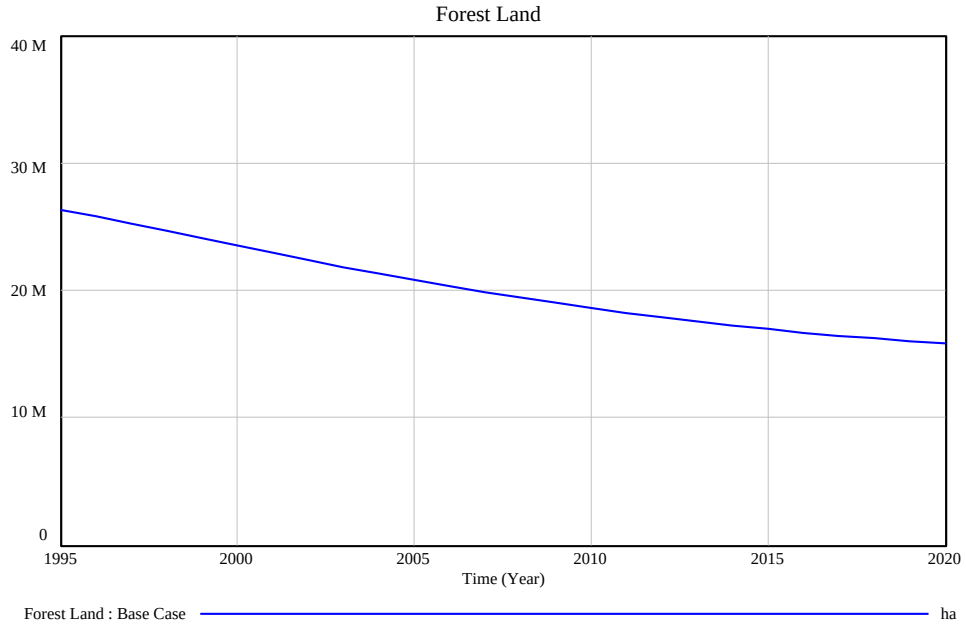


Figure 5

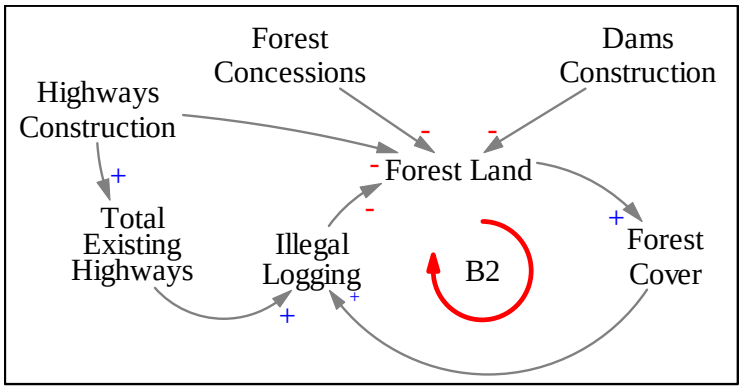
The main elements driving forest loss are four: dams' construction; forest concessions; highways construction; and illegal logging.

Dams' construction causes forest loss directly, because it implies the covering up of vast areas with water.

Forest concessions are given by the government for various purposes, mostly for mining and logging, this last activity being rarely operated in a sustainable way. Though the amount of forest concessions given every year is huge, it seems that the government is slightly reducing this amount over time.

Highways construction affects forest loss both directly, as forest has to be cut to make room for the new highways, and indirectly, by stimulating illegal logging. New highways open up new areas for illegal logging, and make it easier and more profitable.

Illegal logging also reduces forest land and consequently the forest cover, representing the ratio between forest land and the total surface of the region. As the forest cover is reduced it becomes more difficult and expensive to practice illegal logging, which will consequently decrease. This closes the balancing loop B2, the main responsible for the goal seeking behaviour observed for forest land.



Causal Loop Diagram 3

The dramatic forest loss observed in this scenario is also important for the huge consequent losses in terms of biodiversity, as well as of culture and traditions of the ancient tribes inhabiting the forest. The model does not quantify these aspects, but the proportions of the forest areas lost indicate that the size of these phenomena should be seriously taken into consideration by the government.
In Causal Loop Diagram 3, we identified three variables on which the government can directly act to reduce forest loss: highways construction, dams' construction and forest concessions. Out of these three variables, highways construction, because of its effect on illegal logging, represents certainly the most important leverage point. The positive effect of reducing forest concessions and dams' construction, in fact, is in part counterbalanced by the consequent increase in illegal logging.
Introducing drastic measures against illegal logging would certainly be the most effective policy to preserve forest, but the government does not seem to be able (or willing) to move in this direction.

3.1.3 Preliminary comments on the results produced

Some important considerations can be derived from the analysis of the behaviour that the model produced in this case.
First, the model seems to be able to reproduce and project in the future the main issues we are interested in. The increasing share of GDrP over GNrP, the accelerated growth of public debt and the dramatic forest loss observed indicate that resources exploitation does not transform into a substantial increase in the quality of life of local people, and that a harmonic development process does not follow the mere economic growth observed.
A second qualitative observation is that in this case none of the policies implemented appeared to change drastically the evolution of the issues under analysis. None of the policies implemented, in fact, was directed to introduce changes in the leverage points we identified. Table 3 summarizes the leverage points identified for each of the issues analysed.
Finally, it appears that the indicators chosen to monitor the actual state and trends of the major variables in the model well suit our needs of control over the most problematic aspects of the system.

Issue	Leverage Point
Poor Quality of Life for Local People	Domestic re-investment rate
Poor Quality of Life for Local People	Supply of skilled Workers
Increasing Public Debt	Efficacy of Expenditure
Forest and natural resources preservation	Forest concessions
Forest and natural resources preservation	Highways and Dams' construction

Table 3

3.2 Big M Scenario

3.2.1 Description

The second scenario introduced is called “Big M”, where “M” stands for Mamberamo, a Papuan region that is characterised by an abundance of natural resources. In this scenario, we assume a full exploitation of the region, with big infrastructures constructions, in particular hydropower plants and roads, and huge foreign capitals inflow directed to develop the mining sector. This “Big M” project seems one of the public policies under discussion that is most likely to be implemented, and introduces enormous risks in terms of environmental impact as well as of loss of culture and traditions.
The actual governmental policies implemented could be qualitatively described as following:

- A large investment in hydropower (dam and power stations) financed jointly by foreign investors and the local government
- A correspondent investment in power lines financed by the local government
- A relative small increase in the investment in roads in that area financed by the local government

In addition to these policies, we also introduce a further assumption:

- An extra inflow of foreign capitals in the industry and mining sectors

3.2.2 Results

To have an idea of the development of the economy in this case, it is first useful to have a look at the graphical comparison of the GNrP for the current (red line) and the Base Case (blue line) scenarios in Figure 6.

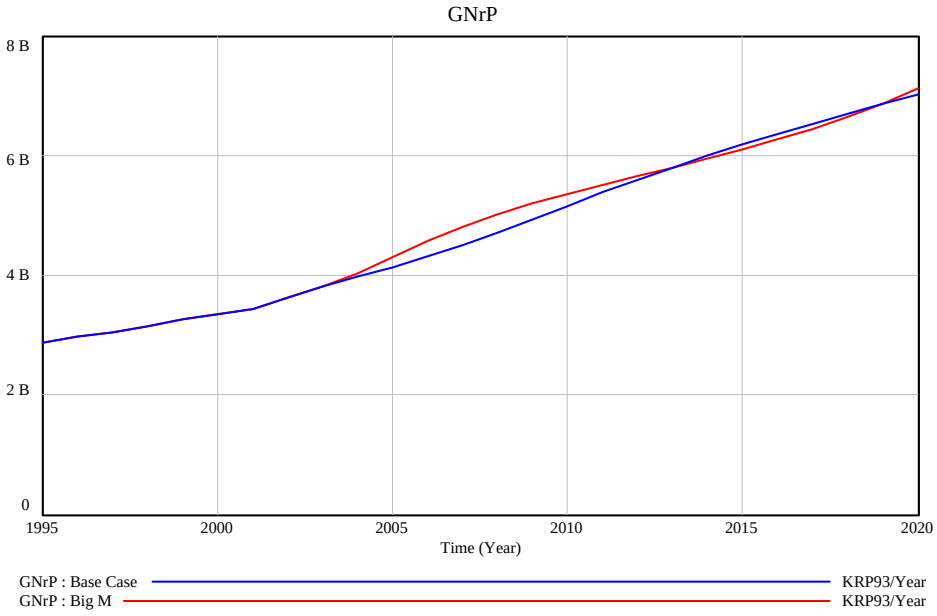


Figure 6

As clear from the graph above, though in this case the model generates a substantially higher growth in GDrP (not shown) than what is observed in the Base Case, the impact on the GNrP is small. This is due to the fact that the boost in production observed is mainly financed by foreign capitals, and the extra labour demand

generated is absorbed by foreign workers. According to Causal Loop Diagram 1, therefore, though GDrP substantially increases, at the same time the share of value added benefiting to local people decreases.

Figure 7 illustrates the behaviour of the Public Debt in this scenario, compared to the Base Case.

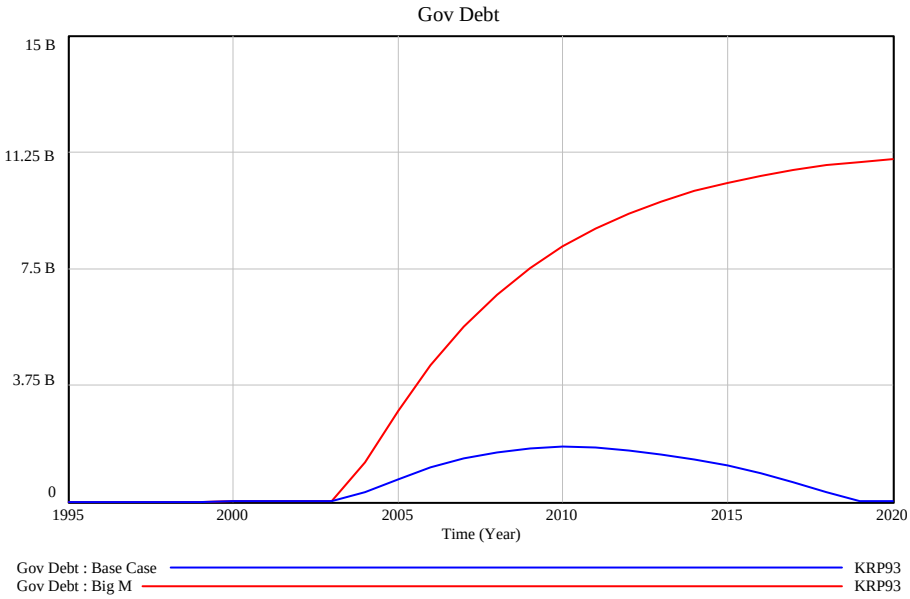


Figure 7

The picture of the regional assets in this graph is dramatic. While in the Base Case the debt reaches a maximum value of about 1.8 billion around 2010, in this scenario the debt keeps on growing, consistently faster, until the end of the simulation, when it reaches a stunning level of about 11 billion.

In this case the debt grows because the government allocates a huge budget to the new big scale infrastructure projects, incurring in a huge deficit. As described in Causal Loop Diagram 2, the growing deficit causes in the short run an even higher deficit, and has a deleterious effect on development expenditure. With the completion of the infrastructure projects, the debt's growth rate tends to decrease. The financial burden left for the future generations is however extremely heavy.

To complete the picture of the development of the system under the assumptions characterising the Big M scenario, it is interesting to observe the development of the forest land.

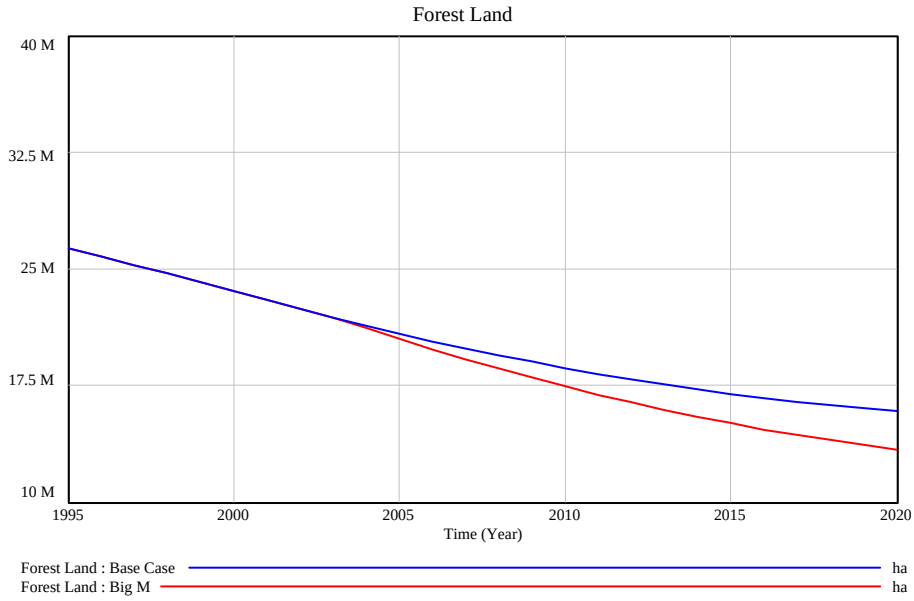


Figure 8

As shown in Figure 8, forest land decreases more rapidly in this scenario than in the Base Case. This is principally due to the highways the government has to build to make the Mamberamo are accessible, to the large scale hydroelectric plants built and to the land concessions the government assigns to develop the area.
As shown in Causal Loop Diagram 3, illegal logging also plays a crucial role in the increase in forest loss, stimulated by the construction of the new highways.

3.2.3 Preliminary comments on the results produced

From the analysis of the selected indicators, we can derive some preliminary conclusions about the development plan simulated in this scenario.
First, the policies implemented in this scenario are economically expensive for the government. In particular, the infrastructure construction projects generate costs that greatly exceed the administration's possibilities, creating a huge public debt.
Second, the economic conditions of local people are not substantially improved, while the appropriation by foreign individuals and companies of the benefit deriving from the use of Papuan natural resources increases.
From the environmental point of view, the situation is even worse, as the forest suffers severe damage from the new infrastructures construction projects as well as from the increase in the land concessions given by the government.
In conclusion, the set of policies introduced in this scenario not only does not provide a solution to any of the critical issues analysed, but also worsens the initial situation from the point of view of the quality of life of local people, of the conservation of natural resources and of public debt.

3.3 More Roads Scenario

3.3.1 Description

With the third scenario, we introduced the hypothesis of an accelerated and intensified process of roads construction. In the "More Roads" scenario, in fact, we assumed that the government undertakes a series of projects to improve the regional viability system, including the huge "Trans Irian" project, an eleven thousand kilometre highway network. This enormous infrastructure intervention would be paid for by

giving logging concessions around the new roads to the foreign companies contracted to build them, and is currently under consideration.
To have an overview of the policies actually implemented in the model in this scenario, they can be qualitatively described them as following:

- An accelerated process of road construction financed by logging concessions around the road
- A small investment in Hydropower and power lines, financed by the government
- A continuation of other government expenditures at current relative levels

3.3.2 Results

For an initial idea of the overall economic performance of the system in this scenario, it is interesting to observe how the GNrP develops over time.
As shown in
, the difference between the GNrP in this scenario (grey line) and in the Base Case (blue line) is not significant. The new "Trans-Irian" Highway network, the main innovative aspect characterising this scenario, has in fact only a limited effect in stimulating the local economy.
This is due to two main reasons. First, the benefit deriving for decreasing costs of transportation is limited, because of the scarce level of production of marketable goods and because the network is not built with the purpose of linking the most strategic economic centres. As the building company is paid with logging concessions, we expect in fact that strong pressures will be made to push the development of the new highways in the most profitable areas for logging, and not through the small developed areas.

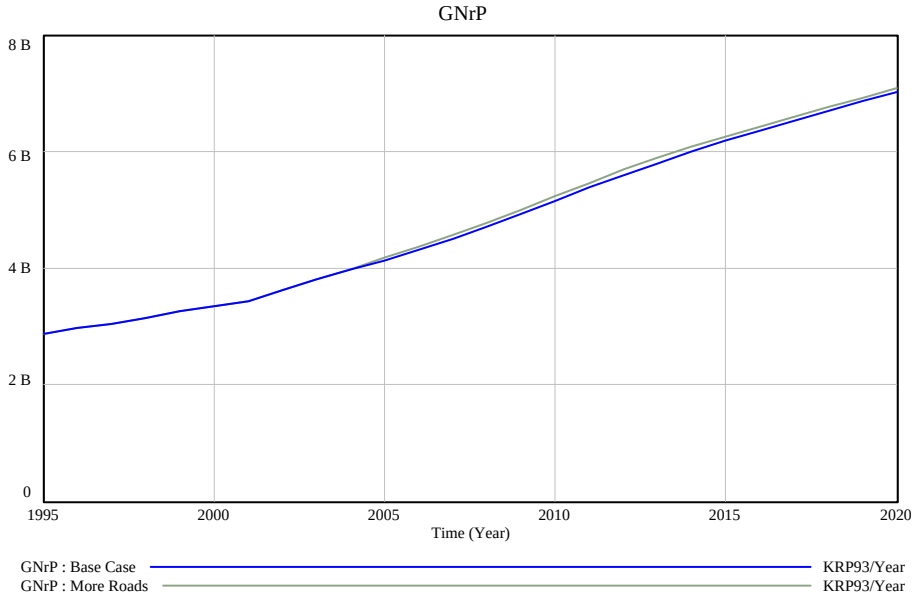


Figure 9

The second reason of the small impact of this large scale infrastructure project is that it will be carried out by a foreign company, employing foreign workers for all the most technical (and well paid) tasks. Consequently, as illustrated in Causal Loop Diagram 1, the benefit for local people deriving from the project is limited.

To complete the panoramic over the effects on the economic system of the new policies introduced, we have to change our focus from the private to the public economy. Figure 10 represents the behaviour of the public debt over time, comparing

the results obtained in the current scenario to those formerly calculated in the Base Case.

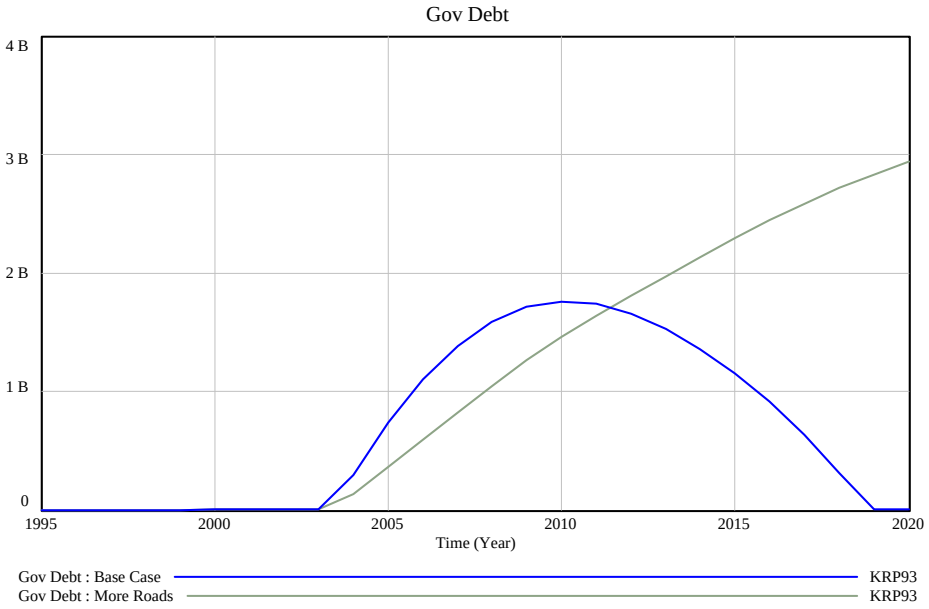


Figure 10

The two curves appear strongly different, the public debt in this case growing steadily over time up to a level twice as high as what observed in the base case.
The most important element causing the increase in the debt is not, in this case, the cost of highway construction, but the cost of maintenance. In this scenario we assumed in fact that the government does not sustain any economic cost for the construction of the additional roads, as they are paid by the logging concessions given. Maintenance costs, however, gradually grow, reducing the funds available for development expenditure and compromising this way the future of both private and public economy, as shown in Causal Loop Diagram 2.

To conclude our analysis of the results produced by the model in this scenario, it is important to have a look at the effects of the policies newly introduced on the environment. Figure 11 illustrates the development of forest land in this and in the Base Case scenarios.
The immediate message this graph is giving is clear: about 50% more of forestland is destroyed in the More Roads scenario, with respect to the Base Case. The rate of forest loss seems, in this case, accelerate from 2003 and, though towards the end of the simulation it shows a tendency to slow down, it is still far bigger than in the Base Case.
The main cause of this accelerated process of destruction of the forest covering the island can be identified in the new, monolithic project of road construction implemented. Road construction affects the stock of forestland both directly and indirectly, as explained by Causal Loop Diagram 3.

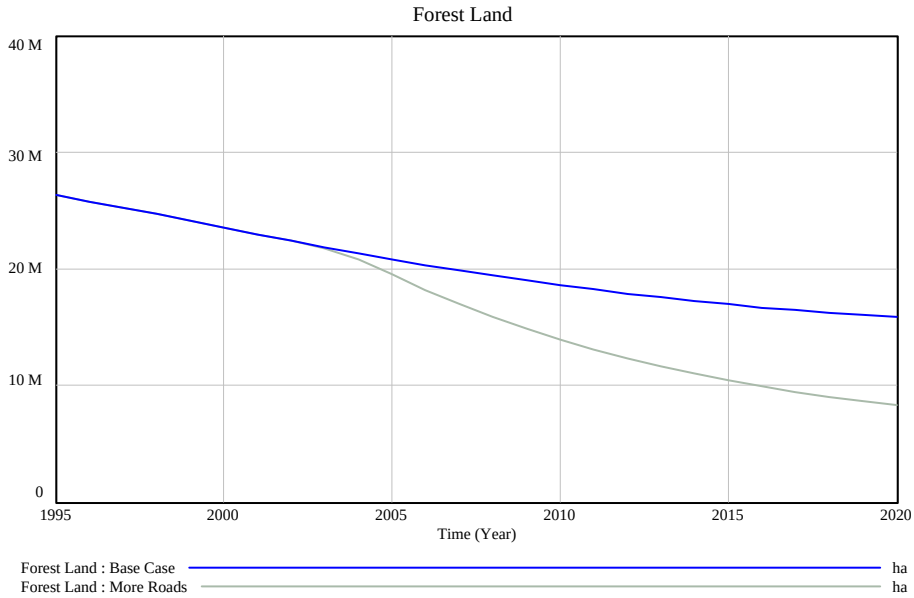


Figure 11

What is left in terms of forest represents only about 30% of the initial value, meaning that most of the vegetation on the island is lost at the end of this scenario, with possible catastrophic consequences. This represents a threat not only to floral biodiversity of the island, but also for the many faunal species living in the forest, including human beings. The numerous tribes inhabiting the rainforest would be in danger, and with them their cultures, languages and traditions. Moreover, the dramatic reduction in the forestland projected in this scenario may create a menace for the whole population by increasing the possibility of floods and landslides and accelerating soil erosion.

3.3.3 Preliminary comments on the results produced

On the one hand, the project of roads construction implemented in this scenario may seem reasonable, considering the government's target of containing the construction cost of the new infrastructures. On the other hand, it generates a series of important negative effects. First, the oversized highway network ends up generating high maintenance costs, which absorb an important part of the government's budget and create a substantial public debt.

Second, the construction of the new highway network has devastating effects on the forestland. This occurs both directly, due to the logging concessions around the road given by the government, and indirectly from the increase in illegal logging that the new roads cause.

Finally, the impact on the private economy of the Trans-Irian project is modest when compared to its cost, deriving from both quantitative and qualitative characteristics of the project.

In conclusion, the More Roads scenario generates the poorest results among those analysed thus far for each of the selected indicators.

3.4 Urban Development Scenario

3.4.1 Description

The last of the scenarios analysed in this study is called "Urban Development" and it has been developed accordingly to the high leverage points identified (see Table 3). In particular, we assumed that the government will increase expenditures on social

services and education, will cut the logging concessions, and will try to create preconditions for the development of the small local economies. To achieve this target, in particular, professional training and micro credit initiatives are introduced, and small infrastructures interventions are realized. With respect to the assumptions in the other scenarios, this more softly-oriented policy plan represents a strikingly different approach to the solution of major issues the Papuan population is actually facing.
With reference to the leverage points identified, these policies can be summarised as following:

- The organisation of Training Courses for local workers
  => To increase the skilled labour force supply
- The introduction of Small Credit initiatives for local enterprises
  => To increase local investment
- Targeted investments to expand the existing road network, to create the missing connections between the most relevant urban and economic centres
  => High efficacy of expenditure and low impact on forest
- A modest investment in energy production and distribution, to substitute hydropower for the more polluting and expensive diesel
- => High efficacy of expenditure and low impact on forest
- A reduction in the number of logging concessions given each year
  => Direct effect on reducing forest loss
- An increase in expenditure for education and health care
  => High efficacy of expenditure

3.4.2 Results

As immediately appear from Figure 12, the GNrP in this scenario (green line) grows substantially faster than in the Base Case (blue line). This is due to the combination of two factors, in particular, that guarantee that the extra growth generated in the GDrP is also well transferred to the GNrP.
First, the small credit initiatives introduced by the government strongly stimulate domestic investment. The increase in domestic investment not only increases production, but also has a positive effect on the balance between local and foreign capital, and therefore reduces the share of value added remitted abroad (as explained in Causal Loop Diagram 1).
Second, the increase in production observed generates a robust increase in the total employment, and in particular in the employment of local workers. The additional skilled labour supply created by the professional training courses introduced is in fact rapidly absorbed, reducing the need of foreign workers. This further reduces the share of GDrP remitted abroad, and has therefore a positive effect on GNrP.

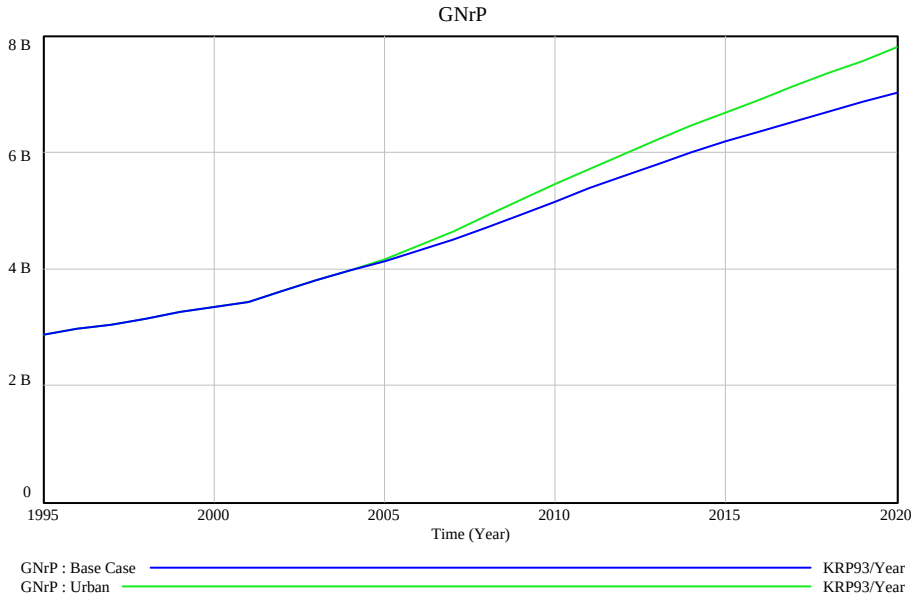


Figure 12

In other words, in this scenario a substantial part of the additional value added produced benefits local people, unlike what is observed in the other scenarios.

To have an idea of the impact on the public finances of the development plan introduced in this scenario, we can observe in Figure 13 the time graph for the public debt, in the current and Base Case. The policy plan introduced absorbs a relatively small amount of public resources, concentrating on small investments in high efficacy areas (see Causal Loop Diagram 2). Consequently, the public debt is contained and rapidly paid back in this scenario, allowing the government to sustain a much higher level of development expenditure.

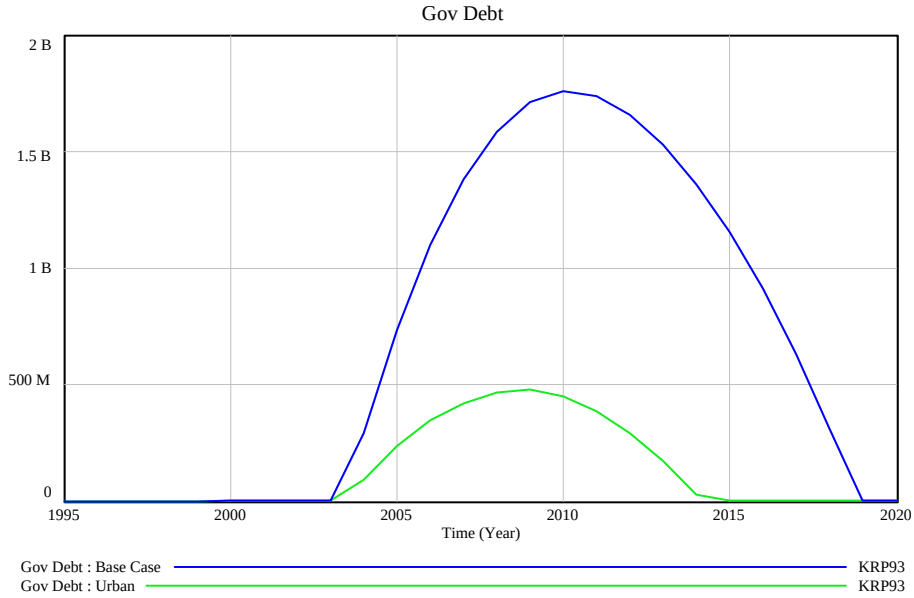


Figure 13

Finally, we can observe in Figure 14 how the policies introduced also have a positive effect on forest land. Thanks to the reductions in the amount of logging concessions, as well as in the construction of highways and dams, forest loss is substantially decreased (see Causal Loop Diagram 3).

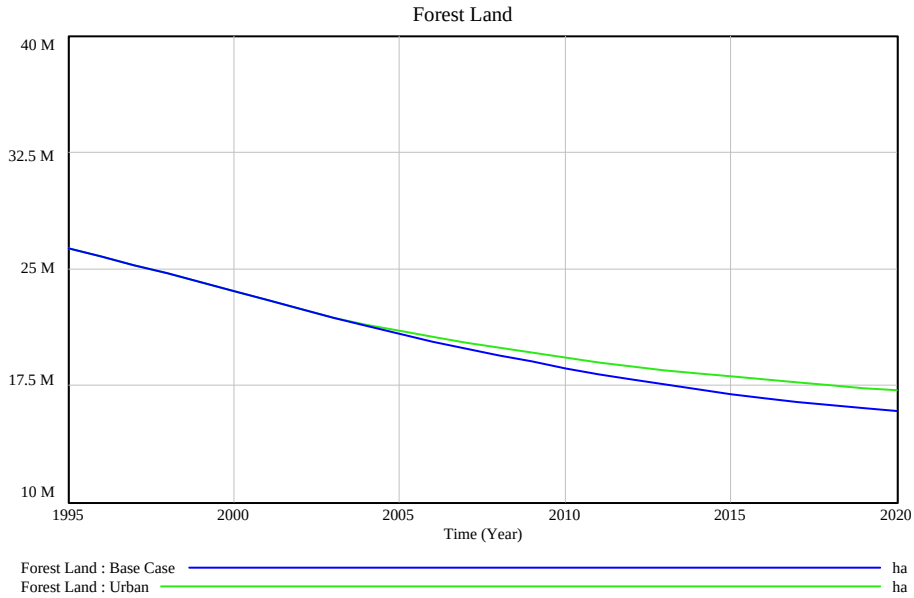


Figure 14

Though the forest loss observed in this case is still dramatic, this scenario highlights how the government can directly intervene to reduce forest loss without compromising the private economy. About 1.3 billion hectares of forest are saved with respect to what observed in the Base Case, and the economic benefit directed to local people has substantially increased.

3.4.3 Preliminary comments on the results produced

The Urban development scenario produces overall the most desirable results.
The policy plan introduced in this scenario generates an endogenous acceleration of the economic growth through the support of domestic investment, as well as a substantial increase in the employment of local people. As a consequence, the value added produced is well transferred to local people, implying a net improvement of their living conditions.
From the point of view of the environment, moreover, forest loss is considerably reduced for the sake of conservation of biodiversity, and of local culture and traditions. This does not appear to have a significant negative effect on the local private economy.
Finally, by reducing the large scale infrastructures budget and concentrating the resources on social expenditure, the government can substantially cut the deficit in the short run and benefit of the increase in workers' productivity in the long run. The public debt is rapidly paid back, and no financial burden is left for the future generations.

4. Final Conclusions

From the analysis carried out on the results produced by the model for the various scenarios, we derived two important conclusions.

The first conclusion refers to the results of the policy analysis: considering the results generated by the model for all the major indicators, the Urban scenario produces the most desirable overall behaviour. We therefore strongly recommend this type of policy interventions for the development of the Indonesian region of Papua. However, some limitations on the results produced by this analysis must be highlighted.

First, the evaluation of the results produced in the various scenarios depends to some extent on the indicators chosen. We believe that the indicators we have chosen are well representative of the overall situation of the socio-economic-environmental system in Papua, but undoubtedly these reflect our particular philosophy of approach to development studies. A different set of indicators may possibly have led to considerably different conclusions.
Second, the Urban scenario has not been built through an optimisation method, but it is based on the suggestions of the field's experts that participated in the modelling process. This approach guarantees a high degree of realism and feasibility of the proposed development plan, but also implies that further policy analysis can be conducted with the model, and theoretically better results can be found.
Nevertheless, the objective of this work, to demonstrate that a more long-term sustainable approach to development planning in Papua is possible, has been fully accomplished. Although the Urban scenario proposed is not necessarily the optimal one, in fact, it surely shows how a quicker improvement of the actual situation of the local population is possible, without huge infrastructure projects and government expenditure, and while saving a bigger share of the natural resources available. The commons dichotomy between economic development and resources conservation seems not to stand in this case.
We hope that the work illustrated in this thesis can lead to a rethinking of the regional development planning in Papua.

The second conclusion does not refer to the results produced, but to the methodology used in this study. Both during the research conduced prior to the model construction and during the analysis reported in this study, the need of an integrated development analysis tool was clear. Only a model incorporating economic, social and environmental aspects of development could support our analysis and give an answer to our key questions. The Threshold 21 model demonstrated to be very well suited for this type of study and flexible enough to incorporate the particular issues affecting Papua. System Dynamics, the methodology at the core of T21, confirmed to be an excellent support for integrated development analysis, allowing the representation of strikingly different systems with the same modelling language.
We therefore suggest the use of this same methodology when analysing complex and integrated development issues.

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