CHAPTER 1

THE CONDITIONS OF SUSTAINABLE FOOD SECURITY. AN INTEGRATED CONCEPTUAL FRAMEWORK

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Abstract: this chapter presents an integrated conceptual framework for the study of the conditions for food security, based on a review of world literature. The systemic model provides definitions of the main variables, and describes and illustrates their mutual—and most often multidimensional—relationships. The fundamental framework is that food security and/or insecurity (both potentially sustainable or not) is seen as resulting from relationships between social factors (demography, health), intermediating mechanisms (food production and circulation in market and customary spheres), and food consumption determinants (accessibility, availability). The program framework is drawn here to provide the reader a tool with which to consider each of the contributions to this volume in a global context, and further, to l guide the synthesis of this volume, as presented in the final chapter.

1. FOOD SECURITY AND SUSTAINABLE DEVELOPMENT

> *(...) the metaphor "food window" [is] a means of gaining insight into a society based on the values, behaviors, and expectations associated with the production, distribution, and consumption of food. Addressing the social factors surrounding food security (...) serves as a window through which we observe the complexities and challenges emerging from the competing structures of production and consumption.* Corbett 1991:251[1].

1.1 Food Security

Over the last quarter century, the evolution of the concept of food security has reflected an increase in knowledge concerning the mechanisms in question (Benbouzid *et al.* 1995:37, Corbett 1991, Davies 1996:15, Le Normand 1996, Maxwell S. 1996:162). In 1975, the definition proposed by the United Nations' World Food Conference characterized food security as a situation whereby adequate supplies are available to meet the growth in world consumption. Food security is:

> "Availability at all times of adequate world supplies of basic food stuffs (...) to sustain a steady expansion of food consumption (...) and to offset fluctuations in production and price" (United Nations 1975, quoted in Le Normand 1996:89).

But the adequacy of stocks relative to consumption needs is not a sufficient definition, as it reduces the processes in question to too narrow a binomial. Subsequent definitions will try to incorporate the factors and mechanisms that come into play over a long food chain that extends from the constitution of world stocks to individual food consumption. In its own definition (1983), the Food and Agriculture Organization indicates that access to stocks is an essential condition of food security, just as is the constitution of the actual stocks:

> "Food security is ensuring that all people at all times have both physical and economic access to the food they need" (FAO 1983, quoted in Le Normand 1996:89).

This organization recognizes that increasing global stocks alone is not enough to put an end to food problems (Benbouzid *et al.* 1995:39). In short, the basic conditions of food security are the constitution of stocks and the accessibility to stocks. Hence, an analysis of food security can no longer be confined to simply measuring stocks, but must include accessibility to stocks and consumption, and the production and circulation of stocks—namely, their availability

It will later be understood that accessibility, and ultimately, individual consumption, are linked to a new set of factors, not reflected in macroeconomic analyses. Indeed, they are linked to the dynamics of the relationships between and within institutions where the circulation of food takes place. Between world markets and nations, between national stocks and regions, between regional stocks and communities and families,

[1] Corbett attributes the metaphor to Joseph Collins (1985:xvi) in *Nicaragua: What Difference Could a Revolution Make?* Rev. ed. San Francisco: Institute for Food and Development Policy.

and finally, between family stocks and individual consumption, the circulation of food is determined according to a complex set of factors. Commercial transactions (and hence all of the variables associated with such transactions, including monetary exchanges at all levels) are among these factors, as well as non-commercial transactions which, within households, determine, to a very large extent, individual access to food, and where factors such as food preferences, the sexual division of roles, and nutritional needs come into play.

In 1996, the World Food Summit proposed a new definition, which we will adopt here:

> **"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" (WFS 1996a).**

This definition presupposes a number of conditions (much more numerous than those set out by the United Nations in 1975) that must be met to achieve a state of food security.

> "To eliminate nutritional problems, it is not enough to increase global food availability. Of course, adequate quantities of healthy and nutritional food must be available to meet the needs of a population, but above all households must have adequate access to existing supplies. Foodstuffs must then be prepared adequately and distributed fairly among all members of the family. Finally, to benefit fully from the foodstuffs consumed, the persons must be in good health and capable of absorbing and efficiently metabolising the nutrients; they must have clean water, basic sanitation and clean air; they must have access to satisfactory health care services and must lead an active and healthy life" (Benbouzid *et al.* 1995).

As one can imagine, these essential conditions are determined by a large number of factors and a complex labyrinth of processes. We will return to this question in greater detail.

Beyond a refinement in our understanding of the conditions of food security, the evolution of this definition also reflects another development: that of the dominant ideas of the time, and of the social players who conceive them. Indeed, food security is not defined solely by characteristics, but also by its final aims. Food security is a basic human right, in the UN humanist perspective.[2] It is also the assurance of an active and healthy life, likely to ensure the availability of functional human resources, a climate of social stability, and a likely expansion of world economic markets, according to the World Bank's view (WB 1986 quoted in Le Normand 1996:89, Johnston 1997, CE 1995)

In summary, the definition does not lead solely to an in-depth examination of a set of conditions that, taken together, would determine a state of food security or insecurity; it also leads to the observation that any judgement made about this state cannot be separated from a normative framework.

1.2 Converging Normativeness

The sustainable development concept has been discussed to such an extent since the release of the Bruntland report that there is no definition that is both the subject of a consensus and that is operative. Indeed, so many slants have been given to this concept that the normative power associated with it is variable. Moreover, we have shown that, within this conceptual framework, it can be understood either as a synonym of "economic growth that is compatible with future needs," and hence be incorporated in the neo-liberal ideological arsenal justifying globalization; or as the antonym of growth, as it necessarily leads to the destruction of the environment (Duhaime 1998).

However, the different variations do not really matter, as the concept still has a normative content: it orients the action to achieve a desired state. To precisely characterize this changeable normative content, one must analyze all of the operative variables brought into play in a given discursive context. Here, we adopt Goodland's definition (1994), where sustainable development is understood to be "development without growth beyond the environment's capacity."[3]

Therefore, the two central concepts on which our work is based are normative. They indicate objectives regarding human development in general that can be adapted to circumstances that are peculiar to each social

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[2] "Our Heads of State and Government or representatives gathered at the World Food Summit at the invitation of the United Nations' Organization for Food and Agriculture, reaffirm each human's right to have access to healthy and nutritional food in accordance with the right to adequate food and the fundamental right of each person to be protected from hunger" (WFS 1996a).

[3] See Duhaime 1998 for a discussion concerning this definition, and the difference between development and growth.

group. The use of normative concepts as the basis of scientific work (in other words, the adoption of a political position by the researcher), can take away from the objectivity of the actual scientific work, and this danger is very real. However, we know that, as has been shown for a very long time now, scientific production is based on strict rules: the explanation of the prior notions, the clear statement of each founding principle, the use of defined concepts for the interpretation of results, including interpretation of results that seem to contradict the working hypotheses. A prerequisite for the objectivity of the scientific method is that the biases themselves must be objectified, in this case the normative concepts must be revealed.

Our position can be summarized using the following premises. First, we recognize that food security and sustainable development are socially desirable; this contributes to the initiation of targeted research. Secondly, we recognize that it is indispensable to reveal our understanding of the normative power of the concepts within this framework. Thirdly, this having been recognized, and this understanding revealed, we must follow all standard research stages in keeping with the rules of scientific method. It is important to point out that the construction of a conceptual model, a task that we are beginning with this text, is but the initial phase of the large-scale research program on food security in Arctic regions[4].

The two concepts have common characteristics in addition to the one that we have just mentioned. Both can be used as the basis for evaluative research, where a given state can be compared to a desired state; they can lead to the identification of necessary changes in behaviors and mentalities. Furthermore, they have common characteristics, both at the theoretical and at the operative levels. At the theoretical level, the two concepts direct concerns toward the durability of the action. In the case of food security, the availability and accessibility of food resources must be maintained to correspond to the needs of human consumption; in the case of sustainable development, the development must be possible indefinitely. At the operative level, both concepts share numerous characteristics, of which we can only give a few scattered examples as our remarks are not yet at the operational level: a process fosters food security and sustainable development if it helps increase fairness and social justice, local participation, if it reduces social conflicts, and so on. This does not mean that the two concepts are synonyms or that they are confused, and through some examples could show that they are at times contradictory; they would tend to show instead that there is a strong convergence of the two.

This convergence can be maximized by juxtaposing the two concepts under the "sustainable food security" formula, as has been done by several authors (Asenso-Okyere *et al.* 1997, Chambers 1988 quoted in Maxwell D. 1996, FAO 1998b, WFS 1996, Speth 1993 quoted in Gürkan 1995). This operation does not eliminate the specific characteristics of the two basic concepts from the onset. Instead, it involves defining a fundamental coherency constraint that is imposed on the model that we are building. In other words, we postulate that the conditions that should be considered in an evaluation of food security must be compatible with our concept of sustainable development and that, conversely, the conditions that should be considered in an evaluation of sustainable development must be compatible with our concept of food security. Perhaps we will succeed in defining a unified concept. This, then, would be an outcome of our endeavour, which we are just beginning. However, the indications that appear thus far are sufficient to lay the groundwork.

1.3 An Integration Model

The objective of this study is to define a conceptual framework, that is, a model that integrates components that are at work within the food system, that assumes multiple interrelations and allows an analysis of the state of food security (or insecurity).

There are several models that describe food systems. Some provide only a partial image of the problem. For example, Freeman (1988b) centers his examination on the importance of social factors and, in particular, of culture as the determining factor in food issues. Harre (1987) mainly focuses on the marketing circuits of a food product, and underscores the operation of exchange systems. Crosnier (1991) also emphasizes food production and distribution networks, which he describes meticulously. He goes further, however, and emphasizes the role of certain social factors as determinants of demand. He does not see, as Freeman does, that social factors are also determinants of production. Finally, Bayliss-Smith (1991) and Greely (1991) attempt to model the impacts of the introduction of a new farming process, or a reduction of forest cover on food security and the environment, thereby detailing the effects of specific changes on food security.

[4] Sustainable Development in the Arctic. Conditions of Food Security. The research program was initiated in 1998 by an international multidisciplinary team, lead by Gérard Duhaime, with Éric Dewailly and Ghislain Otis.

Other authors have tried to consider a broader range of components, and have endeavored to represent more numerous relations. The resulting models are generally complex and, apparently in all cases, difficult to make operative. Despite their complexity, these models fail to consider all of the variables or all types of relations in the dynamics of food security, as it is defined and studied today. For example, Beghin *et al.* (1988 quoted in Benbouzid *et al.* 1995) try to understand the state of nutrition without taking into account environment and technology. These omissions, or these divergent views, can be explained because the aims of these authors are sometimes different from ours: at times they are looking for the determining elements in the consumption demand; at others they are trying to establish the nutritional state of the individual or the state of food security at the household level, and so on (Babu & Mthindi 1994, Pintrup & Anderson 1987 quoted in Gürkan 1995, Salazar de Buckle *et al.* 1989).

Some models attribute predetermined values to the components studied. For example, Atkinson's model (1995) is not an attempt to explain food security systems; rather, he focuses on malnutrition. According to this objective, income is considered at only two levels ('low and 'uncertain'), the relationship between the sexes is recognised as being unequal, the care provided to children deficient, and so on. In fact, this model proposes an explanation of malnutrition rather than provides an assessment tool that might be useful in any situation where malnutrition is not in question. Similarly, the UNICEF model (1990 quoted in Le Normand 1996) presents causal relationships that lead to mortality and death. Finally, Gaburici's model (1995) distinguishes and organises farm production and circulation subsystems of the food consumption system into a hierarchy, and incorporates social factors such as economics and politics. However, his components are limited in number, and the relationship between the subsystems are complex and predetermined.

The model that we propose is based on three basic composition rules, which take the opposing view of the limits that we distinguished in existing models. First, the model must be based on a broad vision of the problem, in order to be able to integrate all of the dimensions, all of the components; the aim here is not to create a causal model, but rather a relational model that incorporates all of the factors that contribute, directly or indirectly, to defining the state of food security in a given geographical area. Secondly, the model must be useful for all situations, not only for malnutrition or food insecurity situations. As a result, the components of the models must describe pertinent realities; their operative categories must permit the integration of all possible values. Thirdly, the model must be functional. The immediate aim is not to render the outline presented here operative, or to provide details on the criteria and variations or algorithms which, in the end, would make it possible to make precise assessments of the state of food security in a given region at a given time. Such an objective largely exceeds the framework of this study. Instead, we want to provide sufficient indications at the conceptual level so that the model can be made functional later, and then implemented. Ultimately, the model should make it possible to identify the conditions on which we can act to increase food security in a sustainable manner.

This first stage comprises long-term research that draws on works published in the field. Apart from a few well-known exceptions, that of Milton Freeman for example, few works deal with the study area of interest, namely the circumpolar Arctic. This is understandable. Even if the food problems of the Arctic are not new, even if they have had tragic effects, they never have been of the scope of the Saharan famines, for example. Beyond the historical analysis, rarely have they led to modeling efforts. This does not represent a major obstacle. Indeed, Arctic areas share common elements with areas that most often have been studied from the standpoint of food security: pre-existing indigenous societies, colonial history motivated by the presence of natural resources, penetration of western culture, disappearance of self-sufficiency, etc. Besides, if the model adequately takes into account all of the relevant conditions, it must allow us to consider the multiple variations of these conditions. In this context, extreme differences, latitude, temperature, local resources, adaptations, etc., between the Arctic and more southern areas are never more than useful variations, as they indicate the relevance of taking into account the variables they illustrate. Our project involves creating a general model that can apply at all latitudes.

Finally, it involves a conceptual framework, a logical list of concepts describing realities deemed essential for understanding the conditions of food security, based on our interpretations of the knowledge acquired in this field. This framework is not a food security or food system theory, i.e., a coherent set of proposals making it possible to produce a reproducible interpretation of the phenomena revealed by the analysis. We do not suggest, for example, that food security is a determinist system, where a variable, or a set of preponderant variables would point to a certain state of food security, and would eventually allow us to predict changes. At its current development stage, the

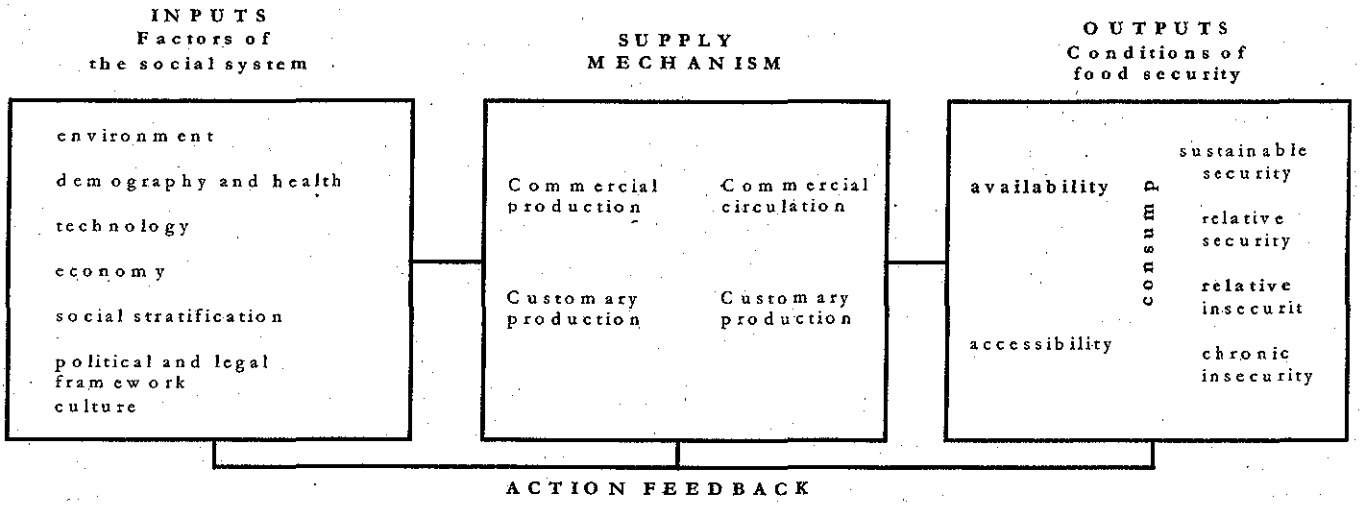

Figure 1. *Sustainable food security system.*

proposed framework forms a systematic checklist to guide the examination of food security, regardless of the context. However, this construction assumes a theoretical vision of the phenomenon, as it exceeds a simple inventory of knowledge. It requires the *selection* and *priorizing* of elements, and hence choices. In this case, it involves a broad vision, initially inspired by the field of socio-economics, where economic phenomena are basically understood in relation to all of the forces in play; to a large extent this approach is similar to that of *Human Ecology* (Miller 1996).

2. A MULTI-DIMENSIONAL MODEL OF SUSTAINABLE FOOD SECURITY

2.1. Overview

The proposed model draws inspiration, in its elementary structure, from a basic cybernetic core (Dion 1971:121, Lapierre 1992:192). It is composed of three elements (Fig. 1). The first is the 'input,' i.e., the element that provides the system with the raw material to be processed. It is a flux (of information, resources, energy) that exerts an influence on the other elements of the cybernetic core. In this model, the input is composed of factors of the social system, which we will examine in detail. The third element is the 'output,' i.e., the element that processes the system material to produce a result. In this model, output is composed of the conditions of food security, which we will also see in greater detail. Between the input and the output is the core, made up of intermediary mechanisms, or interaction mechanisms, which select the information and resource flow originating from the input, which put these flows in interaction and, finally, which transmit the thus modified flows to the output. In this model, intermediary mechanisms are supply mechanisms, composed of food production and circulation mechanisms.

Multidirectional ties link the three elements. They indicate that the elements interact with one another according to all possible theoretical combinations. Indeed, from a synchronic viewpoint, the basic core assumes a uni-linear relation going from input to intermediary mechanisms, then to output. But from a diachronic or dynamic standpoint, the basic core assumes that relationships are multidirectional: not only does output exert a return influence on input (which, thus modified, again exerts its own influence on the rest of the core), but it may also exert a return influence on intermediary mechanisms. Similarly, intermediary mechanisms may exert a return influence on input, and input may exert an influence on output, which escapes intermediation. Moreover, the entire core and these three basic elements are influenced by the global environment in which they evolve, forming an open system.

All of the components, interrelations, and levels are found in the natural environment which forms the basis of the model. To facilitate intepretation of the graphical representation of the food system, we indicated the links between the basic elements of the cybernetic core at each level of analysis, but we have not reproduced all of the links that may exist between all of the components.

2.2 Natural Environment

The model provided by Gosselin *et al.* (1991), was designed to guide the compilation of indicators of sustainable development, and postulates that three basic areas are interrelated, regardless of the field of study or the geographical context: economy, health, and environment. It also postulates that these relations are influenced by natural and human activities, as well as natural and human responses. But the model goes further; it pinpoints key indicators of sustainable development by an analysis of interactions between the basic areas. Equity results from interactions between economy and health; viability results from interactions between environment and health; and durability results from interactions between economy and environment.

But the model assumes that all human activity can be reduced to unveil the state of the economy, the state of health of the population, and the state of the environment. If this is acceptable from a theoretical viewpoint, as one could always link any indicator of human activity to one of these three areas, it is nonetheless difficult to apply. We will see that the economy, health, and the environment exert, in turn, a central influence on all of the variables that come into play in food security, but that we must examine several distinct fields meticulously if we are to succeed in grasping, at least theoretically, all of the variables in question. However, this model is a key: it recalls the importance of the basic areas, in particular the environmental dimensions, where natural and human activity unfolds, and where natural and human responses are shaped.

From this, we will hold that a food security model must begin from the same basic premise. It recognizes that human activity takes place in a given environment, namely the biosphere, and that this essential condition can have major effects. Planetary climate changes, whether caused by human activities or not, can have a decisive influence on human activity, and modify the course, the means, or even the ultimate ends of such activity.

A large percentage of human activity consists in trying to overcome constraints imposed by nature, particularly since the industrial revolution, which was geared to mastering the forces of nature. However, the fact remains that human activity takes place in a given environment, and its changing parameters may be decisive.

2.3 The Factors of the Social System or Inputs (INP)

Factors within the social system are classified into seven main groups:[5] environment, demography and health, technology, economy, social stratification, politics and legal framework, and culture (Fig. 1).

2.3.1 The Environment (ENV)

As a factor of the social system, the environmental to impact on human activities. Understood in this way, the environment exerts an influence on the other elements of the social system, as well as on the other components of the food system. It may have beneficial effects on food security; but it may also have negative effects.

The environment defines the characteristics of the resources available for exploitation for food purposes; a presence, abundance, and diversity of resources, as well as a healthy environment and favorable climate conditions exert a positive influence on food security. In contrast, an absence of, scarcity, or limited resources, an unhealthy environment and unfavorable climate conditions (FAO 1996a) have a negative influence on food security.

The main environmental factors that determine conditions that impact food security either way are the presence or absence of resources, the climate, and the physiography of the soil. A presence of resources and favorable environmental conditions, such as fertility and abundance of resources facilitate production, circulation, availability, and access to food resources (CE 1995, Le Normand 1996, Paulson & Rodgers 1997).[6] Moreover, a healthy environment, where the

[5] Inspired by the classification of Léon Dion (1971:114).

[6] Paulson and Rodgers (1997) show that the food security of the inhabitants of the Samoa Islands is closely linked to generally favorable natural conditions, despite periodic devastations resulting from hurricanes. " Land and crop resources are other important internal factors supporting Samoa's subsistence security. Western Samoa's soil and climate are conducive to year round growth of a wide range of tropical crops. In most parts of the country the dry season is mild, and many soils are moderately fertile." "Samoa's generally rocky and steep landscape limits mechanization and the concomitant pressure for land consolidation. Traditional crops (banana, breadfruit, root crops, and coconut) give the system much of its flexibility. Most serve as both food and cash crop, have a fairly flexible harvest period, and are grown successfully without dependence on external inputs or extension services. They are often intercropped, and a variety of cultivars are used.

water, air and ground are clean, is a factor that has a positive influence on food security (Benbouzid *et al.* 1995, WFS 1996b). In contrast, the scarcity of resources and unfavorable natural conditions make it difficult to exploit resources, which negatively affects production and circulation capacities, as well as the availability of and access to supplies. Food security is harder to ensure in zones that lack resources, in extreme or marginal (Courade & Peltre-Wurtz 1991:3), or abnormal (Froment & Koppert 1991) climate zones, in regions where the configuration of lands, rain, erosion—and we might add cold and obscurity—reduce the fertility of soils or accessibility to the territory (Kermel-Torres & Roca 1991), and where the health environment is unfavorable (Le Normand 1996 :88).

In the circumpolar Arctic, some environmental factors have a more pronounced influence, which impacts the food security of resident populations. A contamination of the food chain by sudden disasters or by pollution carried over large distances affects the quality of local resources. The Chernobyl nuclear explosion modified the characteristics of the reindeer herds that are fundamental to a portion of the Saami economy. Pollution transported by sea and air currents in the eastern portion of the Canadian Arctic has led to a very significant increase in the presence of PCBs, organochlorates, and heavy metals in the fat of marine mammals consumed by the Inuit (AMAP 1997, Dewailly *et al.* 1996). Moreover, global warming, which is thought to affect fish stocks and migration patterns of large land mammals, alters the availability of these resources. Finally, the cold climate and the polar night limit the diversity of potential food-producing operations.

2.3.2 Demography and health (DEM)

The population structure, namely its distribution by age group and sex, and population movements, namely the growth or decline of the population, influenced by fertility, mortality, migration and so on, are major determining factors in food security. Indeed, the population structure determines the characteristics of the human resources employed in food production (or the production of income intended to meet food needs); it also determines the scope of food demand. Demographic variations determine the diversity of food needs to be met; a growth in the population may result in supply shortages (cf. CE 1995, Minvielle 1991:183) and its decline, in manpower shortages (Chastanet 1991:141). The characteristics of households help to determine the accessibility of the food supply. Food insecurity strikes large households more profoundly (Odounfa & Ankidès 1991:233, Haddad & Kennedy 1994:334), and those who are alone and outside the social network (Blaylock & Blisard 1995:961, Rouffignat 1997).[7]

One of the major factors that can influence the demographic characteristics of a given population is its state of health. A population whose state of health is favorable will have a positive influence on other factors of the social system and other components of the food system, thereby promoting food security. It will provide a productive labour force likely to participate in the economy, and to use the necessary resources to meet their needs. A population whose state of health is unfavorable will generally have a negative influence on the other factors; it represents a non-productive population whose needs cannot be met in a self-sufficient manner (Gabourici 1995).

The rapid demographic growth that characterizes a large portion of the Arctic imposes major constraints for food purposes. Associated with the recent transformation of living conditions (permanent homes and access to health services for example), this growth means an ever-greater number of persons to feed. This results in more pressure being exerted on the economic resources needed to achieve this goal, and a risk of destabilization in the supply: outfitters must find greater monetary resources to purchase the food and equipment needed for activities that are directly related to food production, which leads, for example, to a growth in the solicitation of the salaried work market. Crop resources—game and fish—undergo a greater harvest effort, which may, for example, be detrimental to certain vulnerable species. In these regions, emigration is thought to be negligible, which means that all of the pressure would be concentrated on the increase in monetary resources needed to face the requirements imposed by a renewal of their numbers.

These qualities of the crop resources are the basis for the resilience of the current cropping system in the face of both natural hazards and market changes." (Paulson & Rodgers 1997:180).

[7] Among the countries of the world, those that have the greatest proportion (Africa) or the largest number (India) of persons of food insecurity are also those that have the highest demographic growth rate. This further accentuates the deterioration in food security in these countries (WB 1996:3).

Moreover, the relatively recent changes in lifestyle in a large portion of the Arctic have caused imported food products and choices to replace a certain portion of the One of the observable results of this combination is an imbalance in food intake, and the appearance of associated diseases, such as obesity, diabetes, diseases of the circulatory system, which, up until now were only exceptionally found in Arctic latitudes (Delisle *et al.* 1994). Their appearance affects the productive capacity of the population, and diverts resources to health care—resources that can no longer be assigned to other purposes.

Finally, the use of local resources, affected by environmental phenomena, is subject to the requirement of the state of health of human populations. Pollution traveling by air and sea currents penetrates the food chain and is concentrated in certain edible and coveted parts of game (for example, PCBs in seal and beluga fat, cadmium in caribou liver, mercury in freshwater fish meat). These phenomena impose potential limits on the use of game for food purposes, in particular for groups having higher risk factors such as expectant mothers and the elderly, and call into question pre-existing food balances (Dewailly *et al.* 1996).

2.3.3 Technology (TEC)

Technology encompasses all of the means invested to increase human mastery of the environment. These include production, transportation, communication vehicles, and infrastructure.

Resorting to technology is generally presented as fostering food security (CE 1995:4, Gaburici 1995, Gürkan 1995, Kratcht 1995, Salazar de Buckle *et al.* 1989, SMA 1996:9, Blandford & Viatte 1997:7). Its most sensitive effects are to promote the functioning of supply mechanisms, to maintain the stability of the food supply, and to prevent fluctuations. It permits the development of the supply production and circulation processes. The effects of these developments are to increase productivity, reduce losses, attenuate price fluctuations, as well as to promote and diversify exchange including imports and exports (CE 1995:3, Giroux 1995:10, WFS 1996b). The dissemination of information on existing technologies, on services available to facilitate access thereto, and on the knowledge produced by research, lends support to producers and contributes to strengthening the productive capacity (WFS 1996a,b; Blandford & Viatte 1997:7).

The population base does not always have access to expensive technology. Moreover, the adoption of technology does not always promote food security, because it mobilizes considerable resources, which are then no longer available to meet the primary needs of the population, including food needs (Giroux 1995, LePlaideur and Mustier 1991, Kachondham 1995, Chossudovsky 1998). It lowers the value of traditional practices, which are sometimes more efficient for meeting the population's food needs (Lehman 1996:1). It can lead to a poorer diet by promoting, for instance, the distribution of products with low nutritional values (Corbett 1991:245, Kachondham 1995:5).[8] Finally, it can lead to food insecurity by contributing to the deterioration of the environment and a non-sustainable harvesting of resources, which requires growing energy investments (FAO/OMS 1992 quoted in Benbouzid *et al.* 1995:48, Dyson 1994, Gaburici 1995).

In the Arctic, the regular use of air and sea transport has upset the social and economic landscape, by putting an end to the isolation of villages in relation to large cities, by establishing stable supply networks, and by promoting the uninterrupted introduction of imported goods (see Lawn & Langner 1994). The adoption of firearms and snowmobiles has significantly increased the productivity of hunting for food. The establishment of radio and television, travel, and the multiplication of contacts with people passing through have transformed the images of the world that people have, as well as their ability to assert claims to improve their lot.

At the same time, this use of imported production, transport and communication means has imposed constraints. From now on, the residents of the North must have earnings to be able to maintain a consumption based on imports, including the ability to maintain a supply of food production means, such as

[8] Observing Mexico and Central America, Corbett states: "Indeed, there is a certain unhappy irony in the fact that distribution systems for soft drinks and other low-nutrition foods may reach far more people than systems designed to improve nutritional status." (Corbett 1991:245) Kachondham makes the same observations in Thailand: " Commercial advertising and the promotion of processed food in rural areas may result in an adverse situation when people sell more nutritious food in favor of buying less nutritious, but more prestigious, food. In the urban areas, there is an accelerated shift from home-based food preparation to processed or pre-cooked food. (...) Consumer behavior is being modified as never before by intensive advertising and, quite often, by unfounded claims for the health benefits of special foods." (Kachondham 1995:5)

fuel and spare parts for snowmobiles, ammunition for firearms, camping equipment, and so on. Resorting to imported technologies, which has become a normal practice, has contributed to the disappearance of the remnants of self-sufficiency; it has resulted in the establishment of numerous interdependence ties, a movement, which is growing (Duhaime 1990, Kruse 1991, Myers 1982, Simard *et al.* 1996).

2.3.4 Economy (ECO)

The economic organization of society has an influence on other factors of the social system, as well as on other components of the food system. Globally, an economic system in which access to productive resources, the land, capital and work, as well as the distribution of wealth are fair, contributes to food security. In contrast, an organization based on inequity jeopardizes the food security of the population.

Economic factors can have a positive impact on food security (WFS 1996b, CE 1995). The availability of capital at the individual, family, local, regional or national level permits a better use of human resources, the land, and production means (CE 1995, WFS 1996b, Kermel-Torres & Roca 1991:48, Phélinas 1991:69). This profitable use permits the development of farm, commercial, communication, and transport infrastructures, the private sector, remunerated work, etc., and helps stabilise the food supply. These developments promote the intensification of trade flows and a flourishing of the commercial sector.

The establishment of a fair market-oriented commercial system constitutes the main driving force that leads to food security, according to the dominant opinion (WFS 1996b, LePlaideur & Moustier 1991:151, Le Normand 1996:96).[9] However, the transition to a market economy frequently results in a deterioration of food security (Courade & Peltre-Wurtz 1991:12, Giroux 1995:99, Gaburici 1995).[10] For example, a growth in exports that accompanies integration in a market economy can be detrimental to food security if it forces local producers to abandon the component food production that guaranteed the stability of supply of local products in addition to creating jobs (Lehman 1996:1, Whiteford & Ferguson 1991).[11] The progressive generalization of the rules of free trade at the global level makes matters worse. According to the analyses of Chossudovsky (1998), Peemans (1996) and Courade and Peltre-Wurtz (1991), the diktats of the World Bank and the International Monetary Fund deepen inequities associated with access to resources, and increase social exclusion.

Hence, the market economy is not a cure-all, as it does not spontaneously produce equitable access to, or a fair distribution of, wealth. On the contrary, a large number of the undernourished are unable to produce or to purchase. More often than not, they lack adequate access to the means of production (land, water, seeds, income, credit, technology, and so on) due to political unrest or a faulty economic organization, when it is not due to unfavorable environmental conditions, etc.

Finally, there exist some forms of parallel or underground economic systems that are detrimental to food production because they lead to a deliberate diversion of wealth to a particular sector of society. These involve criminal activities, such as the smuggling of foodstuffs (Phélinas 1991:68, Giroux 1995:7, Kermel-Torres & Roca 1991:47) and the stealing of resources (Droy 1991:117-127), occasionaly encouraged by faulty or complacent political measures.[12]

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[9] Integration in the market economy takes place through exchanges that permit the acquisition of a better control over the food resource: "...indeed, it is necessary to succeed in establishing a balance between, on the one hand, the local production of foodstuffs and crops for export and, on the other hand, foodstuff imports, taking into consideration the specific situation of the country" (CE 1995). For producers, the availability of capital, credit, loans, favorable measures, etc. may lead to an increase in production, to the broadening of the diversity of farming practices (Kermel-Torres & Roca 1991:48), to the possibility of making exports (Phélinas 1991:68), and even to the increase in the interest in food-producing practices (Minvielle 1991:183).

[10] Economic measures that encourage the market economy occasionally contribute to the deterioration of food security. For example, the formation of monopolies in the commercialization of foodstuffs may lead to abuses. "The commercialization of foodstuffs is in large part an activity that the private sector is best suited to carry out, but the public sector must intervene in the event that the private sector breaks down and must prevent the abuses ensuing from monopoly situations." (WFS 1996)

[11] On the contrary, several studies show that maintaining traditional practices would be a better way of ensuring food security, that they would promote a better distribution of wealth and a longer-lasting development, and that they would allow households to reduce the tensions resulting from a difficult transition to the market economy (Courade & Pettro-Wurtz 1991, Giroux 1995, Frankville & Prudencion 1991).

In the Arctic, the economic system has undergone rapid and major changes. During the era preceding sustained contacts with colonizers of the New World, self-sufficiency prevailed. The fur trade modified harvesting of resources to suit the requirements of fur-traders; it also juxtaposed market consumption and home consumption, made possible by the use of the income from the fur trade.

During the 1930s, at least in the Canadian Arctic, the Great Depression undermined the fur trade, which had become an unquestionable basis of aboriginal economy (Grygier 1994, Duhaime 1985). The period that followed was one of great distress, where epidemics followed on the heels of famines, to the point where governments had no other choice but to intervene on a massive scale. The construction of permanent villages changed the foundation of the Arctic economy; which would henceforth be based on the generation of wage-earners which supplanted earlier forms of economic production without, however, causing them to disappear completely (hunting and fishing for food purposes), and on the large-scale development of natural resources, such as oil, mineral resources and hydraulic energy, as well as on the development of public administration as an industry.

2.3.5 Social stratification (STR)

The breakdown of resources is never uniform between the players of a given society. It depends on the strata, distinguished by socioeconomic characteristics, the types of social and political participation, and so on. Social stratification, in particular belonging to a specific stratum, largely contributes to defining the food situation of a person, a household, or a region; indeed, it has an influence on other factors of the social system, and other components of the food system.

Wealth, the availability of sufficient income, leads to a state of food security; poverty leads to food insecurity (CE 1995, WFS 1996b, Salazar de Buckle *et al.* 1989). Poverty, which is defined as the absence of or the lack of access to resources and the ability to exploit them, limits the potential to react and adapt to situations of food insecurity. Poverty threatens women (70% of the poor are women, according to the World Food Summit 1996b), children, rural populations, aboriginal populations, unemployed urban populations, minorities, nomads, and the victims of wars and other disasters of a natural or human nature in particular (Denis 1996:99, WFS 1996b, Rouffignat 1997, BM 1996:2-3).[13]

In several regions of the world, the higher strata adopt behaviors that maintain or improve their position, to the detriment of the lower strata.[14] Besides, these behaviors sometimes extend outside the boundaries of legality. In such a context, the control that the upper strata exercises over the lower strata practically prevents any improvement in living conditions, food conditions in particular, for the latter.

In the Arctic, the appearance of stratification is concomitant with the penetration of the market economy; it is crystallized with sedentarization, which diversifies the conditions of life and of access to economic and cultural resources, and so on. Regional and local elites appear everywhere and hold positions of political and economic control; groups of average station appear everywhere; finally, badly-off groups also appear, without power or resources, maintained by the mechanisms of the Welfare State (Duhaime 1991).

2.3.6 Politics and legal framework (POL)

The political power has a profound influence on activities of all kinds practiced on a given territory, at whatever scale. The institutions that exercise this power determine the rules and endeavor to enforce them.

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[12] In some extreme situations, food even becomes a weapon. Food is used as a tool of political and economic pressure by countries such as the Sudan, Liberia, North Korea, Burma, Afghanistan and Sierra Leone. (WFS 1996); human capital is used to exploit international compassion, and the food assistance is diverted to the class in power.

[13] Not all poor persons are in a state of food insecurity, but all persons in a state of food insecurity are poor, according to Dyson (1994). Food insecurity is a characteristic of the poorest of society (Ibrahim 1995, Courade & Petre-Wurtz 1991, CE 1995, Giroux 1995, WFS 1996b).

[14] For example, "the peasants of the corn-producing mountain zone in Mexico are subject to a local control and supervision system that affects the supply and commercialization system. For the local elite, any attempt at organization on the part of the peasants is looked down upon, especially as it calls into question the monopoly trade status that the elite generally enjoys. The latter do not lack means to impose their views, means that range from not hiring the peasants during the work period to not lending assistance in the event of difficulties, and that may eventually take the form of political pressures" (Bernard & Hoffman 1991:87).

Some fields of application have a direct link with food security; this is the case for key policies concerning national food production, domestic and foreign trade, and the constitution of stocks. This said, the orientation given to such policies, and the impacts of similar ones, can be very divergent from one country to the next, according to a variety of contexts. In principle, the World Bank and the International Monetary Fund promote an increase in national production and stockpiling capacities to attenuate price fluctuations and limit shortages; in short, they contribute to a state of food security. Yet, they also help create the opposite situation. By requiring payment of the national debt before granting new loans for development, these institutions prompt debtor countries to dismantle the social policies they no longer have the means to support. These prerequisite *structural adjustments* lead to a deterioration in the living conditions of an ever-greater portion of the population of both hemispheres, in rich countries and in poor (Courade & Peltre-Wurtz 1991). In the countries of the former Eastern Bloc, they upset price stabilization and wealth redistribution practices, and weaken purchasing power. This spiral leads to food insecurity: decline in business revenues, decline in domestic production, increase in debt level, widening of technological gaps, reduction in reserves, increase in low quality imports, and so on (Giroux 1995). A country facing such an imbalance between imports and exports, and which must resort to international food assistance confirms its political and economic dependence situation. The social and economic future of a country becomes compromised (Kermel-Torres & Roca 1991). Other areas of international politics can have effects on food security, such as declarations concerning human rights, respect for the environment, and the exploitation of natural resources. Cooperation, international solidarity, and refraining from taking unilateral measures that do not comply with international law and the United Nations Charter are seen as promoting food security (CE 1995, WFS 1996b, Asenso-Okyere *et al.* 1997, Phélinas 1991, Lehman 1996). However, international policies do not always have an impact on national situations, as their efficiency depends on numerous factors, such as the willingness of countries to participate in these exchanges, the availability of discussion sites, the ability on the part of national participants to negotiate and defend their interests, and ultimately to implement these policies.

National policies also influence the food security balance of populations. For example, policies concerning exports and imports can permit a certain control over production activities. Export policies can promote the competitiveness of national products on international markets by establishing quality, quantity, and cost criteria that are in keeping with demand and with international trade agreements. Commercial protection measures can make it possible to manage the flow of imported foods. The ability of the population to meet its needs—including food-related needs—can be increased by policies on access to health care and education, the fight against poverty and social assistance, and controlling fertility (WFS 1996b, Benbouzid *et al.* 1995, CE 1995, Franqueville & Prudencio 1991, Asenko-Okyere *et al.* 1997, Delgado 1991). Finally, national policies limiting access to resources can also limit the population's economic potential (Diskin 1991). The diversity of the fields of intervention of national authorities is as broad as, if not broader than, that of international authorities.

However, political power does not exert an absolute influence. This dense set of decisions, laws, agreements, and regulations can be challenged by equally complex legal mechanisms, responsible for producing arbitration between the various social players and between the various sources of power. Moreover, what we said earlier about the limits on the efficiency of international powers also applies to the lower levels of power. It is not enough for the law to be proclaimed; it must also be applied. Finally, extreme forms of challenges can undermine the political power and the legal framework itself. Terrorism, wars, and conflicts result in the disintegration of the political system, the isolation of populations and the precariousness of their situation. In this context, the food aid, which has become necessary is difficult to deliver (WFS 1996b) because it must be conveyed under fire or over destroyed roads, or because leading officials take advantage of these crises to divert aid for their own gain.

In the Arctic zones, international policies have major impacts on the food supply: international decisions concerning whaling, the hunting of migratory birds and seals have an influence, more often than not limiting, on the food-producing activities of northern populations (Lynge 1992, Maracle 1998, Wenzel 1991). Freeman (1997:8) reports that the interruption in the hunting of marine mammals, brought about by the European policy, had profound impacts on the economy of Arctic populations. The sale of furs made it possible to make hunting, an activity that produced a large portion of

the family food supply, profitable. These revenues were lost, destabilizing the food economy.

Similarly, in principle, the territorial rights acquired through negotiations between aboriginal groups and national governments promote their economic development. For example, they guarantee access, occasionally even exclusive access, to the resources traditionally exploited by the populations for food-producing purposes. However, these rights are not absolute guarantees. Indeed, the ability to have access to resources does not necessarily mean that local populations will exploit them. Moreover, the rights recognized in recent treaties have not been systematically put before the courts, with the result that their value is not known, for example in Canada. The right of first refusal concerning the development of outfitting establishments in Nunavik granted to the signatories of the *James Bay and Northern Québec Agreement* could be legally contested, if a non-Inuit entrepreneur wanted to develop this industry (Otis & Melkevik 1998).

2.3.7 Culture (CUL)

Culture, as a manner of comprehending the world, is a basic condition of food security. Indeed, it allows the players to symbolically appropriate the worlds that surround them, namely to give a meaning to material existence. As a result, cultural characteristics influence food security.

In regions inhabited by recently sedentarized populations, the resources of the inherited culture perpetuate the knowledge of traditional activities and promote a customary use of local resources. This exploitation ability helps to meet a portion of the food needs and to limit recourse to foreign resources. The erosion of this knowledge may make the populations more vulnerable by eliminating certain reaction mechanisms likely to act as a counterbalance in situations of insecurity (Cannon 1995). The formal recognition of these characteristics by the political powers may promote preservation. (Le Normand 1996: 3, Wenzel 1991, Lynge 1992 quoted in Freeman 1997:8, WFS 1996b, Lehman 1996:1). However, this situation is not unequivocal. Indeed, cultural traits lose some of their value with the dissemination of different types of knowledge. Literacy promotion, and more generally, education open new avenues to transform the world and ensure that needs are met. They increase emancipation with respect to the constraints of nature. They allow the dissemination of knowledge concerning health and nutrition, (WFS 1996b, Benbouzid *et al.* 1995:48), child development, (World Summit for Children, N.Y 1990 quoted in WFS 1996b), and mastering fertility (Benbouzid *et al.* 1995:48). Education also makes it possible to disseminate consumption models that are compatible with the protection of the environment and available resources, (Lehman 1996:1) to promote food products and practices (CE 1995), to increase human skills and abilities (WFS 1996b), to promote openness to the outside world in order to develop social cohesion and to create different associations, in particular commercial exchanges, and the defense of the right to belong to associations (WFS 1996b, Droy 1991:117, Thieba 1991:102).

These changes in culture may, however, increase vulnerability. Indeed, there is a relation between the availability of remunerated work and the consumption of imported food; the growth in imports that follows may reduce the revenues from producing homemade goods and destroy this production. These movements contribute to the disintegration of families, which must split up so that some of their members can migrate to find a paying job (Delgado 1991:80). In turn, these phenomena produce new cultural changes. Aboriginal cultures are not the only ones to be reconstructed from multiple sources of heritage and innovation. Local and natural cultures are also continually being modified by these major social movements associated with the integration of communities in the market economy, the monetarisation of work and resources, urbanization, and the integration of farmers as consumers in the market economy (Sklair 1991, WFS 1996b).

In the Arctic, the multiple and diffuse effects of this social construction process are visible everywhere. The contemporary culture of aboriginal populations reflects the new conditions of existence, such as the generalization of wage-earners, the massive use of industrial food produced locally or imported, and so on. Pluralism, a characteristic of highly urbanized western societies, is henceforth part of the common landscape (Duhaime 1991). Depending on the schools, the effects are designated as westernization (according to the regional variations: Americanization, Russification, etc.) or acculturation. There have been calls for the preservation of the persistent elements of aboriginal cultures (language, harvesting activities, values) and for the preservation of their environment by international, national and regional organizations (see for example Griffith & Young 1989), agreements with this goal in mind have been reached, or integrated into more global agreements. These calls, these agreements, by their very existence, already show the

scope of the transformations that have taken place. If so-called traditional food remains a central element in the discussion surrounding aboriginal culture, imported food today represents the greater share of food consumed (Duhaime *et al.* 1998).

2.4 Supply Mechanisms (SM)

All of these factors influence food production, circulation and consumption in the Arctic. In the model, food production and circulation are grouped under supply mechanisms. These mechanisms are twofold, as the production and circulation may take the commercial route or the non-commercial route. This situation, which is well known in the regions under study here (namely at the local level), also applies to the other geographical levels, as we will illustrate hereinafter.

2.4.1 Commercial production (CP)

Food production is the economic activity that consists of bringing together the necessary factors—work, capital and resources—in order to transform nature to to obtain food products therefrom. Food production is commercial when interactions between factors are settled by legal currencies.

Commercial food production is influenced by upstream factors, such as environmental conditions (Paulson & Rodgers 1997), the state of transportation corridors (Benbouzid *et al.* 1995), available technologies, the orientation of policies (Lehman 1996), and the dispositions of the culture in relation to production (Bernard & Hoffman 1991, Droy 1991:117-127). A situation where all of the factors are generally favorable leads to two types of effects. First, production permits, making available for circulation a food supply that contributes to food security. Secondly, production generates profits that can be directly reinvested in production; they can also be saved, thus made available for investment in other branches of economic activity (Denis 1996:98, Le Normand 1996:1, IFPRI 1995, Dyson 1994). This capacity generated by profits and savings promotes food security because it reduces the vulnerability of production in the event of unfavorable fluctuations in upstream factors. However, when the factors as a whole are generally unfavorable, the effects are the opposite. Production potential, profitability, and revenues all decline. The food production available for circulation also diminishes, which is unfavorable to food security.

Food production is organized differently according to the level considered. There is organized commercial production at the local, national and international levels. Local production is intended for local consumption and lies with local entrepreneurs. LePlaideur & Mountiers (1991:156) identifies it as the 'popular network' where each of the players, producers, merchants and consumers, seem to get something out of an apparent anarchy.[15] As for highly technical production, it requires injections of non-national capital and is fostered by the State in a global market context. This production, which is highly competitive in relation to local production, is often intended for international circuits. Finally, small local producers have little control over imported production, which is concentrated in the hands of foreign capital (LePlaideur & Moustier 1991). This production generally offers a comparative advantage over local production. The importance of these two latter forms of production, namely highly technical production and imported production, determines the dependence of a country, a region or a locality on the outside world (Salazar de Buckle *et al.* 1989, Gaburici 1995). Commercial production may be sustainable if it is based on an organization and processes that permit the perennial nature of the activity and of the actual resources, if it meets local needs, if it is controlled locally and if the profits, also controlled at the local level, can be re-invested on site (Kachondham 1995, IFPRI 1995).

In the Arctic, a portion of the food production is acquired through commercial mechanisms. In Greenland, the marine and land resources are processed and marketed in the form of finished food products: shrimp, groundfish, and others. An unusual characteristic of the Greenland situation is the industrial production of migratory birds and non-domestic mammals, such as the whale and the muskox. (Marquardt & Caulfield 1996, Rasmussen 1998).

2.4.2 Non-commercial production (NCP)

Food production is non-commercial when the interactions are not settled with legal currencies. This involves the production for self-consumption, namely

[15] Various experiences show that when local productions benefit from appropriate support (funds, technical aid, etc.), they can be efficient, can guarantee the stability of the supply, and can reconcile production, respect for the environment and job creation (Lehman1996:1). Other experiences show that local production can lead to a deterioration of the environment, when the support is limited or inappropriate (IFPRI 1995).

the production realized by households that are intended for their own consumption. Although this production can use elements acquired on markets, for example farm tools, firearms or motorized vehicles, it is non-commercial as the productive activity is not mediated by currency. Hence, the work is not remunerated; if it is, it is by means of a portion of the production. Non-commercial food production is occasionally realized at the level of the extended family, the neighborhood or the locality. This may involve, for example, the raising of family herds or the collective hunting of big game. But rarely does it appear at a level that extends beyond the local level.

Non-commercial food production undergoes the same basic influences as commercial production. As a type of production that is mainly practiced by households, it is particularly sensitive to factors that modify the productive capacities of households. For example, political, legal and economic measures, that reduce a household's access to resources, may cause a reduction in non-commercial production and a resulting increase in poverty (Courade & Peltre-Wurtz 1991). Such is the case when Saami shepherds are denied access to pastureland by logging and mining companies. In contrast, non-commercial production can be encouraged by conditions that are unfavorable to commercial production, such as policies that do not support purchasing power (Byé & Frey 1995), and the absence of appropriate infrastructures and funding (Cheneau-Loquay 1987); a situation described as a 'scarcity economy.'

This type of production is often inherited from the social order that precedes the generalization of capitalism and its central institutions (currency, market, wage-earning work). The penetration of capitalism often results in the disintegration and putting down of this type of production; (Freeman 1997, Cannon 1995) it is gradually abandoned when the members of the household turn to commercial production or wage-earning work (Chastanet 1991, Paulson & Rogers 1997). This movement limits the possibility of rebounding; it makes difficult any subsequent recourse to this type of production, for example when the market economy does not manage to provide sufficient revenues to households (Freeman 1997, Cannon 1995). In the circumpolar Arctic, non-commercial food production is present everywhere, and its importance varies according to the region.[16] In the North American Arctic, hunting and fishing are still practiced, but the harvest is rarely commercialized. As a result, a large portion of the consumption of locally produced food comes from non-commercial production (Duhaime *et al.* 2001).

2.4.3 Commercial circulation (CC)

Food circulation is an activity that consists of exchanging food production between economic players. This circulation is commercial when the exchanges between economic agents are settled by legal currencies. The main form of commercial food circulation is the sale of food through legal stores. Generally, the circulation of food is organized in supply networks, in 'chains' or 'channels,' that vary in complexity according to the level considered. These networks include the producers of foodstuffs, who first furnish the supplies. They also include all of the intermediaries who are involved in the distribution of products. These middlemen can be organized in specialties, defined by the type of food products that they offer (e.g., milk, meat, food) or by the type of services that they offer (e.g., wholesale or brokerage service).

Food circulation is influenced by upstream conditions, such as the state of transportation corridors (Benbouzid *et al.* 1995, Bernard & Hoffman 1991), available technologies, economic practices (generalized use of currency in exchanges), political and social stability and a state of peace (Maxwell D. 1996:5, Le Normand 1996, Brunel 1998, Dyson 1994, WFS 1996b), property rights (access to territory and to resources; Cannon 1995:137), and cultural practices (Freeman 1988b). According to several observers, the factor that most influences the organization of the circulation of food products is the role played by the State. Policies can be oriented according to several different objectives and viewpoints. For example: they can systematically favor small local producers, or favor large national producers to the detriment of local producers (Bernard & Hoffman 1991:86, Thieba 1991:97, Haubert 1989, Bertrand 1985 quoted in Salazar de Buckle *et al.* 1989), or favor international producers to the detriment of all others. Depending on the orientation of the policies, the circulation may or may not promote food security.

An appropriate organization of the circulation of food supplies contributes to food security. It permits the constitution of stocks likely to attenuate

[16] Berkes 1990, Caulfield 1993, Condon *et al.* 1995, Feldman 1986, Freeman 1988a&b, 1992; Juniper 1988, Portnoff 1994, Richling 1989, Wein 1987, Wein & Freeman 1995, Wein *et al.* 1996.

fluctuations in consumer prices, to meet consumption needs during periods that are not favorable to production, to reduce the migration toward cities by heads of families in search of food, etc. However, a faulty organization of circulation leads to the interruption or, more generally, the irregularity of the supply, which is unfavorable to food security. For example, the invasion of the markets by imported products (Lehman 1996), or smuggled (Franqueville & Prudencio 1991:33, Kermel-Torres & Roca 1991:46, Phélinas 1991:67) places the circulation of foodstuffs produced locally at a disadvantage, jeopardizes the viability of the operations of local producers, increases dependence on foreign markets, and multiplies the chances of conflicts (Denis 1996). For example, the massive export of the domestic production, under the pressure of outside decisions, reduces the value of production activities intended for local markets and affects the population's ability to process local resources to meet its own needs.

Commercial food circulation takes place at all levels. Generally, however, food circulation between members of a family household is not subject to the rules of commercial exchanges; non-commercial circulation is still the rule here, even if the actual foodstuffs are, for the most part, acquired by way of the markets.

As we mentioned in passing, commercial circulation may include illegal activities, namely activities that, although they use legal currencies, illegally escape taxation, and involve criminal activities. Smuggling food is a form of illegal commercial circulation. Smuggling is found in food shortage situations, as in Siberia and in Bolivia (Giroux 1995, Franqueville & Prudencio 1991, Kermel-Torres & Roca 1991). In similar situations, food production put in circulation may have been purchased on legal outside markets (of the region, of the country), but may also involve humanitarian aid, illegally diverted by the national, regional or local authorities, then sold for profit (Thieba 1991).

In the Arctic, food circulation is organized according to regional or national networks that go from the South, where producers, brokers and wholesalers are located, to the North, where one finds retail stores that offer food merchandise to consumers (Lawn & Langner 1994). Circulation sometimes takes place in the opposite direction to sell commercial food production, in particular, fishing and breeding products, for example Northern Shrimp (Rasmussen 1998). In these cases, Northern producers sell their products to brokers or wholesalers in the South. Food circulation then contributes to the food security of the North in that it ensures revenue (wages, profits) for economic agents in the North, income that is then available for savings, re-investment, or consumer spending. The international circulation of products, namely importing and exporting, is a rarely observed phenomenon. On one hand, few food products are exported from the northern regions to foreign counties; on the other, products that circulate in the North were imported by nationally based 'brokers' before being redistributed in northern latitudes.

2.4.4 Non-commercial circulation (NCC)

Food circulation is non-commercial when exchanges between agents are not settled by legal currencies. There are several forms of non-commercial food circulation. Within the household, food exchanges with no payment in return are, without a doubt, the most common form of non-commercial circulation. Within nations, regions and localities, charitable or state-run institutions organize the free distribution of food on a temporary basis to attenuate the effects of a crisis, a localized natural disaster, or on a permanent basis to combat urban poverty or to provide relief to those persons excluded from development, for example (Delgado 1991). Finally, at the global level, international organizations (whether or not linked to governments), and national governments, set up food aid on a temporary basis to attenuate the effects of, for example, a crisis, a large-scale disaster, famine, or war, or on a permanent basis to combat long-term scourges, or the endemic poverty of a given region of the world, for example. Whatever the level considered, non-commercial food circulation is always organized in more or less complex and multi-branched networks.

The organization of non-commercial circulation is influenced by general upstream conditions, such as the state of transportation corridors (Benbouzid *et al.* 1995), available technologies, and so on. But some factors have a peculiar influence on this type of food circulation. Within the family, the non-commercial distribution of food is subject to numerous determining factors, such as the sexual division of roles (WFS 1996b, CE 1995, Savadogo *et al.* 1995). Hence, this distribution is not necessarily fair and does not naturally ensure the food security of each member of the family. Moreover, practices such as bartering and reciprocity are occasionally adopted as a palliative measure against the disintegration of local economies (Delgado 1991:80).

At all levels, non-commercial circulation—basically food aid granted to individuals, households,

regions or nations—is subject to various determining factors such as the humanitarian considerations of non-profit organizations and governments (Denis 1996, Brunel 1998, Bernard & Hoffman 1991). Moreover, food aid can be diverted by governments that may use it for their own purposes, by criminal organizations that steal the food and then sell it, by certain members of the family who monopolize the food and re-sell it in order to buy other market products, such as alcohol.

Non-commercial circulation can contribute to food security (Ankidès 1991). However, being subject to often-volatile social and political determining factors, which are certainly not as rigid as the laws of the market or global economic structures, non-commercial circulation of foodstuffs at the national and international levels may only temporarily contribute to food security (Byé & Frey 1995:131).

In the Arctic, non-commercial circulation is still extensively practiced. At the household level, it continues to be the general rule for distribution of food supplies between family members, whether the supplies come from a store or from food-producing activities. At the local level, formal networks (municipal) or informal (e.g., networks of relatives, or those involving more or less distant neighbors) play an important role in the non-commercial circulation of foodstuffs, mainly products of hunting and fishing. Mention is made of the existence of game redistribution in the Canadian North funded by central governments and managed by local governments (Barrett 1994, Duhaime 1990, Feit 1982, Simard *et al.* 1996), food banks, and food exchanges organized by non-governmental organizations, such as the shipment of food aid transported by air and intended for Choukotka in 1998-1999, organized by the Inuit Circumpolar Conference. Similarly, there is abundant literature on food production redistribution practices that take place within households or localities and occasionally between localities (Condon *et al.* 1995, Dahl 1989, Freeman 1988b, Quigley & McBride 1987, Smith 1991, Wenzel 1991).

2.5 The Conditions of Food Security, or Outputs (OUT)

All of the previous components contribute to define a state by virtue of which the population can have food that is likely to meet its consumption needs. However, this state is only theoretical; the fact that food is produced and circulates is not enough to meet the population's needs. There are additional factors that must be taken into account to arrive at an appropriate assessment of the situation. They are the availability of food, as well as its accessibility. The two work together to determine the potential acquisition of food and the actual consumption by the population. On the basis of this actual consumption, it then becomes possible to make an assessment of the state of food security.

2.5.1 Availability (AVA)

Availability is defined s the ability of producers of food goods (production) and services (circulation) to effectively make supplies available for the use of consumers. It corresponds to what is known as "the supply" in economics, namely the quantity of products actually offered for consumption. However, we distinguish availability from 'supply,' because the latter generally only considers the commercial supply.

Availability is the result of supply mechanisms, in terms of the quantity and quality of available food. It is influenced by numerous determining factors. As for the availability of supplies from the commercial sphere, it is determined in particular by the ability of producers of goods and services to reach consumers geographically (Le Normand 1996:88, LePlaideur & Moustier 1991:151, Franqueville & Prudencio 1991:31). A vast production may remain unavailable if it is not transported to the regions and localities where the population can acquire these goods, if it remains centralized in major cities for example, when required by a rural population. This is true for the commercial supply; but it is also true for food aid.

2.5.2 Accessibility (ACC)

Accessibility to food supply is defined by a population's ability to acquire the supply made available on markets. It corresponds to what is known as "the demand" in economics, namely the quantity that the final consumers are able to acquire, because they have the material and financial means to do so. However, we distinguish accessibility from demand, which is too narrow because it generally only considers the commercial demand.

Accessibility is itself influenced by numerous determining factors, which are linked to the social factors of the model. A supply that is available at the right place and at the right time may not be accessible because the prices are beyond the population's ability to pay (Salazar de Buckle *et al.* 1989:8).

Moreover, the relative accessibility of food supplies does not necessarily mean that food needs are adequately met. The supply may be accessible because its cost is affordable; but this supply may satisfy only a portion of the food needs, either in quantity (not a

very abundant supply) or in quality (supply having a low nutritional value which is detrimental to health) (Kachondham 1995, Gabourichi 1995, Cannon 1995, Froment & Koppert 1991). As a result, the relative accessibility of supplies is a prerequisite for food security, as it partly defines consumption; however, it is not a sufficient condition for food security (Le Normand 1996:88).

2.5.3 Consumption (CON)

Consumption is the final use of food products and services. It occurs when a supply is acquired by an individual, ingested, and then metabolized. Consumption determines the nutritional state and, to a large extent, the state of health (Benbouzid *et al.* 1995, Bertrand 1997) of a population.

Consumption meets the needs of individuals in a variable manner. Adequate consumption consists for a given organism, regardless of its age and the energy expenditures required by its condition, in the satisfaction of its nutritional needs by an adequate contribution in quality and quantity of essential nutrients. An adequate consumption permits a healthy and active life. Moreover, the satisfaction of subjective needs can improve the perception that individuals have of food consumption, depending on the context (Le Plaideur & Mouster 1991:147, Freeman 1988b), for example, the possibility to satisfy individual tastes and food preferences in a situation where the supply is abundant and easily accessible.

Consumption is influenced by upstream factors that determine the supply, its availability, and its accessibility. It is also strongly influenced by factors that determine the condition of individuals themselves: the economic system in which they find themselves, the political regime that determines their rights and duties, and the social stratum to which they belong. Among these factors, the state of health is of particular importance, since the ability of an individual to meet his nutritional needs is, all things being equal elsewhere, limited by his state of health. Indeed, it determines the biological capacity to ingest and metabolize food, a function that is necessary for the development and preservation of life.

As a component of the food security model, consumption is one of the most important immediate determining factors of food security. An adequate consumption, ensured over a long period, for all individuals and in a fair manner, defines sustainable food security, as we will see shortly. Consumption is not always adequate. It can be inferior or superior to the needs; and it can be vain or impossible when the individual is in a state of health that prevents the correct functioning of his biological ingestion and absorption capacities.

	Strong resistance to fluctuations	Weak Resistance to fluctuations
Balance between needs and resources	1—Sustainable security	2—Relative insecurity
Imbalance between needs and resources	4—Chronic insecurity	3—Relative insecurity

Figure 2. *Categories of food security*

Under-consumption results from an interruption in supplies (e.g., in the event of ecological disasters, economic crisis, war), the inaccessibility of supplies (e.g., in the event of poverty or exorbitant prices), or individual inability to ingest and metabolize available and accessible supplies (e.g., in the case of severe malnutrition or serious illness). Over-consumption results from the ingestion and absorption of food quantities that exceed the needs of the organism (e.g., the absorption of too much fat), the ingestion and absorption of foods of inadequate quality to meet the organism's needs, or foods having characteristics or elements that are detrimental to the organism (e.g., the absorption of *persistent organic pollutants* through the consumption of game). Over-consumption appears in a context where food supplies are available and accessible; however, other determining factors come into play, such as the information available to consumers to make choice, to adopt a diet that meets their food needs, or to avoid superfluous foods or foods with toxic loads (Kachondham 1995:5, Dyson 1994:430, Froment & Koppert 1991). Malnutrition is the state that results from an inadequate consumption that does not meet the needs of a given organism, whatever the immediate reasons (under-consumption, over-consumption). It leads to a deterioration in health, and reduces the possibility of leading an active life (Gaburici 1995, Kachondham 1995:5).

The circumpolar area is of particular interest due to the coexistence of various types of consumption within the aboriginal populations subject to extreme environmental conditions, in diversified social contexts that are the result of separate historical developments. Under-consumption, often observed in the past, is thought to be still present in the Siberian and Canadian Arctic, whereas over-consumption is present in the North American Arctic, as shown by

pathologies related to diet, obesity, and cardiovascular diseases for example (Delisle *et al.* 1994, Dewailly *et al.* 1998b).

2.5.4 Food security (SEC)

To a greater or lesser extent, food security is the capacity of human beings, as individuals or as a group, to consume food to meet their needs. This capacity is variable, according to the conditions that define it. We propose four categories that make it possible to place these variations on a continuum ranging from a situation where security is greater, to a situation where it is lesser: sustainable security (SS), relative security (RS), relative insecurity (RI), and chronic insecurity (CI) (Fig. 2). Despite the apparent rigidity of the categories proposed here, we are indeed dealing with a continuum. This continuum is that of the intensity of security or insecurity and of the resistance to fluctuations, the four categories of which express key positions.

According to the definition of the World Food Summit presented earlier, 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. Sustainable food security is the situation where this capacity is maintained and reproduced, thanks to a strong resistance to fluctuations in the components of the food system (WFS 1996). Food security is, however, relative when the food system, while maintaining the capacity to meet food needs, offers a low resistance to fluctuations in the components of the food system. Under such conditions, the food system tends to adapt to fluctuations, which makes it possible to pass from one state to the other (from relative security to sustainable security, or to relative insecurity) (Davies 1996:24, Savadogo *et al.* 1995:148, Le Normand 1996:93).

Food insecurity is defined as a situation where the balance between the needs and the system's resources is upset. Relative insecurity exists when the food system presents a low resistance to fluctuations in its components; under these conditions, the food system tends to adapt to fluctuations, allowing it to go from one state to another (from relative insecurity to relative security, or to chronic insecurity). Chronic insecurity exists when the food system presents a strong resistance to fluctuations in its components; under these conditions, the food system tends to maintain the imbalance that characterizes it (Davies 1996, Savadogo *et al.* 1995, Le Normand 1996).

We do not have the necessary data to make an adequate assessment here of the situation in the circumpolar Arctic, or of the situation in its various regions. Indeed, to be able to identity the state of food security, one must be able to evaluate the conditions on which it is based. If the categories of food security cannot immediately provide a basis for conclusive analyses, they nevertheless lead to the following observation: they invariably refer to the dynamics of the food system. Indeed, according to our conception, food security is a state that is never defined once and for all, but rather one that must be re-evaluated constantly, because it is likely to change over time.

2.6 Feedback (FEE)

Feedback is the influence exerted by a component of the system on any other upstream element; this influence contributes to the modification of the element in question, and, from there, to a modification of the entire food system. A given state of security produces feedback and a subsequent modification in the food system. The feedback may take several distinct forms, the most common ones being reaction and adaptation.

Reaction or reaction mechanisms (REA), depending on the authors, are short-term practices that lead to modifications in the situation of food security or insecurity. They are actions that seek to counter the effects of crises or unfavorable circumstances, or to minimize the risks associated with these circumstances. This may involve increasing food production, boosting revenues through new activities, soliciting aid from social networks, etc. A large range of feedback mechanisms promotes a strong resistance to fluctuations, whereas a limited range of feedback mechanisms promotes a low resistance to fluctuations.

Adaptation or adaptation mechanisms (ADA), depending on the authors, are long-term practices that lead to modifications in the situation of food security or insecurity. They are actions that seek to counter the effects of unfavorable structures or to minimize the risks associated with these circumstances. Adaptation is not necessarily deliberate feedback. It may call upon characteristics that are genetic (size) and physiological (fertility, growth, metabolic adaptation). But it may also result from the desire of players, as in the case of certain types of behavioral changes (reduction in physical expenses, changes in the activity on which the

acquisition of the revenue or the food supply is based) (Le Normand 1996, Davies 1996).[17]

The capacity to resort to feedback and adaptation mechanisms is a major determining factor in the improvement, preservation, or recovery of food security. This capacity depends on several variables, such as the number and type of potential recourses (diversity of the modes of access to food resources, variety of available networks, availability of capital), the perception of risks, which varies according to education and culture, and the choices made according to the potential recourses and the perception of risks (Benbouzid *et al.* 1995, Kachondham 1995, Le Normand 1996, Maxwell S. 1996, Savadogo *et al.* 1995).

However, feedback does not only take place from the output or one of its components to the input, to the supply mechanisms or to one of their components. Feedback may take place from any one of the basic elements of the cybernetic core (supply mechanisms, output) to any other basic element situated upstream (input, supply mechanisms), or from any other component of the system to any other component situated upstream from the latter.

2.7 Dimensions of the Model

2.7.1 First dimension: space or the level of analysis

The works dealing with food security contain observations and analyses at several different levels, depending on the final objectives sought and the fields of studies and scientific disciplines used. The nation, the household, and the individual are the focus of specific studies.[18] These works indicate, explicitly or implicitly, the need to take into account the various levels of analysis in the study of food security (SMA 1996, CE 1995, Dyson 1994, Asenso-Okyere *et al.* 1997, Maxwell S. 1996, Paulson & Rogers 1997, Courade & Peltre-Wurtz 1991, *etc.*). No longer does it simply involve studying world stocks, as suggested by the perspective of the World Food Conference of 1974 or that of the United Nations in 1975, but rather examining the interrelations between numerous factors from the international level to the individual level.

[17] Le Normand (1996) gives a detailed description of these mechanisms in the case where the impoverishment of the household is responsible for the imbalance between needs and their satisfaction. These mechanisms are based on production, exchange and solidarity strategies. The production strategy consists of increasing the food production through an increase in performance, namely by increasing the work load, or by increasing or diversifying the production, as, for example, resorting more to wild products (picking, hunting), to more productive species, to the diversification of productions (plant or animal), to a greater exploitation of available resources, periods of the year, soils (complementarity of the ecosystems), by resorting to more efficient techniques (method, tools, products), or by increasing storage capacities (by building or maintaining warehouses). The increase may call on both the formal and informal sectors, legal and illegal activities. The aim is to increase the energy availability through a modification in the energy investment. The exchange strategy mainly concerns capital-producing but not necessarily food-producing economic activities. The aim is to increase revenues by resorting to exchange activities between the formal and informal sectors, whether legal or illegal, or by investing in non-productive goods such as jewelry, property, or by exchanging products, for example humanitarian aid products for liquid assets or other assets. The commercial system permits energy exchanges between the various ecosystems with no limitations. Social mechanisms imply the availability of and accessibility to an efficient social network. The possibility of having recourse to cash credit or credit in kind, as well as the presence of mutual assistance and support mechanisms, are practices that make it possible to maintain or to attempt to recover food security. Resorting to formal or informal networks, whether legal or illegal, makes it possible to adjust the food consumption so that needs are met. Social mechanisms permit the acquisition of energy through a loan or a donation provided by the social protection net. When the practice of these mechanisms allows the achievement of a surplus, the latter is used in capital: "In a crisis situation, capital can be mobilized to meet food needs. When the situation worsens, the capital that the family household has will decline, or even be used up completely, which may lead to a situation of food insecurity or vulnerability. The family is no longer able to make use of the adaptation mechanisms allowing it to limit risks." (Le Normand 1996:92). In a market economy, capital represents the main recourse used to adjust its food consumption to the necessary level.

[18] Beghin *et al.*1988 quoted in Benbouzid *et al.* 1995, Gaburici 1995, Atkinson 1995, Kennedy & Pinstrup-Anderson 1983 quoted in Courade & Peltre-Wurtz 1991, Salazar de Buckle *et al.* 1989, Crosnier 1991, Babu & Mthindi 1994, Davies 1996, Greely 1991, Bayliss-Smith 1991, Siaamwalla & Valdes 1981 quoted in Asenso-Okyere *et al.* 1997, Le Normand 1996.

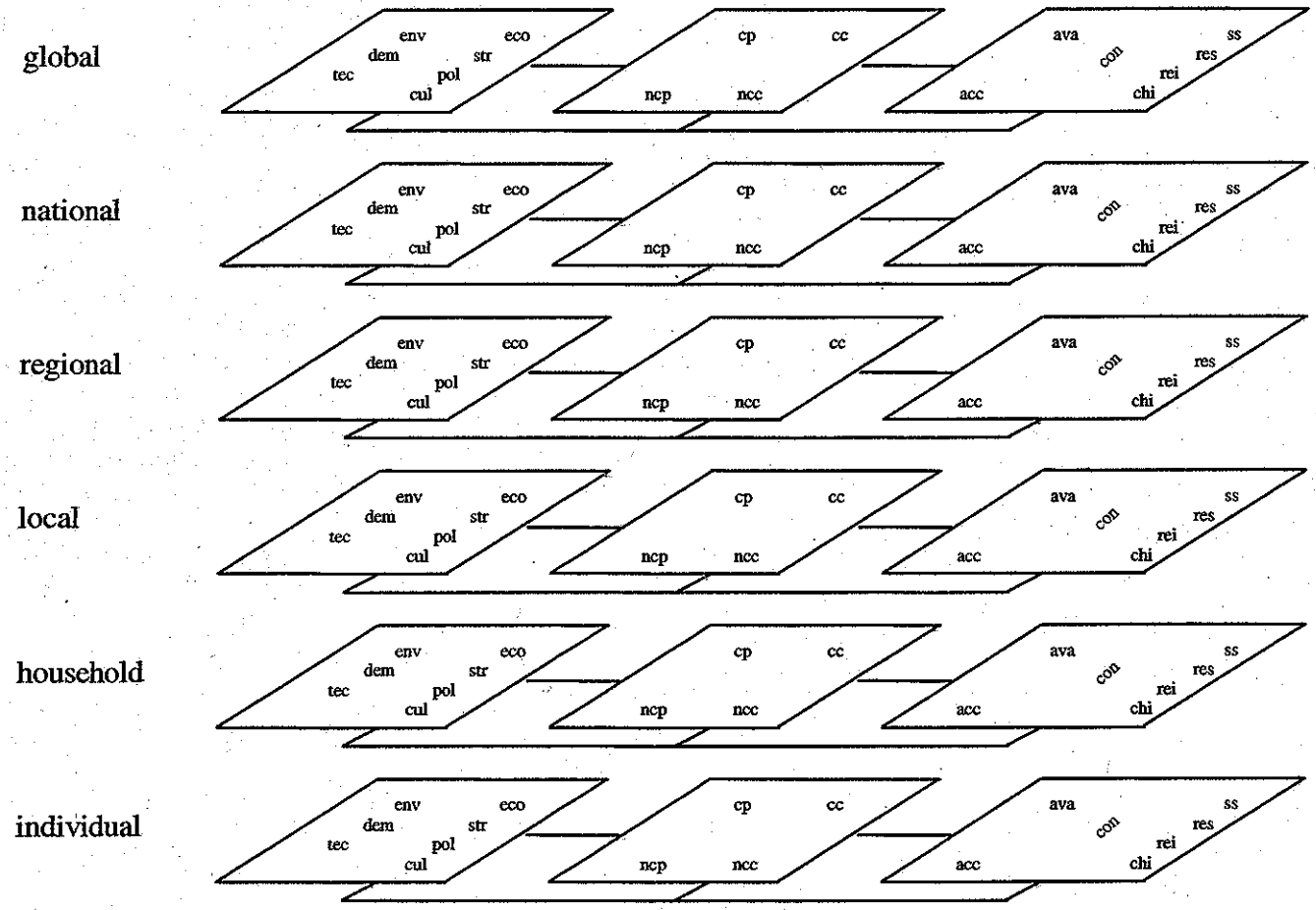

Figure 3. *Level of analysis of the sustainable food security system.*

Yet some works do not explicitly distinguish the levels. For example, the model presented by UNICEF in 1990 links certain social factors to situations of food insecurity or to bad health conditions without taking into account the geographical levels (UNICEF 1990 quoted in Pelletier & Johnson 1994). However, to clarify the model presented here, we will distinguish the levels of analysis. For each level surveyed in the available studies, factors help to model the state of food supply mechanisms and the ability to have access to the supplies. Moreover, there are interrelations between the levels of analysis. For example, international economic structures (such as the World Trade Organization) have an influence on the mechanisms that a given nation implements for food production (such as its business subsidy policies); national production has an influence on the supply of regions and localities; the social policies that lead to transfer payments to households have an influence on the economic capacity of households to gain access to the supply and to consume (Davies 1996, Maxwell D. 1996, Rouffignat 1997), and finally, the distribution of the power within a household has an influence on the food of which each member of the household can access (Abbi *et al.* 1995, Dyson 1994). The model must reflect this multiplicity of levels. That is why, in its vertical dimension, the model is organized into six levels of analysis: global (G), national (N), regional (R), local (L), household (H), and individual (I) (Fig. 3).

The internal components of each level of the model, namely its horizontal dimension, are more or less identical at all levels. Despite identical names, their content they refer to different realities. In the analysis of the food security of a given geographical area, food production and circulation do not refer to the same realities within the various levels considered. At the

global level, they refer to global food stocks and cross-border transactions. At the national level, they refer to domestic production and to the circulation of the supply by domestic production or import. At the local level, they refer to the specificities of the production realized on site and to local supply networks. Finally, at the household level, they refer to the production activities carried out by households and to the rules for circulation of supplies between members of similar households. However, at this stage of analysis, we will retain an identical nomenclature from one level to the next, to reduce the complexity that is inherent in the model, while agreeing that empirical realities may differ.

2.7.2 Second dimension: time

The model elaborated thus far can be used to assess the state of food security at a given time and in a given geographical area, by considering the multiple influences between the variables considered. However, the state of food security can change. Indeed, a variation in a component of the model can have an influence on the whole, such as the equilibrium or the resistance, which define food security and its duration. As Davis recognizes (1996:22-24), the ability to change is of prime importance in the analysis of food security. For example, in a context of insecurity, households can resort to means that have been put aside for a long time, such as food production techniques or informal exchanges in the family network. The proposed model makes it possible to consider such change. By repeating the analysis at different moments in time (T1, T2, *etc.*), the model takes into consideration the variations in the components studied, and may lead to a different assessment.

But the model can go beyond that. The model makes it possible to identify the variables in which changes could be made in order to deliberately bring about a change in the state of food security Suppose, for example, that the analysis makes it possible to identify the environmental contamination of local food products as one of the factors determining food insecurity in the Arctic. Under these conditions, one might envisage controlling this factor, either by eliminating the environmental contamination (by strict legislation at the appropriate level), or by circumventing the problem of exposure to the environmental contamination (by modifying dietary habits). Suppose that the analysis makes it possible to identify the lack of monetary resources of households as one of the major factors of their relative food security or insecurity. Under these conditions, one might envisage controlling this factor, either by increasing the monetary resources of households (by improving the social security system) or by lowering consumer prices (through business subsidies). In either case, one may suppose that an assessment made after the envisaged changes could be modified in relation to the initial state.

This aspect of the model makes it a useful tool for defining the conditions that must be acted upon to modify the situation; at the cost of appropriate methodological developments, it could permit a simulation of the impact of envisaged modifications.

2.8 Interrelations and Inter-Influences

Until now, we have described the food security system in a linear fashion, as if the relations between the components necessarily move from upstream to downstream, namely, from left to right, from top to bottom and, thanks to feedback, from downstream to upstream as a rebound effect. This presentation strategy—as that is what it in fact is—is misleading. Indeed, the relations between the system's components are multidirectional, an entanglement of inter-influences (Davies 1996, Dyson 1994:147, Maxwell S. 1996). To arrive at a correct analysis of conditions of food security, one cannot ignore, for example, that the population structure can have an influence on the economic situation and *vice-versa*, that the rights granted to a given population can modify the social stratification and *vice-versa*, and that the state of health can have an influence on access to the supply and on consumption and *vice-versa*, and so on.

A detailed analysis of the conditions of food security assumes that one takes this set of inter-influences into account. This task is extremely vast, as the number of relations between the components of the model is substantial because this number is even greater when one considers the variations in the components, and because, finally, the relations between the components have repercussions on other components of the model. We can only raise the question here. Multiple examples of these inter-influences appear when we examine the factors of the social system, the relations that they have with one another and with the other components of the food system. We will examine a few of these here, not to deal with the subject exhaustively, but rather to illustrate the need to take these entanglements into account.

2.8.1 The environment and the food system

Natural conditions (ENV) are never absolute deciding factors of food security because, as we have already said, human societies are capable of reacting and adapting, which allows them to occupy and exploit a multitude of different environments, to minimize the risks by ensuring a certain regularity in the distribution of resources between the good and bad years, between the economically productive and unproductive members (STR), etc., or to migrate if the conditions are too hostile (ENV, POL) or if they become uncontrollable (Chastanet 1991, Le Normand 1996:91, Maxwell & Smith 1992 quoted in Davies 1996)[19]. These reactions and adaptationsoccurs as a result of modifications in other factors of the social system (new technology, reorganization of the economy, etc.), or other components of the food system (changes in production, circulation, consumption).

These reactive or adaptive capacities can be modified over time, influenced by a multitude of factors[20]. Among them, environmental factors can be of considerable importance (ENV). Several years of difficult environmental conditions, such as droughts or incessant rains, can lower these capacities. The effects on food securitymay be even more drastic when difficult environmental conditions are added to problems ensuing from other factors of the social system (POL, ECO) (Chastanet 1991:138, Courade & Peltre-Wurtz 1991, Giroux 1995).

Indeed, the viability that the environment offers populations is a fundamental condition of food security. An unhealthy environment gives rise to diseases, the effects of which are devastating in terms of reactive and adaptive possibilities, when they do not directly impact on food security.[21]

Environmental conditions can be modified by human activity at the local (L) and planetary (G) levels. At the local level, an intense exploitation of resources that does not respect the physical limits of the environment leads to ruin (ECO). The over-exploitation of resources, the massive use of fertilizers, or the irrational use of water causes the desertification of fragile zones, the destruction of forests, the disappearance of species or the decline in the fertility of the environment; anarchic urbanization eats away at the best lands (Denis 1996:98, Speth 1993 quoted in Gürkan 1995, Whiteford & Ferguson 1991). The pressure exerted on the environment reduces the possibilities of exploitation over the long term, and forces the search for new adaptations. Moreover, a deterioration in environmental conditions may result from a reduction in or the abandoning of human activity, such as the reduction in or abandoning of maintenance, irrigation, the reduction in seeded surfaces, or the use of fertilizers and pesticides (GP, NGP). These changes may aggravate the state of soils and make the environment less productive. At the planetary level, ecological conditions may also be modified by the effect of human activity, more often than not in developed countries. Climate changes and variability, the destruction of the ozone layer, the erosion of biological diversity, of genetic diversity and the various forms of environmental pollution, including man-induced disasters, affect food security (WFS 1996a,b) by modifying or reducing access to and the possibilities for exploitation.

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[19] For example: " (...) it can be inferred that they [human beings] are also highly resilient, given the ability of human populations to adapt to variable resources with great flexibility, exploiting a wide range of environments and economic processes (...)" (Maxwell and Smith 1992:37 in Davies 1996:26-27). Speaking about a Sahelian society, the Soniké, Chastenet (1991) explains: "The reproduction of this society over the long term required the implementation of strategies to adapt to a restrictive environment – which nevertheless made possible an economic and demographic expansion in times of prosperity – and survival strategies in times of famine. Subsistence and survival strategies call on different logic but are two components of the same regulation system." (Chastenet 1991:134). For Le Normand (1996): "The populations residing in zones where the situation is regularly unfavorable (unfavorable weather, permanent conflict...) develop specific practices the purpose of which is to minimize the risks: these are adaptation or reaction mechanisms" (Le Normand 1996:91).

[20] The difficult conditions that modify the ability to react and adapt may originate from factors that are not linked to the environment, for example, the slave trade or an armed conflict can lead to a reduction in the work force likely to threaten food security. Chastenet (1991:138) observes that the exceptional duration of the famines at the turn of the 20th century is symptomatic of a deep crisis in the old regulation systems, such as food collection and migration.

[21] "Infectious diseases, mainly diarrhea, the leading cause of mortality and malnutrition under the Tropics, are very costly in terms of calories and must remind planners that more often than not, development is achieved through sanitation and vaccination rather than through agriculture." (Froment & Koppert 1991:196).

2.8.2 Demography and the food system

Major demographic variations increase the risks of food insecurity. The imbalance between demographic conditions and the capacity of food supply mechanisms, to the detriment of the satisfaction of needs, increases if there is no intervention, such as improving health conditions and the level of education (Benbouzid *et al.* 1995, Bertrand 1997), improving the production capacity (Gürkan 1995), demographic adjustments (Chossudovski 1998), and emigration (Chastanet 1991).

On the one hand, strong population growth produces an imbalance between the population, the production capacity (GP and NGP) and the environment's carrying capacity (ENV) (CE 1995, Minvielle 1991:183). Demographic growth and emigration may take place in response to unfavorable conditions, including the deficiency of the food supply; as a result, the impacts of food insecurity on demographic movements add to food insecurity. Moreover, a major demographic decline results in a serious labour supply shortage, which affects resource exploitation systems (GP and NGP) and the efficiency of existing supply mechanisms (Chastanet 1991:141). The decline can be linked to a massive exodus (SMA 1996, Chastanet 1991:141), the aging of the population (Giroux 1995:4), high mortality due, among other things, to epidemics, political unrest (POL), or major environmental upheavals (ENV) (Froment & Koppert 1991:194, Chastanet 1991:145). These two contrary phenomena of growth and decline produce an imbalance between the needs of the population (CON) and its capacity to obtain supplies (ACC). This imbalance results from an insufficient quantity of appropriate resources to maintain stability or to maintain symmetrical growth between demography and development (WFS 1996b)

Nutrition is a major deciding factor in health and demographic characteristics (Bertrand 1997, Benbouzid *et al.* 1995, Dyson 1995). Adequate nutrition (CON) is promoted by a sufficient standard of living (ECO),[22] adequate access to health services, (Giroux 1995:4, Le Normand 1996:89), the application of appropriate hygiene measures and, above all, education (POL) (WFS 1996b, Arnold 1981 quoted in Froment & Koppert 1991:201, Bertrand 1997:7). However, adequate nutrition supposes the availability of healthy food (AVA) and a sufficient, quality diet (ACC) to meet the needs of each person (CON); in summary, it supposes food security.

In other words, food security promotes health (DEM) and contributes to a stability of demographic characteristics. Health and demographic stability are conditions of food security. Consequently, it appears that, regardless of the prime factor, their positive variations would always be closely associated. Examined from the opposite perspective, the phenomenon would present the same negative variations. Food insecurity frequently gives rise to problems such as a general state of health and welfare that is poor or bad; mental complaints such as stress and the resulting physiological distress appear to have a negative effect not only on physical health (DEM), but also on the reaction capacity of individuals (RÉA) (Bertrand 1997). On a large scale, this can be reflected by variations in the productive capacity, by an increase in subsequent food insecurity, and by demographic changes, such as morbidity, mortality, or migration (DEM) (Chastanet 1991, Giroux 1995).

In this context, access to health services is a factor of prime importance (DEM). It allows vaccination, the fight against infectious and parasitic diseases, an appropriate intake of micronutrients, birth control, etc. Moreover, health and nutritional education make it possible to transmit vital information concerning good dietary and health practices (WFS 1996b, Benbouzid *et al.* 1995:48). In this respect, women play an important role in attaining a food balance, a role that is largely recognized around the world. (CE 1995:1, WFS 1996b).

2.8.3 Technology and the food system

Technology permits economic and agricultural development (ECO) through the development of rural infrastructures, transport infrastructures (transportation systems, roads, vehicles) and marketing infrastructures (CC), the development of which ensure

[22] The WFO (1987 quoted in Dyson 1994:430) and Steckel (1983 in Froment & Koppert 1991:196) have demonstrated a link between body stature and per capita income. "Weight follows a similar trend but tends to reverse itself for cultural reasons, which explains why in poor countries, the rich are fat and the poor are thin, whereas in the West, the poor are fat (access to cheap glucidic and lipidic calories) and the rich are thin." They underscore the different characteristics of food ingested according to the country: the quantity for developing countries, the quantity of food for developed countries. Bertrand (1997:12) indicates that for Québec the link is more significant between weight and the level of schooling, than between weight and income. Hence, she links diet with the level of education first and foremost. People with less education, regardless of their income, are more frequently overweight.

the stability of the supply (AVA) and increase the population's purchasing power (ECO). (Franqueville & Prudencio 1991:31, Bernard & Hoffman 1991:95, CE 1995:4)[23]. The production of farm surpluses and the presence of reliable transportation corridors reduce the degree of isolation, and integrate populations into the market economy (GP, CC). Exporting then becomes possible. If, in addition, the use of technology increases competitiveness (Phélinas 1991:68), permits the meeting of trade standards of importing regions, and permits the making of profits that can be re-invested (CE 1995:4).

Similarly, importing, which is part of food supply mechanisms (CC), is made possible by the existence of transportation corridors (TEC) and purchasing power, itself linked to local productivity (ECO) (CE 1995:5).

Technology is part of all aspects of a region's development, and the food security of the population appears to be linked to the wise use of technology for the exploitation of natural resources (Kermel-Torres & Roca 1991:48, WFS 1996b). Indeed, a limited appropriation or non-appropriation of technology caused by the absence of exploitable and profitable natural resources (ENV), the absence of the support of producers (insufficiency of financial means, debt) (ECO, GP), or a lack of openness on the part of the populations, leads to stagnation or to a decline in local food production (NGP), or the lack of experience, a lack of processing and storage capacities (CC). These situations are obstacles to food security (Bernard & Hoffman 1991:88, 94; Minvielle 1991:183, Giroux 1995:9, WFS 1996b, Kermel-Torres & Roca 1991:47).

As Courade and Peltre-Wurtz mention (1991:5), in the case of India, the technological solution is limited by basic determining factors, namely the ability of populations to obtain food (ACC), regulations at various geographical levels, and arbitrations established by the State and commercial corporations (POL, CC).

[23] Technology makes it possible to limit the deterioration of the environment caused by an intensive exploitation of resources (Corbett 1991) and to offset the negative effects of exploitation. For example, global warming modifies the productivity of agriculture, and the adoption of suitable technologies makes it possible to maintain productivity. This localized phenomenon can have global repercussions: "Technology development could partially offset the potential decline in these areas [developing countries], and increased production potential in developed regions could ensure global food security." (Kracht 1995:70-71)

2.8.4 Social stratification and the food system

Being a member of a social stratum, which influences food security, is itself subject to determining factors. Courade and Peltre-Wurtz (1991) surveyed zones where poverty and food insecurity are found. They mention marginal climate zones (ENV), under-populated (DEM) zones, and zones inhabited by people who live in the country but have no land (ECO). They note that, more recently, food insecurity has affected small farmers raising export crops, who in some cases have seen their monetary income cut to a half or a third (Brazil, Mexico, Sub-Saharan Africa) (GP, CC). Zones with high agronomic aptitudes (ENV) and a high density such as cities (DEM) are increasingly being affected by food insecurity.

The introduction of favorable economic and political measures helps to attenuate the unequal distribution of resources and powers, that otherwise would produce a disparity in access to food resources (Dyson 1994). These measures can be the recognition of rights, improvement of health care and education, strengthening productive capacities, an adjustment toward a fair distribution of revenues, and increasing the purchasing power, and would likely help to combat poverty and food insecurity (POL) (Delgado 1991:80, WFS 1996a,b). However, they must counter highly integrated behavioral models and cultural convictions, that are unfavorable to changes (CUL) at regional and local levels (Thieba 1991:103, Droy 1991:117), the national level (Denis 1996:100), and the international level (Lehman 1996:1). Moreover, such measures are not sufficient to counter major trends, such as the deterioration of macroeconomic conditions (in China and Japan for example) (ECO) associated with political changes (POL) (e.g., in Russia Lewin 1998, Giroux 1995), or associated with structural adjustments imposed on developing countries by international agencies (ECO) (Denis 1996:99, Courade & Peltre-Wurtz 1991:3, Chossudovsky 1998), which bring about a decline in social security measures (POL) and deepen inequalities (Kachondham 1995:5).

Poverty itself leads to behaviors that are likely to be detrimental, over the long term, to food security, such as the deterioration of the environment (ENV) (Dyson 1994:436, IFPRI 1995:2)[24].

[24] "(...) large areas of land are being degraded and deforested, largely due to poverty, population growth, and limited access to appropriate technology." (IFPRI 1995:2).

2.8.5 The others

In summary, the model proposed here is based on the premise, shared by several authors, that the variables affecting food security are interrelated, and that their reciprocal influence must be considered. As we have just seen, this applies to the environment, demography and health, technology and social stratification. But it also applies to other factors of the social system, as well as to other components of the food system.

To arrive at a detailed analysis of food security at a given time for a given geographical area, it is necessary to evaluate the relations of each variable in question with the entire subject being studied; to succeed in studying change, it is necessary to repeat these analyses over time and to note the differences. Finally, to model the desired changes, because it would be favorable to achieving or maintaining sustainable food security, we must be able to simulate the impact of changes affecting certain known variables on the entire food system. This, then, is our project, which understandably requires major subsequent methodological developments.

Some researchers such as Haddad and Kennedy (1994), have focused their work on the study of the interactions between various indicators of food security, for example, low calorie intake and large size of households combined with a high dependency ratio. Davies (1996) uses matrices (tables 2.4, 2.5, 2.6, etc.) to show the relationship between various components. These two-entry tables relate national, household and geographical levels and certain components such as production, exchange, goods, reaction and adaptation mechanisms, consumption, demand and protection of income. One advantage of this illustration is that it clearly shows the relationships even though the number of components studied are limited. If one were to place the theoretical interrelations between the components sketched here in a square matrix, that is, a table having as many lines as there are columns and where the components are listed both in lines and columns, one would discover 324 possible intersection zones between the components (18 X 18). But this matrix would have to be six times bigger, to take into account the conceptual differences in the six levels of analysis. Hence, it would have 1,944 cells (18 X 18 X 6). In such a matrix, each of the intersections could, theoretically, provide information on the relations between the components, taken from the state of the knowledge. Each of the relations between the components, documented at the intersections, can have an influence elsewhere in the matrix. By translating the relations into symbols, one can easily conceive of a schematic transcription of the interrelations and the chains of interrelations in algorithms.

3. APPLICATION POTENTIAL

In the meantime, we will illustrate the analytical potential of the model by proposing a summary of the type of analysis that it could permit. We are using an example taken from the past because it involves relatively well-known situations. The contemporary situation could have been analyzed; however, limits in current knowledge and the emergence of radically new variables (environmental contamination and its potential impact on food security) call for caution.

In Nunavik, in the era preceding the construction of permanent villages, the situation was alarming. The constraints imposed on food-producing activities (M-NGP, M-NCC[25]) were numerous and cumbersome. The cold climate forced inhabitants to resort to the harvest of fish and game to ensure their survival (R-ENV). Caribou herds were rare and few in number (R-ENV). The population was dispersed in small nomadic groups (L-DEM). Life expectancy was low, and vulnerability to new diseases high (L-DEM). Activities that would ensure survival were founded on technologies of low productivity, in particular, land transportation means (dog sleds) (TEC). The economic organization was largely dominated by bartering (L-NGP, L-NCC); the fur trade (G-GP) also provided a portion of the monetary revenues (L-ECO), useful to purchase basic consumer goods (L-ACC). However, the economic system did not manage to meet all needs, and there was practically no social support under the political organization (POL). The scarcity of game and the low productivity of hunting made it difficult to acquire income, commercial goods (L-ACC) and the food necessary for survival (L-ACC, L-CON). This deficient food supply made the population even more vulnerable to diseases, and this deficient state of health further weakened the productive capacities of individuals (L-DEM).

[25] H-NGP, H-NCC: non-commercial production and non-commercial circulation at the household level. In the following examples, the levels of analysis are indicated by the first letter of the level (I for individual, H for household, L for local, R for regional, N for national and G for global), before the component in question. The data is taken from Duhaime (1985).

Epidemics worsened the chronic food insecurity situation (CI).

This initial assessment would be modified by the action of players involved in solving problems. Indeed, knowledge of the situation would give rise to rebound actions (FEE) that would have multiple impacts on the food system, some direct, others vague.

During the 1960s, political authorities (N-POL) reacted to the situation by establishing permanent villages. They were prompted to take action by pressure exerted by merchants (N, R-ECO) and missionaries on site (N, R-CUL), by doctors who ascertained the seriousness of the situation (R-POL), and finally by the imperatives of Canadian sovereignty in the Arctic (G, N-POL). With permanent villages came regular medical care (R-POL), schools (R-CUL), the gradual generalization of wage earning (R-ECO) and the systemization of social assistance (R-POL). The increase in the economic capacities (R-ECO) and the improvement in the health of the population (R-DEM) made it possible to gradually improve the diet (R-CON); the situation entered a phase of relative security (RS). However, some households had more difficulties than others because they did not have the same access to monetary and wage-earning resources (M-ECO, M-STR). They were in relative insecurity (M-RI).

This example illustrates the usefulness of the conceptual framework for taking into account a vast series of components that impact food security. Applied to the contemporary situation, it would force the analyst to consider the impact of factors such as technological transformations (use of the snowmobile for food-producing activities), the strengthening of social stratification, the role of government aid programs associated with hunting and fishing activities, the appearance of health problems related to changes in life styles, and environmental contamination affecting game in particular. This is the horizon before us.

4. OPERATIONALIZATION AND NORMATIVENESS

We stated that the conceptual framework presented here had to meet certain requirements. It had to be based on a broad vision of the problem, incorporate all the possible permutations of the variables considered, and lend itself to operationalization. Moreover, it had to satisfy the constraint of coherency between food security and sustainable development, where the measured conditions of food security had to be compatible with the conditions of sustainable development. Does the model that we have built meet these requirements?

The question of coherence is fundamental and encompasses the others. It is resolved by the fact that sustainable food security corresponds to a precise position in the model (SS), and because this condition must correspond to one or more particular configurations of the model, within which the variables considered present specific results. In other words, an assessment of sustainable food security cannot be made without multiple conditions being met upstream (factors of the social system, supply mechanisms, and interrelations) and downstream (feedback and interrelations) from the model: economic policies and organizations that promote participation in decision-making at the regional or local level; fostering the perennial nature of the food-producing resources; organization of production and food circulation that promotes the satisfaction of local needs; availability and accessibility of food, allowing an on-going adequate consumption for everyone; strong resistance to environmental, demographic, economic and political fluctuations, making it possible to attenuate crises (cataclysms, economic crises, shortage of seasonal stocks); and so forth.

This possibility does not mean that the model does not allow assessments other than that of sustainable food security. The model can lead to other assessment positions on this continuum between sustainable food security and chronic insecurity, depending on the state of the variables studied. It may lead to identifying and elucidating a multiplicity of situations, because the variables that make it up can take all possible values.

However, this characteristic requires major developments for the model to be functional, namely for it to be useful for making real assessments of actual situations on the basis of measurements of variables. The development of this model should lead to an examination of each factor of the social system, each supply mechanism and each condition of food security, in order to draw up a list of the variables in question; next, it should lead to an examination of each of the variables to draw up a list of the permutations that these variables may exhibit. Once this has been accomplished, it would still be necessary to examine the interrelations of variables and of categories of variables to know the final impact on

food security.[26] In reality, this work plan is misleading. Each component of the model represents more or less a field of knowledge, like 'commercial production' or 'political' factor. If, from a methodological standpoint, each component can be compressed into a two-position variable, this operation assumes a superficial understanding of the underlying processes. The risk one incurs is to create a formal model claiming to be the actual comprehension.

There is another possibility leading to the operationalization of the model. It involves examining in what way, and under what conditions, each component contributes to sustainable food security. In summary, it involves creating a standard ideal, a yardstick, based on available material and the standard would be used to evaluate the distance that separates it from empirical reality, studied from all the necessary angles simultaneously. This program is also vast. However, it corresponds very closely to the potential that we have for the continuation of our work.

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[26] If the model already has 1, 944 cells when one creates a matrix of interrelations, the number of cells is even bigger when one creates useful categories for each variable. Let's suppose binary categories only, the number of cells then increases to [(18 X 2) (18 X 2) X 6], namely 7,776 cells. Here again, each of the relations between the components, documented in 7,776 intersections, can have an influence elsewhere in the matrix. By translating the relations into symbols, one can conceive a schematic transcription of the interrelations and chains of interrelations in algorithms. This is a colossal task.

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