

A Proposal for Global and Local Food Policies Modelling

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Abstract The world is facing a great dilemma because the current food production model is not sustainable from the ecological and social perspectives. Therefore, it is necessary to study the public policies adopted in the last century and to analyse new possibilities, in accordance with the XXI century context. The Food and Agriculture Organization (FAO), an agency of the United Nations (UN), developed several food policy proposals aimed at eliminating hunger and malnutrition. In 1974, FAO launched the Food Security Policy influenced by food commodities traders. Two decades later, a critical examination of the effects of Food Security Policy in peripheral countries revealed the degradation of small farmers ecological economies and undesired lateral effects as unemployment, hunger and rural exodus. The main critic came from the peasant movement "La Via Campesina", which is an organization of small farmers, indigenous people and rural workers from all over the world, and also researchers committed to their cause. They presented, as an alternative, the Food Sovereignty Policy, to rescue ecological-traditional practices that value the small farming ecological production and environmental preservation. The research proposal will use energy systems modelling to simulate the effects of global food security policy and the trends expected from food sovereignty policy, both studies will offer quantitative and qualitative indicators.

Keywords Food policy impacts, Fossil energy dependence, Modelling and simulation of economical-ecological transition

1. Introduction

Ensuring the population food needs is an essential duty of governments. In 1778, Thomas Malthus theorized that population growth would overcome food production capacity, generating hunger and misery (ALENCAR, 2001). The problem was solved due to Europeans emigration to the colonies, the use Peruvian *guano* and Chilean *salitre*, and food imports from abroad.

After the First World War, with the reappearance of hunger, famine was discussed as one of the major global issues by the League of Nations, established in 1919. This organization disappeared when it shows itself incapable of avoiding Second World War (BRAGA, 2016). After the Second World War, the United Nations Organization was created to solve world's problems. A special agency, the Food and Agriculture Organization (FAO), was created to develop strategies against hunger (SILVA, 2014).

Since 1947, FAO has published an annual report "The State of Food and Agriculture" which discusses agriculture and famine all over the world. It was evident the existence of hunger in some countries and the opportunity for

preservation of food raw-materials by industrial processing. Consequently, FAO (1947) main strategy was "modernizing" farm production using chemical fertilizers, pesticides, machinery, irrigation works and, also, food exports to countries with food shortages, quite common in countries devastated by war. In the 70s, FAO's objectives were: food prices stabilization, creation of buffer stocks, and crops industrialization to cope with food lacks (FAO, 1975).

The concept of "Food Security" was launched at the World Food Conference in 1974. It was defined as "the availability of adequate world food supplies, at all times, to sustain a steady expansion of food consumption and to offset fluctuations in production and prices" (FAO, 2006). In 1983, Food Security focused on "access to food commodities" and the need "to ensure that all people have physical and economic access to the basic food that they need" (FAO, 2006). In 1996, in Rome, the FAO World Food Summit's Plan of Action established food security as "access, use, and availability, since even with increased agricultural production, there was difficulty for families in buying food and also instability in supply and demand that prevented food security from being achieved". The Rome Declaration states that "food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life". Meanwhile, the existence of environmental problems was recognized as a fundamental factor for satisfying human needs and demands strategies at the regional and international levels, and the

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coordination between institutions, societies, and economies (FAO, 1996).

In 1996, the global movement of peasants, indigenous people, farm workers, and research organizations from all over the world, called “La Via Campesina”, criticized the concept of food security proposed by FAO, since it excluded and harmed small rural producers by means of unemployment, hunger and rural exodus. This movement suggested a new policy called “food sovereignty” to guarantee the right of peasants to maintain and develop their own food according to local resources and traditional culture (LA VIA CAMPESINA, 1996). This organization defined food sovereignty as “the right of every nation to maintain and develop its ability to produce basic food while respecting cultural and productive diversity”.

La Via Campesina assumed that food sovereignty was the main requirement for a genuine food security. A few years later, they added “the need to create public policies based on democratic control of resources, ecological sustainability, equity, cooperation and different type of measures to prevent events that cause damage and bankruptcy” (LA VIA CAMPESINA, 2001).

In the International Symposium on Agroecology for Food Security and Nutrition, organized by FAO in 2014, FAO recognized that the concept of “performance” in agriculture, requires a new definition and that the key points for that are: (a) recognizing the reality of small family farmers; (b) reduction of fossil fuels dependence to decrease negative impacts on society and environment; (c) actions based on local agroecological knowledge and, finally that (d) a sociopolitical context favorable to agroecology must be achieved to reduce the destruction of environmental resources, for the biodiversity protection and for the payment of environmental services. FAO recognized that “Biodiversity” is an essential component for the resilience of the rural system and it must be maintained without burdening small farmers, as a biological capital that facilitates adaptation to a future without fossil fuels and with strong climatic changes. Important factors for the transition to real sustainable development are the ownership of land and seed autonomy (FAO, 2015).

In recent publications (FAO, IFAD, UNICEF, 2017, FAO, 2018), it is considered that the achievement of the food security objectives depends on progress in rural areas and strengthening the local economy in an inclusive and sustainable pathway. They recommend taking into account the untapped potential of food systems for agroindustry development and measures to support small-scale farmers. The United Nation’s goals in Agenda 2030 include to end hunger, achieve food security, improve nutrition and promote sustainable agriculture (FAO, IFAD, UNICEF, 2017). These organizations estimate that 815 million people around the world suffer from chronic malnutrition, which indicates that there is still much to be done for quality of life, prosperity, and peace. The food security concept changed in

past decades approaching more and more towards human rights policies. Unfortunately, the basic solution considered by these organizations is food production increase using the agribusiness or industrial perspective.

However, FAO (2018) recognizes the importance of agroecology as a factor that can achieve the goals proposed in Agenda 2030.

The agroecological approach can solve the real causes of hunger and has proven to be a solution to maintain the existing resilient communities in a path that integrates the social, economic and environmental dimensions of sustainability. The agroecological solution arises from family and community farmers, as indigenous peoples, “African descendants’ communities”, riverine fishermen, rural women, and young people. It seems, each day more clearly, that the junction of scientific knowledge with popular wisdom can build the ideal scenario that meets future needs (REGANOLD & WACHTER, 2016; NICHOLLS & ALTIERI, 2018).

Food sovereignty emphasizes the study of the internal and external relations generated by capitalism and the impacts it causes on the environment, as well as the autonomous and democratic control of land, water, and ecological management (JAROSZ, 2014).

The food sovereignty defended by Via Campesina implies in respect for the native productive capacity and cultural diversity of each nation and rejects the intrusion of international capital and technology. This movement argues that agroecological practices, based on new and ancestral knowledge in harmony with nature, are capable of feeding the world, building equitable alliances between people, organizations and movements of the countryside and the city (LA VIA CAMPESINA, 2017). It is a very important issue that, as Dussel proposes (2003), deserves a critical political attitude in order to change the destiny of many people.

2. Food Security and Food Sovereignty: It is Necessary a Systemic Comparison

The scientific literature review reveals the world’s food and hunger issue complexity. Therefore, there is a need of analysis, formulation and forecasting of public policies. The comparison of security and food sovereignty politics, in a systemic and dynamic perspective, using energy systems modelling (ODUM & ODUM, 2000) can allow a critical analysis. A holistic point of view is necessary to identify the most important parameters and variables that can be used in the modelling and simulation of these two policies. A systemic perspective allows to investigate the performance of the complex phenomena of food production, trade, consumption, and recycling of nutrients and their impacts on the environment and society, aiming to base technical decisions and public policies.

3. The Emergy Modeling of Food Security and Food Sovereignty

Howard Odum (1924-2002) believed that systems modelling tools, based on minimodels, would facilitate the understanding of complex systems, using unified concepts that encourage systemic thinking to induce appropriate actions. The emergy methodology, proposed by him, allows discussion of the interaction between human and natural systems. It allows the evaluation of all the contributions of nature and human economy, in terms of previous work, as equivalent aggregated solar exergy or emergy (ORTEGA et al., 2008). It can measure carrying capacity, ecosystem services, negative externalities, yield ratio, investment ratio, emergy exchange ratio, fair price etc.

Emergy modelling is based on open-systems thermodynamics, chemical kinetics, and electrical circuits concepts aiming to represent the evolution of ecological and socioeconomic systems in a dynamic form (ONCKEN, 2017; ODUM 1972). Some of these “minimodels” will be used to build-up the simulation models of food security and food sovereignty policies, among them are the following:

Mini-model	Description
PCCYCLE	Model to simulate the effect of the quantity of materials being recycled
RENEW	Model to simulate growth with renewable resources
NONRENEW	Model to simulate growth using non-renewable resources
2SOURCE	Model to simulate the use of two resources (renewable and non-renewable)
LOGISTIC	Model to simulate logistic growth

EXCLUS	Model to simulate competition in the use of limited resources
CO-OP	Model to simulate cooperation between two populations
INFOBEN	Model to simulate a state driven by another system
PEOPLE	Model to simulate the pulse of the world population
STATECON	Model to simulate a state driven by another system

A set of mini-models based on the analysis of the global problem of food production, trade and consumption will be prepared to infer the relationship between a pair of countries that obey the FAO food security policy. Food security suggests the purchase of subsidized food produced in a country with a large capacity to produce agrochemical food and a country with an ecological peasant agriculture with limited food production capacity in a process that ends with the destruction of national policies aimed to protect the peasant economy and does not bear the consequences.

After that, other two models will allow to discuss the ecological transition and the operation of fully sustainable communities.

3.1. Criteria Used for Food Security and Food Sovereignty over Time

Tables 1, 2 and 3 present the criteria used for food security and food sovereignty over time.

In practice, FAO's food security policies (1996) hampered small-scale producers who had to compete with the subsidized products of large commodity enterprises. The small producers went into crisis and began to fail, abandoning their production systems and suffering hunger and poverty.

Table 1. Comparison of Food Security and Sovereignty policies in 1996

Food Security (FAO 1996)	Food Sovereignty (Via Campesina 1996)
It suggests buying "cheap" food commodities to nations to end the population's hunger. In other words, it suggests the opening of markets for multinational companies that operate in the food trade. The opening up of markets favors large agricultural producers using industrial inputs. It is a policy determined by multilateral institutions influenced by speculative capital.	It defends that each nation develops and maintains its own productive capacity respecting the cultural and productive diversity, protecting the natural resources. It rejects economic policies that destroy the productive capacity of small producers. It considers a basic human right the access to nutritious, safe and culturally adequate food. It defends Agrarian Reform for those who do not have land. Besides this, to defend the right of native people to use their territory and encourages the permanence of the young and the women in rural areas.

Table 2. Problems generated by the FAO Food Security Policy (1996)

Proposes (FAO, 1996)	Problems generated
Access to cheap food (commodities) produced on a large scale by countries with export-oriented agriculture.	Loss of economic balance in nations obliged to import food. Concentration of wealth in central countries. Creation of poverty by the destruction of the traditional agricultural activities. Governments abandonment of the family farmers causing migration to the cities' peripheries.
To induce a change in the world's agricultural sector in order to obtain more production through the use of hybrid seeds adapted to chemical inputs and pesticides, and also a greater use of machinery.	Purchase of small farms by the big land-owners. Concentration of wealth in the countryside by people who benefit from food security policy and rural modernization.
Stabilize the food supply through the creation of regulatory stocks. Generation of jobs in the agroindustry sector.	Creation of warehouses. Establishment of large agroindustries.

Table 3. Comparison between Security and Food Sovereignty main proposals

FAO (2017) – Food Security	Via Campesina (2017) – Food Sovereignty
Rural activities are reducing poverty and many people are emerging from poverty, without leaving rural areas.	Controlling the common good is essential to the lives of people and nature, it should not to be appropriated by a few who have easy access to capital to avoid disastrous effects.
Urbanization helps reduce poverty in rural areas through economic connections.	The environmental, economic and nutritional crisis shows the need to change the agricultural model and the food model.
Job creation in small and large cities can play an important role in rural development and alleviate poverty.	Promotion of exchange of experiences among the agents of the social movements to strengthen the struggles. Deep analysis of public policies to develop new proposals.
Visualization of the food system with a territorial perspective considering the formation of a net of small cities.	Develop collective knowledge to change production methods, Democratize access to resources and defense of territories.
Provide conditions for rural development to be economically viable, providing adequate income and good living conditions for farmers, workers, and families.	Democratic participation in the construction of alternatives. Fights against the concentration of land, monocultures, and the use of genetically modified seeds.
Provide information to improve productivity, access to transportation, obtain loans, and develop new skills.	Actions to make technological and organizational options visible, with a broad communication of agroecological research results.
To keep small producers competitive in the domestic market through public policies and improvements in infrastructure.	Promotion of international and national debates. Via Campesina collaborates with the FAO but rejects the criteria used by the World Bank, WTO, IMF.
Generate non-agricultural jobs in rural areas, in the agroindustry sector or in other manufactures.	Protection of peasants' collective rights to land, water, seeds etc.
Connect small producers with sources of knowledge, inputs, and credit.	Encourage "Good Living", which is part of ancestral knowledge, to enable harmony between humans and nature.
Reduce transaction costs; develop credit, technical support and rural insurance; provide infrastructure, research, information and training; and risk mitigation mechanisms.	Build a strong alliance between organizations of people from countryside and city movements.

3.2. The Proposal of Agroecology

According to FAO (2018), three-quarters of the 815 million people that suffer hunger are food producers. Therefore, Food Security Policy is not obtaining its desired results. The farmers' poverty needs to be placed at the heart of innovation systems. On the other side of food problem, one-third of the world's population is overweight, and suffers from obesity and chronic diseases due to the consumption of unhealthy food. The current chemical-based agriculture model provides large amounts of food for global markets but does not offer well-being. It uses toxic external inputs, generate deforestation, water scarcity, biodiversity loss, soil depletion, greenhouse gases emissions.

A sustainable food production should ensure real food security and good nutrition, social well-being, economic equity, and biodiversity conservation to produce ecosystem services on which agriculture and society depend. Agroecology is able to face-up the future needs, focusing on communal and family farming, maintained until now by indigenous peoples, riverine fishermen, mountain farmers and pastoralists. This productive model provides long-term solutions based on shared knowledge; that combines local, traditional knowledge with multidisciplinary science. (FAO, 2018).

Although not a new concept, agroecology is gaining interest among many, as an effective response to climate change and the challenges of food provision. FAO's recent engagement helps agroecology to bring together knowledge

and experience from ecological producers' organizations, research institutions, public organizations and the private sector. Each partner can contribute to a better world through coordinated action and collaboration (DUSSEL, 2016).

Agroecology can contribute decisively to the Objectives of Sustainable Development (ODS) and the achievement of the objectives of the Paris Climate Agreement, the Convention on Biological Diversity and the United Nations Convention to Combat Desertification (FAO, 2018). Table 4 presents the ten basic and interrelated elements of agroecology:

Table 4. The ten elements of agroecology (FAO, 2018)

The ten elements of agroecology (FAO, 2018)
1. Diversity
2. Co creation and sharing of knowledge
3. Synergies
4. Efficiency
5. Recycling
6. Resilience
7. Culture and Food Traditions
8. Human and Social Values
9. Responsible governance
10. Circular and solidarity economy

From the perspective presented above, it is possible to identify variables that should be considered in the study of food policies, as shown in Table 5.

Table 5. First list of variables related to food policies

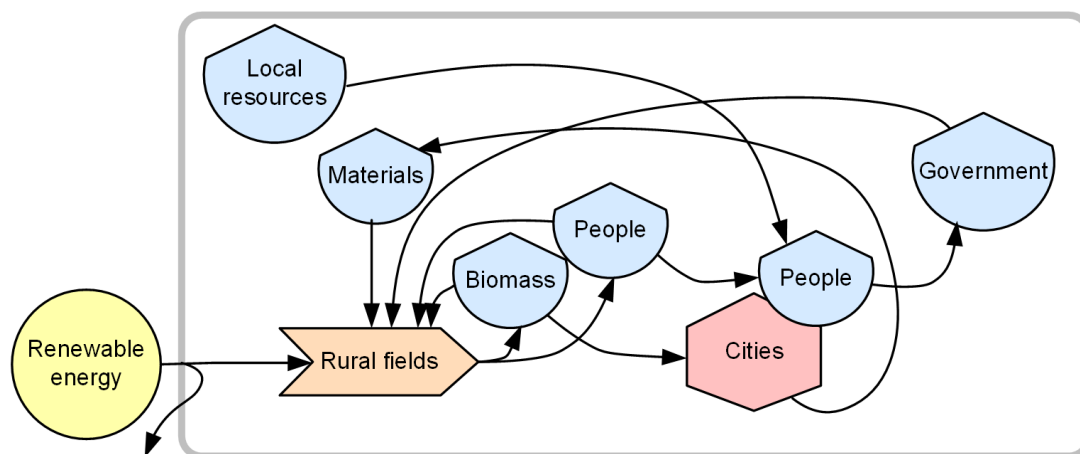
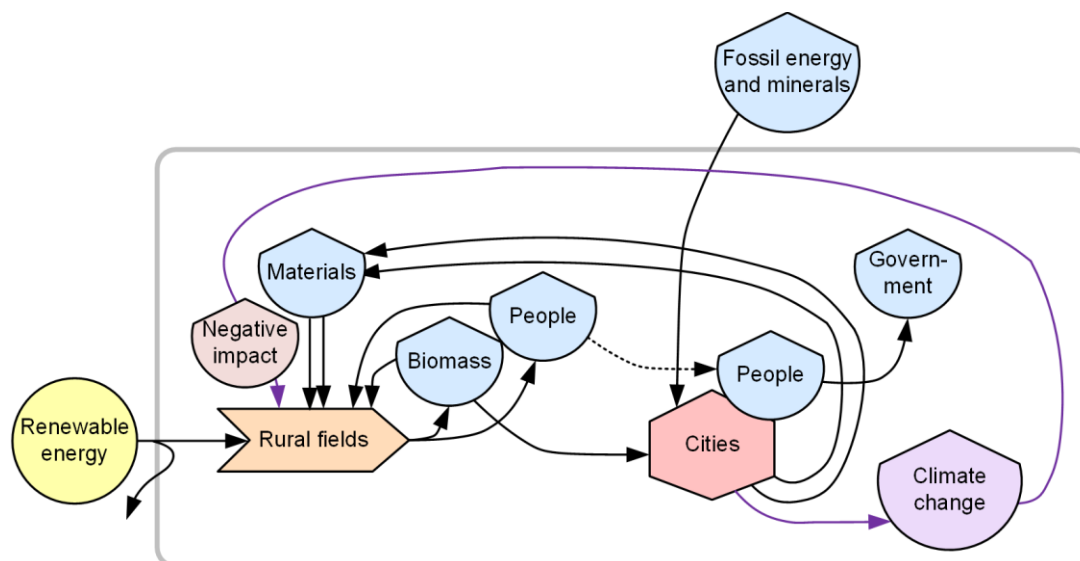
1	Agricultural area and land distribution
2	Waterworks and irrigated area
3	Agricultural soil quality
4	Rural and urban employment generation rates
5	Local and external resources on rural productivity
6	Area preserved in rural areas (for ecological resilience)
7	The accumulation rate of monetary resources for social use
8	Variation in the price index of food and agricultural inputs
9	Policies for the preservation of the degraded environment
10	Subsidies, taxes and labor costs in the various regions
11	Mitigation and adaptation of climate change impacts

4. The Composition of a Mini-Model to Simulate the Effect of Food Policies

Five centuries ago, Portugal and Spain developed

transcontinental navigation to occupy Africa, South Asia and America, for their own benefit. Three centuries ago, the Industrial Revolution allowed the use of non-renewable resources in agriculture, industry and transport (DUSSEL, 2000). The Renew model (ODUM and ODUM, 2000), represents the natural resources use in an ecological form that prevailed until in the beginning of the 20th century in Latin America despite resources extraction by foreign countries (Figure 1).

The combination of the NONRENEW and PCCYCLE models (ODUM and ODUM, 2000) allow to represent USA, at the beginning of XX century (Figure 2). The use of cheap coal allowed to export low-cost products and, at the same time, the country implemented actions to impede Latin America from gaining autonomy, and self-sufficiency (TOWNSEND, 2015; GROSFUGUEL et al., 2005). At the end of World War II, as there was an excess of food production, political decisions were taken to open markets:

**Figure 1.** Diagram of Mexico's energy flows in 1900 (based on Odum and Odum, 2000)**Figure 2.** Diagram of energy flows of USA in 1900 (based on Odum and Odum, 2000)

- Use of economic surplus for investment in technology.
- Encouraging food habits changes in peripheral countries to adopt a similar eating profile.
- Direct aid from US government to exporting farmers.
- Lobbies influence in FAO's Food Security Policy.
- Exporting food at low prices to countries that had difficulty in producing enough food to meet the demand of its population.

The FAO's Food Security Policy application in the peripheral nations caused strong damages in the communities' economy based on local resources and traditional culture. This kind of farming used seasonality, crop rotation, interaction with biodiversity, but when it adopted monoculture, hybrid seeds, agrochemicals and heavy machinery, it lost autonomy and self-sufficiency and, as main result, the national agricultural planning was lost (SCHANBACHER, 2010).

The peripheral countries' farmers movement called Via Campesina, became aware of the problems and proposed a totally different food policy, called Food Sovereignty, to

rescue and strengthen their ecological food production and consumption system.

4.1. FOODSEC

The first proposed model (FOODSEC) represents FAO's food security policy and its effects on the food importing and raw-materials exporting of peripheral nations. This model was build-up after considering two other minimodels: 2SOURCES and STATECON (ODUM and ODUM, 2000).

The small-scale, self-sufficient family and community production was replaced by large-scale farms, with monoculture, imported industrial inputs, production oriented to export and great environmental damage (SCHANBACHER, 2010). A subsidized economy based on oil, that has greater force than an economy based on renewable resources. This interaction involves privatization, deregulation, trade incentives, farm specialization and growth and, ownership concentration (GROSFOGUEL, 2007).

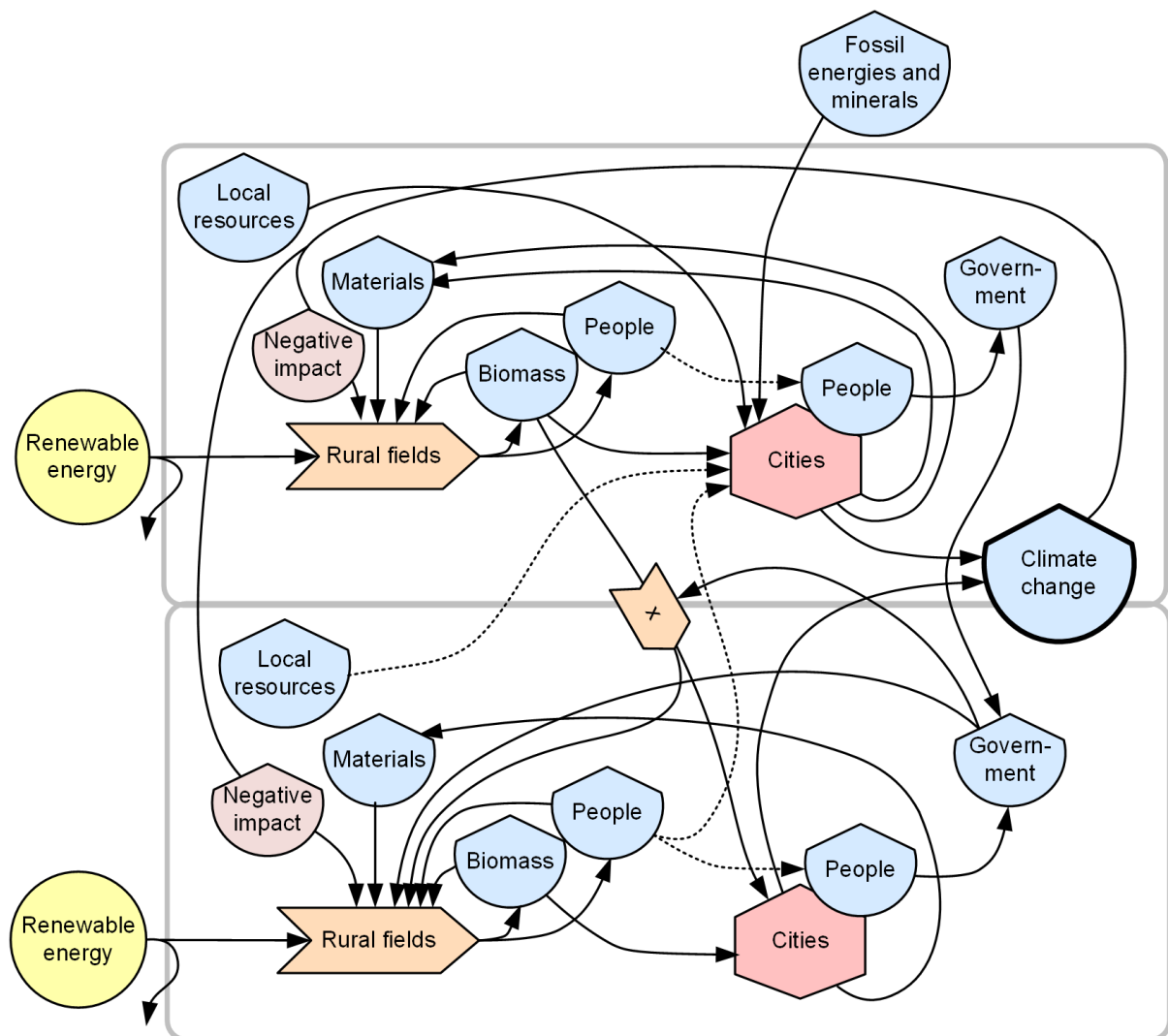


Figure 3. Diagram of food for resources exchange (based on Odum and Odum (2000))

Nowadays, it is possible to perceive that the peripheral governments adopted actions contrary to the interests of their population. It is possible that they were not aware, at that time, of the side-effects of importing subsidized food. The food security policy disrupted the rural systems organization of the peripheral countries and generated social and environmental problems. The large monoculture farms expanded over the territory, using non-renewable resources, producing soil erosion, land ownership concentration, reduction of preserved areas, deficit of ecosystem services, species extinction and climate change. All these factors affect the family and community farming, causing hunger and migration (GIRALDO & ROSSET, 2017).

4.2. COOP

The COOP minimodel (ODUM and ODUM, 2000) represents the transition, with shared use of strategic resources and good quality information. The concept of food sovereignty overcomes the concept of food security since the public policies created from this FAO concept did not achieved real success for several decades. Food sovereignty emphasizes the vision of community and family agriculture, occupying large biodiverse spaces, sharing ecological knowledge, emphasizing local and regional consumption, and innovation based on community cooperation (SCHANBACHER, 2010).

Important studies of several scientists, conclude that globalization is not beneficial to the majority of the population and that only through the change of cultural values and public policies that will be possible the social and environmental advances needed for the planet (DUSSEL, 2000; BARTRA, 2011).

The following list, shows the parameters that affect food sovereignty according Via Campesina's ideas and it complement Table 5, both will be merged and considered in the modelling and simulation of the historical process under research and in the prediction of future scenarios.

Food sovereignty factors (LA VIA CAMPESINA, 2017):

1. Unemployment in rural and urban areas
2. Income distribution in rural and urban areas
3. Variation in the area of ecological agrarian reform
4. Policies to preserve cultural and productive diversity
5. Decentralization and degrowing Policies
6. Research policies involving the issue of hunger
7. Policies for valorization of rural work
8. Alliances between rural and urban organizations
9. Promotion of agroecological practices
10. Job creation in cities and rural areas

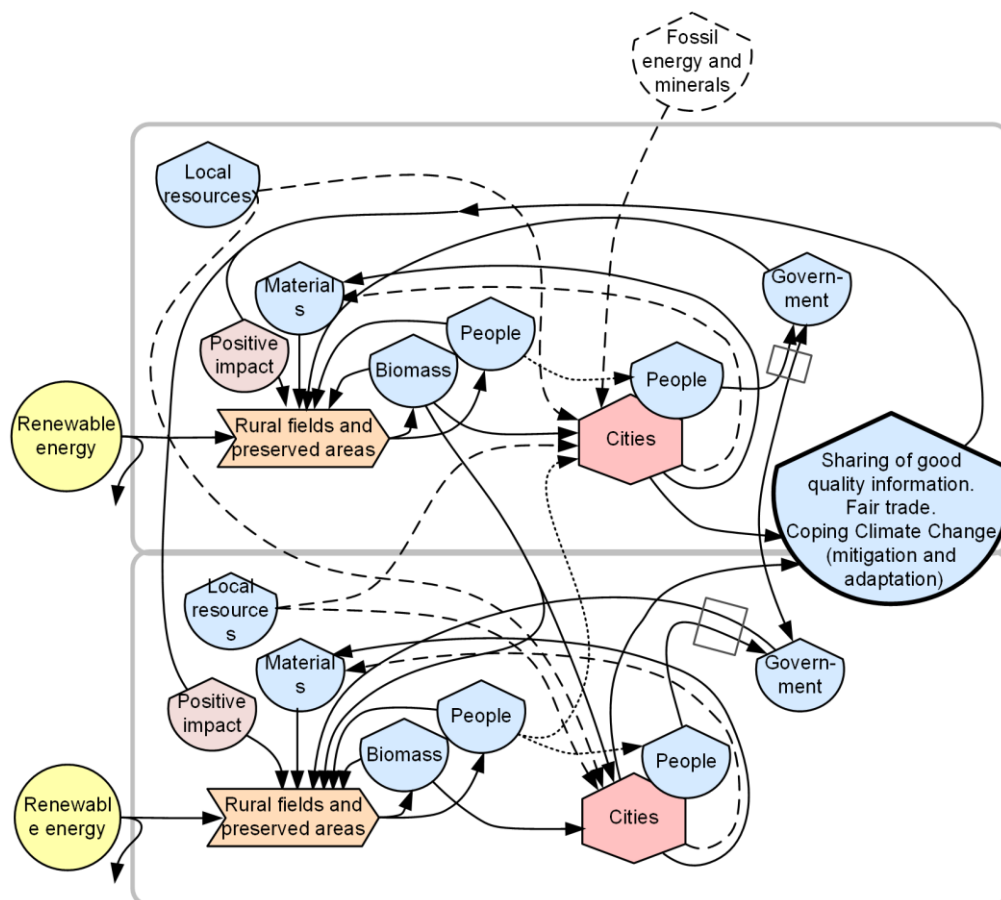


Figure 4. Diagram of countries adopting new priorities (based on Odum and Odum, 2000)

4.3. INFOBEN

The INFOBEN model (ODUM and ODUM, 2000) implies in the use of shared information and economies based on local renewable resources; in sustainable, independent and biodiverse systems. The model assumes that the development of good quality information will enable

a new pattern of coexistence among nations, with renewable power maximization at all levels and fair relations. This model would allow local resources to be used in the production of food, fiber and bioenergy, and recovering of preservation areas, with a positive impact on the environment and society.

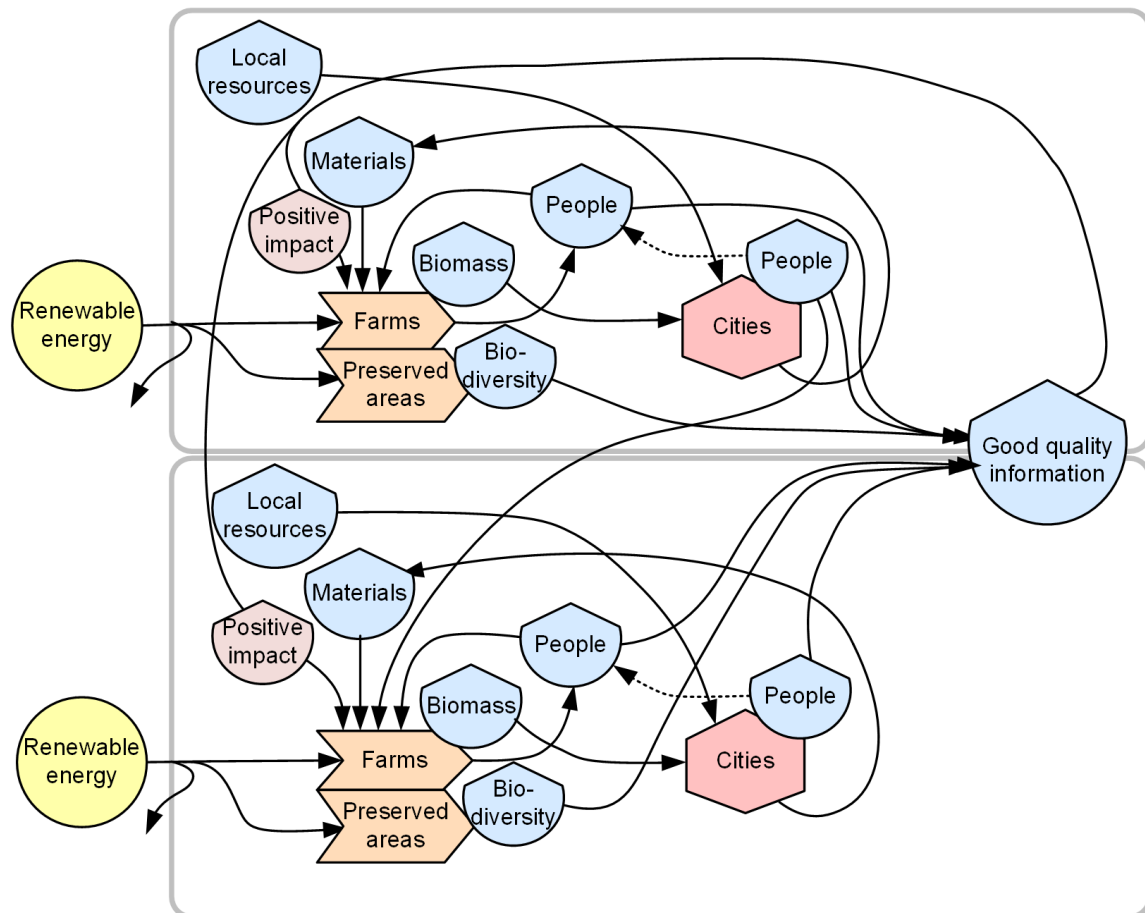
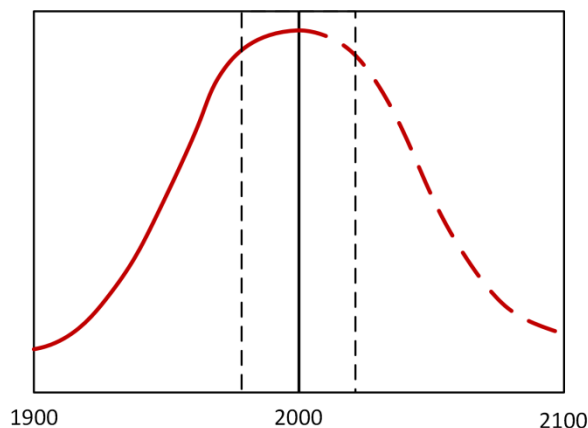


Figure 5. Diagram of energy flows from countries with high sustainability and biodiversity (based on: Odum and Odum, 2000)



GROWTH AND DEGROWTH OF ECONOMY

Urban population
Agricultural area for export
Exported agricultural product
Urban per capita income
Deforested area
Production of rural inputs
Environmental impact
Concentration of property
Concentration of income
Poverty and diseases
Migration from countryside to city

Figure 6a. Expected results in two countries relation, with different histories and resources

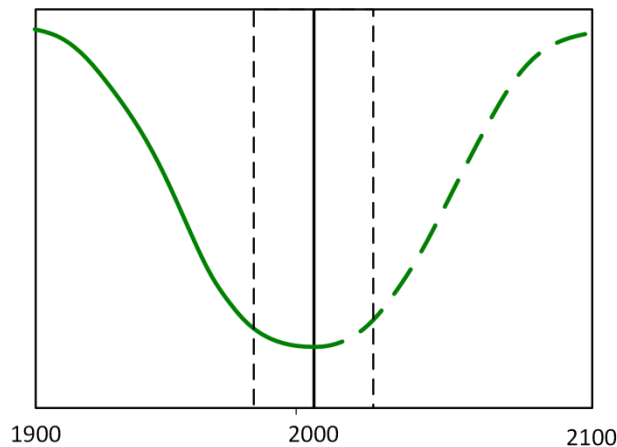


Figure 6b. Expected results in two countries relation, with different histories and resources

DEGRADATION AND RECOVERY OF ECOLOGICAL AND SOCIAL ASSETS

Population in the countryside
Agricultural area for local consumption
Production for local consumption
Rural per capita income
Preserved areas
People engaged in farming
Ecosystem services

5. Expected Outcomes

The emergy balance of the two countries system to be studied and the simulation of its performance over the period of adoption of the policy of food security and food sovereignty policies would lead to obtaining curves similar to those in Figures 6a and 6b, below shown.

6. Conclusions

The emergy modelling and simulation is proposed to reveal the effects of global public policies assumed during capitalist expansion and also to forecast future scenarios, considering an economic downturn, and, at the same time, a natural spaces recovery. The software application to be created can play a critical role in discussing effective public policies to address critical issues, such as hunger, because they allow the analysis of ecological-economic complex phenomena with deterministic equations that simulate the interrelations with a holistic perspective.

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