

# Ant-hill town:

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*Parameters for a sustainable small territorial town.*

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## *Abstract*

The phenomenon of global urbanisation has reached unsustainable levels, with an unprecedented 50% of the total population living in urban areas in 2008. This situation has accentuated, furthermore, the abandonment of rural areas and subsequently the unsustainability of the countryside and cities worldwide. The growing urbanisation affects the consumption and production patterns, increasing the ecological footprint of human beings; which at the present is 2,7 hectares per capita, while the world's total bio capacity is 2,1 hectares per capita. The result is a deficit of -0,6 hectares per capita.

Colombia is a dramatic example of urbanisation in the past 50 years, with all the negative impacts that this involves. Paradoxically, this country has an ecological footprint of 1,8 hectares per capita, and a bio capacity of 3,9 hectares per capita; the result is a +2,1 hectares per capita reserve.

Small sustainable territorial towns could be an efficient way to develop sustainably rural areas and stop the migration flux towards the big cities. This research proposes a sustainable territorial town in Colombia as a pilot project; inspired in the ant-hill and based on bionic principles, involving concepts such as bioregionalism, territory and territorial cohesion.

## *Keywords*

Sustainable, development, alternative, bioregionalism, territory.

# 1. Background

## 1.1 Precedents

The migration phenomena from rural areas to large cities in developing countries, often results in social alienation, economical exclusion and environmental deterioration; and yet it is an increasing trend that seems to ignore its negative impact.

According to the United Nations, the world population have started to slow down its growth, especially in the rural areas. Simultaneously, the percentage of the world population living in urban areas has increased dramatically from 30% in 1950 to 49% in 2007 and it is projected to 70% in 2050. (Department of Economic and Social Affairs, 2007). At the same time, the world population has reduced its annual rate of change from an annual 1,90% in the period 1950-1975 to 1,54% from 1975-2007; and it is projected a slow down to 1,02 from 2007-2025 and to 0,55 from 2025-2050.

The figures show that the world's population is increasingly becoming more urban, despite the devastating social, economical and environmental impacts; in particular in developing countries where the tendency is to migrate to big and overpopulated cities, leaving the countryside in complete abandonment. In 2008, the world population reached a landmark: for the first time in human history the urban population equalized the rural population, which means that from this point on, the world population is in its majority urban (Fig.1). This is a consequence of the accelerated rural migratory flux to the cities in the last 50 years, especially in developing countries.

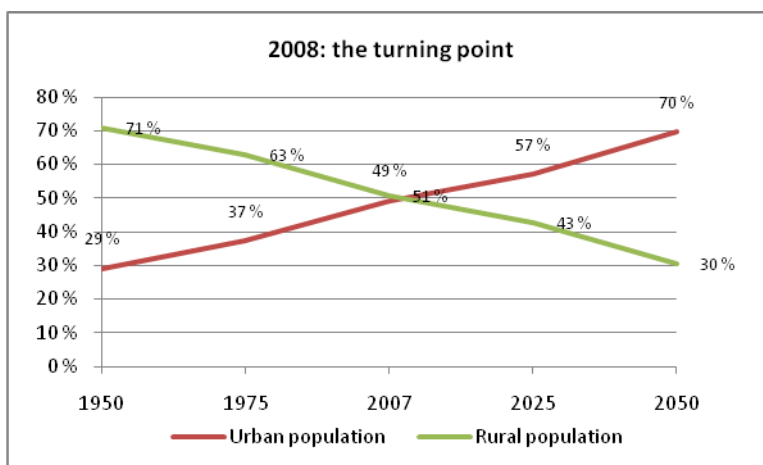


Fig. 1 Urban and Rural World Population Crossing Point

Under these perspectives, from now until 2050, the urban centres of the world will have to absorb all the population growth expected in that period of time, while the rural population will decrease. The consequence of this is that the world rural population in 2050 is expected to be 0.6 billion lower than today.

## **1.2 Paradox: Why people migrate from the countryside to the city?**

Too often the social, economical and environmental situation for the rural-urban migrants is worse in the city than in the deserted countryside; so why do they migrate knowing the risks and uncertainty of that choice? There are two main causes triggering this flux: one is stagnation (inertia) and the other one is expectation (dynamism); the stagnation of an unbearable present and the expectation of an elusive future. In the developing countries, small farmers normally live in surviving conditions without even reaching a minimal level of food security. This extreme poverty situation is characterised by physical, social, economical, institutional and alimentary insecurity, which is accompanied by isolation, ignorance, lack of self esteem and exclusion. Under these circumstances, the city represents a promise of a future in regards to a present, and an illusion in contrast to a reality; the city becomes a promised land, a mirage.

The crucial rupture the rural-urban migrant faces is to change the character of his activities; shifting from agrarian to urban without having the skills to compete in the urban working market. This single fact determines the future of the newly arrived migrant, who initially swells the rate of urban unemployment. This situation leads to a parallel urban economy with ingredients such as: exploitation, informal employment and delinquency; resulting in a total marginalised status of the migrants. The marginalisation is generally accompanied by ignorance, violence, prostitution, drug addiction, slums, homelessness and anonymity. At this point the migrant has no means to return to the countryside and start again, and even though his situation is worse in the city, at least he has the illusion of being part of the progress.

## **1.3 Colombia, an example of the paradox**

At the outset of the twentieth century, Colombia's population was approximately 4 million; by 1951 it grew to more than 12 million; and in mid-1980s it reached an estimated 28 million. The population growth rose from 2 % annually in the 1940s to a peak of 3.4 % in the 1950s; then it slowed down to a 2% rate by the mid-1970s and stabilised at that level through the 1980s. Even at this lower rate of growth the population reached 38 million in 2000 and 44 million in 2008.

On the other hand, Colombia has one of the highest urbanisation rates in Latin American. The percentage of the population living in urban areas increased from 31 % in 1938 to nearly 60 % in 1973. Over the 1951 to 1964 period, the average rate of urbanisation was 5.5 % per year; but from the 1980s to the present the rates of both, population growth and urbanisation, fell to an annual average of 0.6%. (Fig. 2)

Since the late 1930s, massive rural-urban migration has been the main factor in increasing the urban population, changing it from less than one-third to four-fifth in 2008. Urban growth between 1951 and 1973 was dominated by the

growth of the largest cities: Bogotá, Medellín, Barranquilla and Cali; all of which were already large metropolitan areas of more than 500,000 people in 1951. From 1951 to 1973 the population in these four cities shift from 5 % to 25 % of the national population, which represented 500% increase, while the national total urban growth was less than 50 % during the same period. (Departamento Administrativo Nacional de Estadísticas, 2008)

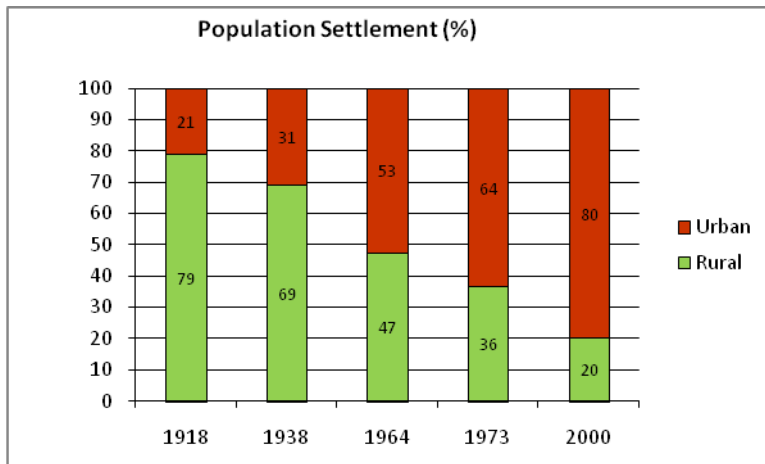


Fig. 2 Urban and rural population in Colombia

From the Colombian urban and population evolution, Bogotá is the city that resumes the rural-urban migration paradox and its dramatic consequences. The historical records of Bogota show that the city's population has grown very fast in the last 50 years. (Fig. 3) (Fig. 4)

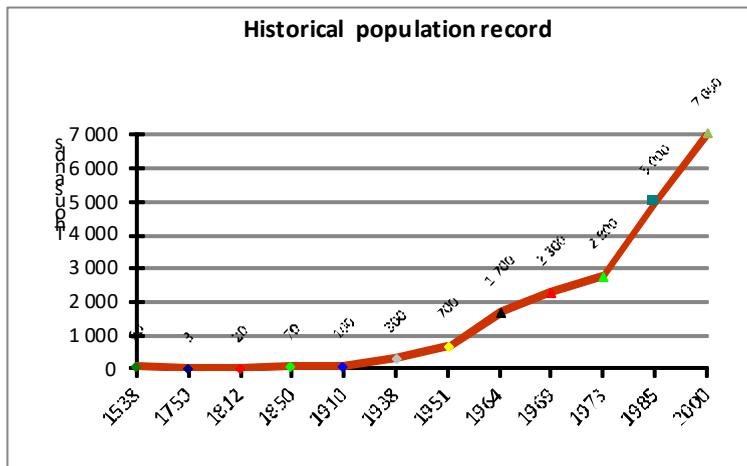


Fig. 3 Population in Bogota (number inhabitants)

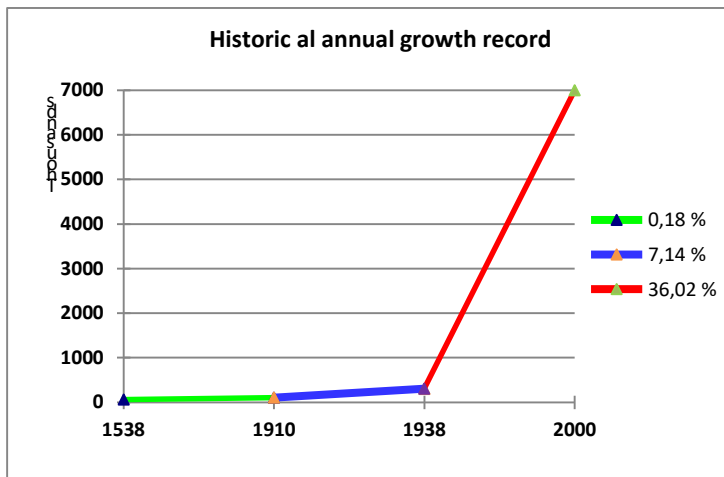


Fig. 4 Population in Bogota (% inhabitants)

While Colombia had 4 million people in 1910, Bogotá had 100.000, which represented the 0,25% of the national population; in 1951 Colombia had 12 million people and Bogotá 700.000, which was the 5,83% of the whole population; in the mid-1980s Colombia had 28 million people and Bogotá 5 million, which was the 17,85%; and in 2008 Colombia had 44 million people and Bogotá 8 million, which was the 18,18% of the national population. (Fig. 5). The comparison between Colombia's and Bogota's population evolution in the last 100 years, evidences a faster growth in Bogota's population and the consistent concentration of population in this city. (Fig. 6) (Fig. 7)

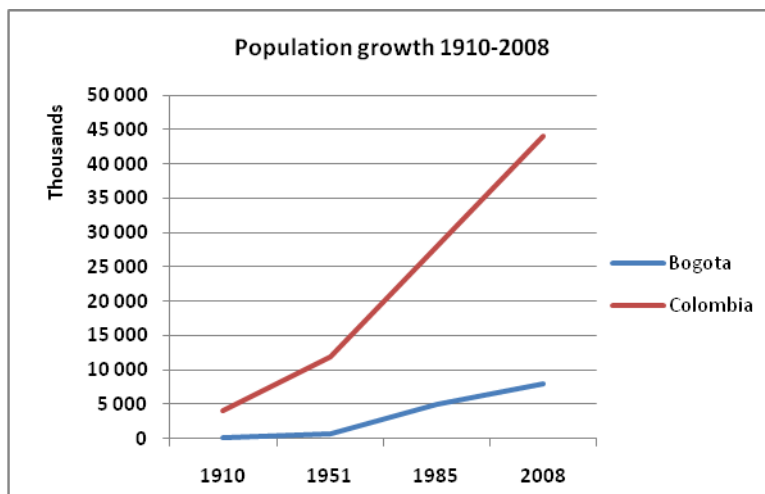


Fig. 5 Comparison populations in Colombia and Bogota (number inhabitants)

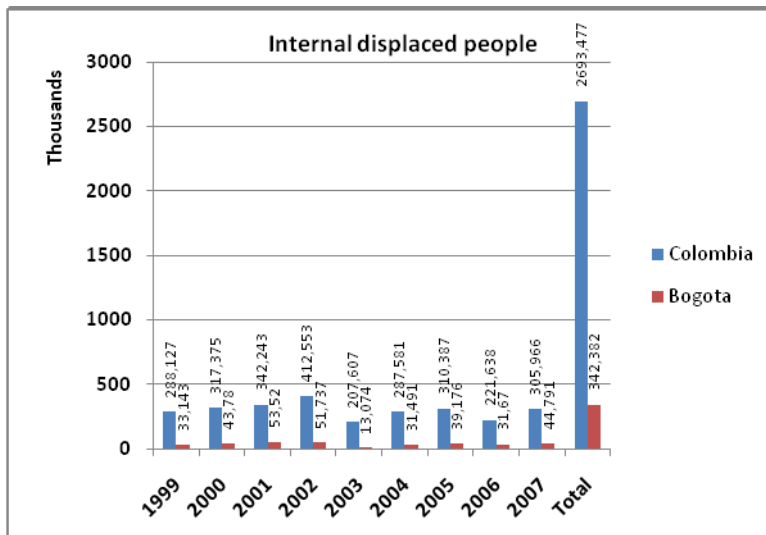


Fig. 6 Comparison populations in Colombia and Bogota (%)

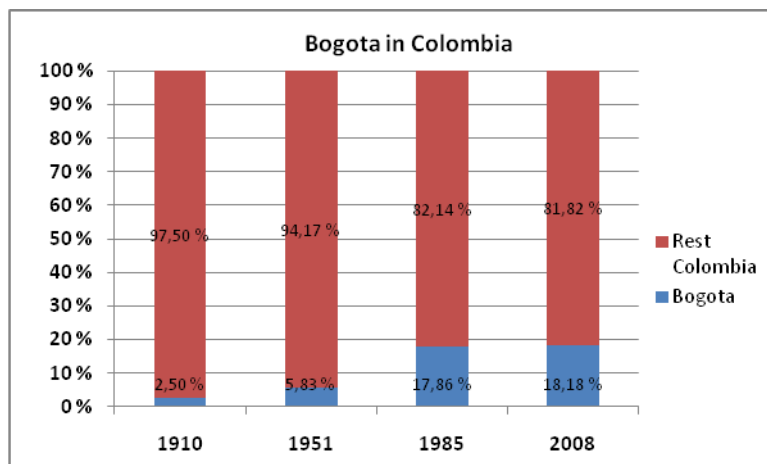


Fig. 7 Distribution of population in Bogota and Colombia

One of the main factors affecting the demographics in Bogota is the flux of internal displaced people migrating to the city, from which 78% are peasants. As an average, 13% of all the internal displaced people of Colombia move to Bogota. (Fig. 9) Between 2000 and 2007, Bogota's population increased in 1 million people (14,28%) and in the same period it received 300.000 internal displaced people. (Fig. 8) This means that 30% of the new inhabitants in Bogota were internal displaced people; 23,4 % of them were peasants and 6,6% from small towns. (Consultoría para los derechos humanos y el desplazamiento , 2008)

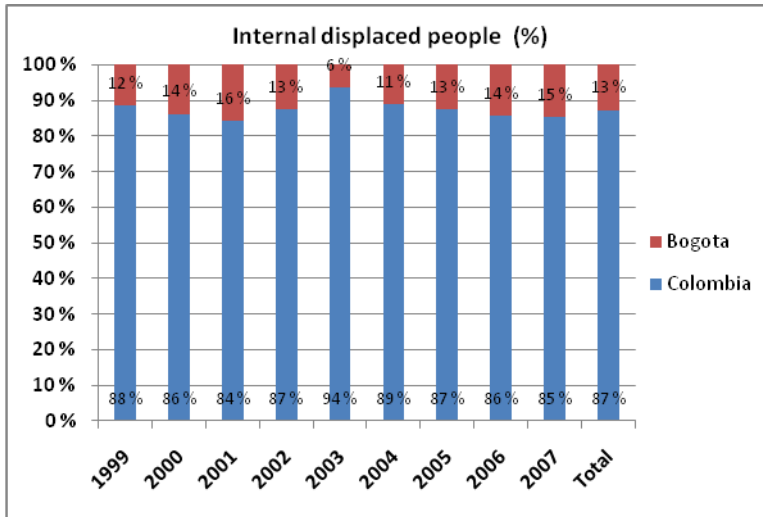


Fig. 9 Rural to Urban migration (%)

The disproportional growth of Bogota's population results in an incapability of the city to integrate and provide with the primary services to the newly arrived. The dynamics of the economy of the city did not managed to generate the necessary jobs to cover the population growth; which results in 11% of unemployment and 30% of informal employment in 2009. (Fig. 10) This situation is reflected in the level of education reached by the people, which attains to a dramatic 1% of graduated students. (Fig. 11) (Departamento Administrativo de Planeación Distrital, 2006)

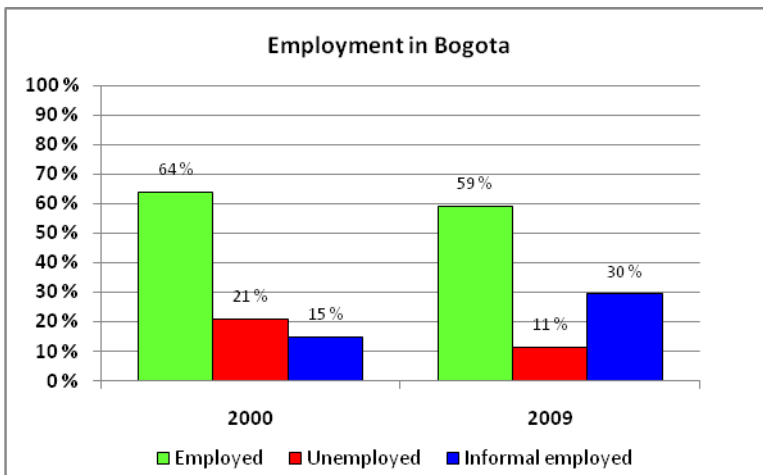


Fig. 10 Employment market in Bogota

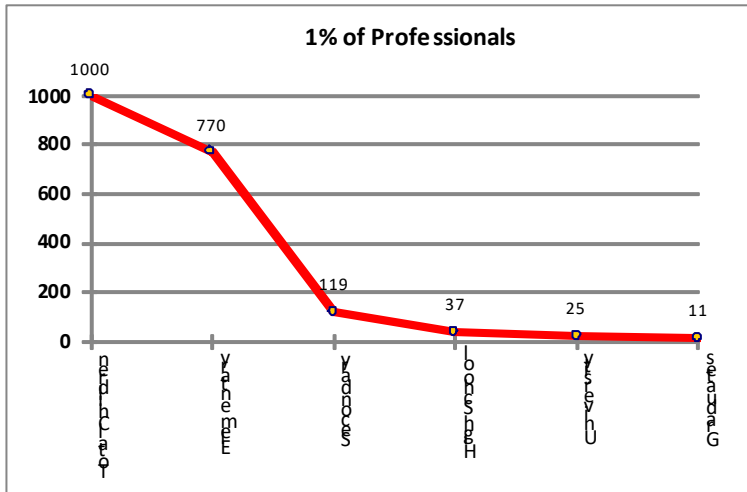


Fig. 11 Education level in Colombia

The socio-economical pyramid of Bogota is a good element to better comprehend the magnitude of the situation. The society is divided in to the following 7 levels or stratums: (Alzate, 2006)(Fig. 12) (Fig. 13)

- 1) Stratum 6: High or rich people were 1,97% of the society in 2003.
- 2) Stratum 5: Medium-high or upper middle class was 2,33% in 2003.
- 3) Stratum 4: Medium or middle class was 5,16% in 2003.
- 4) Stratum 3: Medium-low or lower middle class was 26,62% in 2003.
- 5) Stratum 2: Low or poor people were 34,13% in 2003.
- 6) Stratum 1: low-low or very poor people were 15,25% in 2003.
- 7) Without: Under poverty level or marginalised 14,54% in 2003.

The statistics show that 4,30% of Bogota population is wealthy; 31,78% are middle class and 63,92% are poor or marginalised. In addition, 227.000 homeless IDP live in the capital at the present, and 22% of Bogotá's population (almost 2 million people) (World Bank, 2009) live in informal settlements, virtually slums. It is clear that rural-urban migrants are the most excluded of the urban society and that their migration to the city increased the social problematic. (Fig. 14)(Fig. 15)

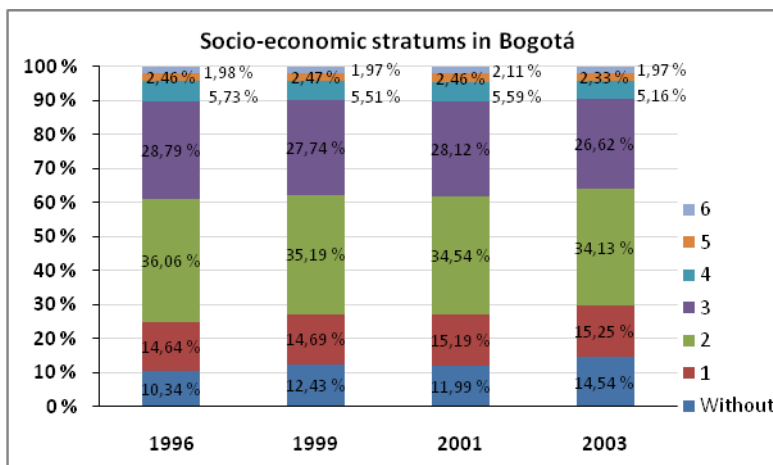


Fig. 12 Social stratification (%)



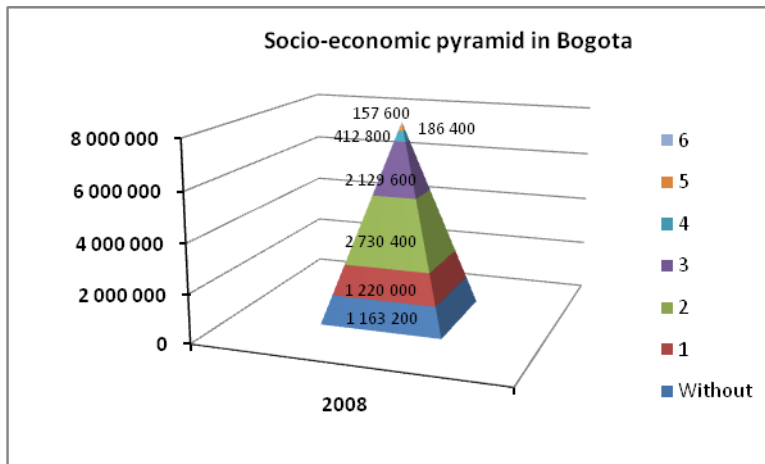


Fig. 13 Social stratification (number people)

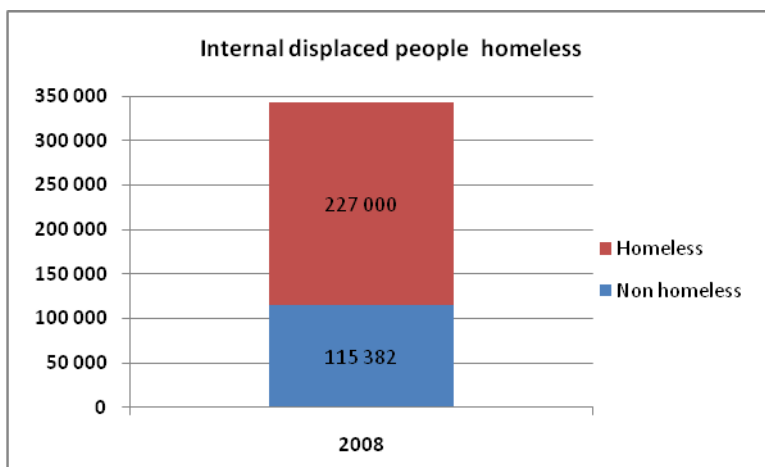


Fig. 14 Internal displaced people homeless in Bogota (number people)

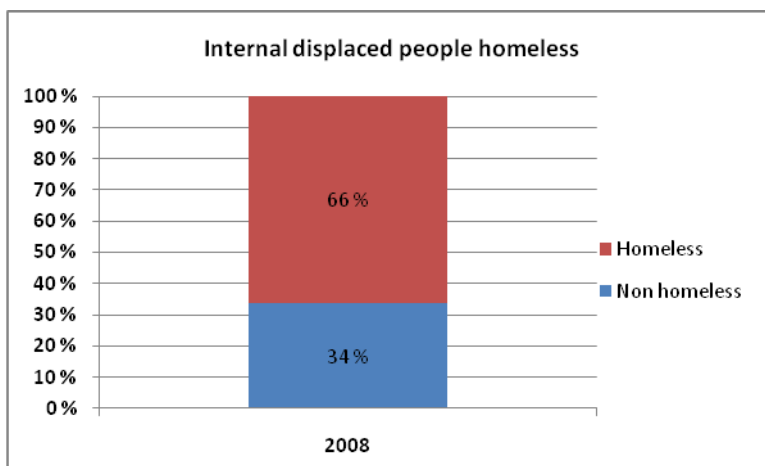


Fig. 15 Internal displaced people homeless in Bogota (%)

The main conclusion of these statistics is that the big cities are not economical, social nor environmentally sustainable; they do not have the capacity to cover the necessities of its inhabitants and they are not coping the expectations, dreams and basic needs of the migrants coming from the rural world. Actually, the former peasants live in worst conditions in the city than in the countryside.

#### **1.4 Challenge: Can small territorial-towns become catalysts for rural sustainability?**

The departing assumption of a small territorial-town is that rural sustainability is a mean to improve the countryman's life, so that the community and its individuals can cope with their expectations and develop their potential, in mutuality with nature today, while protecting biodiversity and endemic ecosystems in order to secure these ideals through time. The main goal is to understand and define: the meaning, scope, dynamics and mechanisms of rural sustainability; comprehended as an economic, social, and environmental concept, applicable to the territorial-town project. Within this area there were met primal challenges to confirm the viability, realism and coherence of the Territorial Town concept. Initially, it had to be demonstrated that rural sustainability is not an utopia, and in which circumstances; that in developed and developing countries it has different needs and approaches; that it is feasible in developing countries; that it is a catalyst that will cover the breach between rich and poor, and city and countryside; that small territorial-towns are an appropriate solution to rural sustainability in developing countries; and finally, that small territorial-towns is a proper concept, and a viable and replicable model in accordance with rural sustainability as defined for developing countries.

#### **1.5 Case Study: Nepal, a rural country.**

Bhishna Nanda Bajracharya shows an interesting case study about the importance of small towns in the development of rural areas. The study is based on Nepal, a country with just 10% of its population living in urban areas. (Bajracharya, 1995) This country has a very strong topography, which fragments the development and the economy in to small clusters, making difficult the exchange of products and condemning the agriculture to subsistence levels. Usually studies on small towns state that their development depends on the agriculture growth of the area; while the new approach is that small towns increase the agriculture production of the area. The first studies are normally on territories with an agriculture production beyond subsistence; and they do not focus on the relationship between the town and its territory, neglecting the connection with villages and farmers in terms of urban services, marketing for agricultural products and generation of urban employment. In the case of Banepa, in Nepal, the town's development is not the consequence of the agriculture production in the territory, but it is due to its strategic location and gateway function for the agriculture production of the territory, in which transportation infrastructure is the key. This town is the exchange centre between its territory and large urban areas, becoming the engine of the agriculture growth of the territory. Small towns work as hinges between the countryside and city; and are the places where famers can trade and transport their products to other regions, while getting agriculture inputs and services coming from large urban areas. But one of the most important functions of the small towns is to generate diversity in activities, creating urban jobs and market

opportunities, and providing urban infrastructure and services to the territory. These elements are the key to make small towns attractive and to become filters to fix to the countryside the potential migrants to the big cities.

In non industrialised economies, the development of the countryside depends on exchange centres, which is the very essence of a town and the historical reason that gave origin to the urban phenomenon. (Annales Economies Sociétés Civilisations, 1970) But the creation of new small towns in developing countries implies a process of decentralisation: political and economical; which could be associated to the Greek "city-state" idea, fused to the medieval European concept of "sobborgo" that is still valid in most of Europe. (Momford, 1964)

## 2. Research

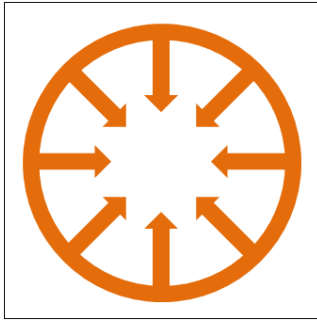
### 2.1 Status

Planning research related to small towns is scarce, the one related to small territorial-towns is very little, and related to sustainable small territorial-towns is basically inexistent. Urban research has been largely approached, in developed countries, from a technological and industrial point of view, with the subsequent solutions. On the other hand, sustainable planning research has concentrated in efficiency, productivity and recomposing of the existing urban tissues, leaving aside the social and environmental issues.

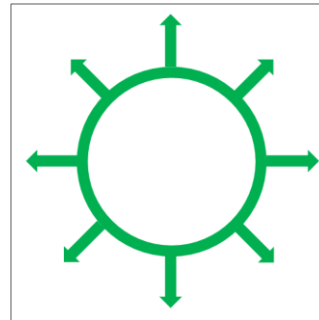
In developing countries the research on small towns is either ignored or approached from a rural to urban, countryside to town, perspective. This approach is based on the premise that small towns are the consequence of the agricultural development of a certain region; which leads to the bottleneck of having a rural productivity increase without having the appropriate infrastructure for exchange. Under this traditional approach the results are often inefficient and poor, from the social and environmental stand.

In both approaches, the industrial urban-centric (Fig. 16) and the agrarian rural-eccentric (Fig. 17), sustainability and small towns tend to be fragmentary and the solutions independent and isolated, focused on punctual issues disconnected one from the other. In the case of the urban-centric approach, the small town is the product of an industrial revolution and evolution. This town has its own socioeconomic dynamics, which has been changing through time according to new technologies and society's needs. This approach is directed to adapt and adjust the old urban fabric to new demands, including environmental ones. On the other hand, the rural-eccentric approach, typical of developing countries, visualises the small town as a spontaneous phenomenon product of a long process of agricultural growth. This type of town becomes a point of commercial exchange deprived of its own dynamics, which depends entirely on the countryside but without developing a symbiotic relationship with the region.

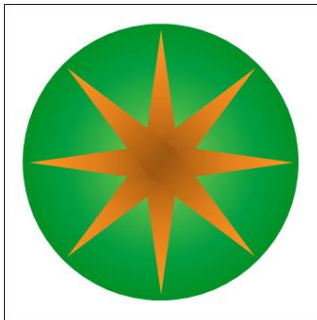
The Ant-hill town project aims to combine the two approaches: the industrial with the agrarian; the economic with the social; and the productive with the environmental. An intra-concentric (Fig. 18) approach is proposed with the territory as a unit interrelated with a “nuclear” town, with new dynamics which provides solutions that could be simultaneously, efficient and affordable, flexible and adaptable to diverse social and environmental contexts.



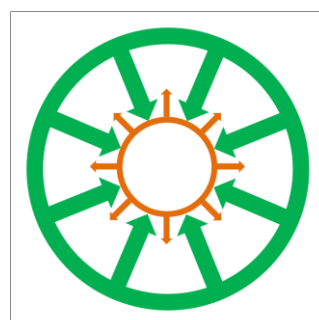
*Fig. 16 Urban-centric approach*



*Fig. 17 Rural-eccentric approach*



*Fig. 18 Intra-concentric approach*



*Fig. 19 Intra-centric town-countryside symbiosis*

This approach develops a symbiosis between town and countryside, in which the town not only generates commercial exchange activities, but it introduces urban activities such as transformation of agrarian products and by-products industries. The town becomes an engine of innovation for the region and its agrarian activities. Like in the case of Banepa, in Nepal, the Ant-hill town will acquire a character and function of gateway, from and to the countryside, and a hinge between the countryside and the big cities.

The Ant-hill town is an innovative concept in regards of the international status on rural sustainability, due to its bioregional approach from a planning perspective. Research is quite limited on this area, especially for developing countries.

## 2.2 Method

The Ant-hill town research is part of a larger one, Human Habitat, that involves the creation of a settlement based on sustainable development principles; which includes planning and architecture research. The whole research is framed under the following international acts as the sources regarding the social, environment, economic, planning and construction guidelines: 1) The Rio Declaration as global principles on sustainable environment. (UN, 1992); 2) The

Agenda 21 as global parameters for sustainable environment. (UN, 1992); 3) The UN Millennium Declaration and its Goals (MDG) as global commitment to social sustainability. (United Nations Development Program, 2000); 4) UN-Habitat as global parameters for urban sustainability. (United Nations Committee on Economic, Social and Cultural Rights., 1996); 5) The Kyoto Protocol as a tool to a proactive approach. (United Nations Framework Convention on Climate Change, 1997)

The Ant-hill research evolved from a large vision to a small focus, from the organ to the cell, (Wallner, 2004) from an abstract to a concrete concept that responds to universalities and adapts to singularities. The starting point was the definition of rural sustainability as a general notion; then it was introduced the specific elements related to developing countries, which conducted to the concept of rural sustainability in developing countries and the rural migration problematic; being rural migration to the cities the fundamental scenario to the Ant-hill town proposition. At this point a premise was stated, that rural sustainability is the result of a synergic dynamics and symbiosis between a territory and an exchange centre, assuming that each one of them must be environmentally sustainable by its own. The conclusive step was the assertion of the territorial town as a punctual concept, accompanied by the formulation of an archetype of bionic, self-sufficient and sustainable countryside for developing countries. Bio-regional planning including the territory, the environment and the migration facts, was the link between the core areas of the rural sustainability concept and the notion of town. Finally, a contextual framework was defined to implement the Ant-hill town model in different environments; which included a scheme to define a real case study scenario, based on the comprehensive background of each particular case.

### **3.2 Approach**

The approach to the research has been from a Bionics (Luxton, 2001) viewpoint, which means analyse nature's best solutions and inspire on their design and processes to solve human problems; in this case to apply those solutions to the territorial and urban planning. In this context the town is compare to an ant-hill, a living and evolving organisation, involving a dynamic exchange process of interacting specialised groups. Meanwhile, the territory is assimilated to the natural surroundings supporting the ants' activities and life; the whole ruled by ecological efficiency, symbiosis and synergy. The town and the countryside interact between them, complementing and supporting each other, creating self-sufficient communities. The town, as an evolving organism, has flexible structural and circulation systems; and efficient respiration, nutrition, energy and waste processes; all of them directed to achieve high interchange and low operating costs.

## **3. Sustainable Small Territorial-Town**

### **3.1 Definition**

Small towns have been defined as nucleated settlements with between 5.000 and 20.000 inhabitants (Hardoy, 1986). However, this definition is closely related to the national context and population; while Latin American and European nations use the relatively low threshold of 2.000-2.500 inhabitants, nations such as India and other Asian countries use higher thresholds of several tens of thousands inhabitants. (Satterthwaite, 2002) A more appropriate approach to small town would be based on its functions, involving the services, facilities and infrastructure provided to its own population and its surrounding territory.

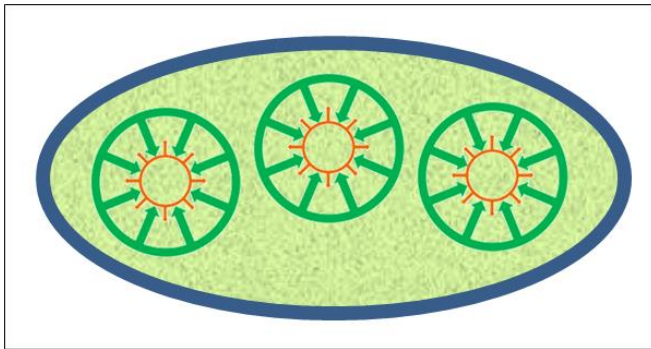
In this framework the main functions of a small town should be: 1) As the centre for the production and distribution of goods and services to its territory; 2) As the market for the agrarian products of its territory. 3) As the pole for the development and consolidation of non-agrarian activities. 4) As the filter for rural migration.

The sustainability of a small territorial town depends on the design of a general platform based on sustainable development principles; but especially, in the adaptation of that platform to the local particularities involving: social, economical and environmental own backgrounds. A key factor to achieve sustainability is to guarantee the access to natural and productive resources to the vast majority of the population of the town and its territory. Finally, the function and character of every single town should be correlated to the territory's carrying capacity, ecosystems and natural resources and vocation. Supplementary to these elements, four strategies should be implemented to facilitate the consolidation and sustainability of small towns: 1) Improvement of exchange and communication infrastructure between the town and its territory, and between the town and other urban centres. 2) Promotion of decentralisation, which makes more efficient and anchored to the local reality the decision processes. 3) Reinforcement of governance and empowerment that promotes democracy and civil society participation, which develop a strong sense of ownership and identity. 4) Promotion of equal opportunities involving access to services, information, education, credit, and resources; while supporting small and medium size local enterprises.

### **3.3 Bioregionalism**

Bioregion is an area with similar topography, climate, biota and human culture; which are frequently organised around watersheds. (Berg, 2002). Bioregional boundaries are organic, and normally differ from political borders such as states, provinces and nations. The ideal is that bioregions are self-sufficient areas in terms of food, products and services, while being environmentally sustainable. (McGinnis, 1999) Therefore, a bioregion is an environmental, social

and economical unit defined by natural, cultural and productive factors, which determine the typology, vocation, function, scale and potential of one or more settlements; determining their sustainability. (Fig. 20)



*Fig. 20 Bioregion scheme*

### **3.4 Territory**

A territory is the surrounding area of a settlement on which its sustainability depends, and the addition of several territories constitutes a region. Socially, a territory is a political unit defined by the human capability and governance of the community; environmentally, the territory is the habitat where all the activities of a community are developed, and it's determined by the carrying capacity (GDRC, 2008) of the ecosystem and the environmental footprint of the community; and economically, it's an efficient entity derived from the relation between the community and the environment, determined by the soil vocation and the productive chain. As shown in equation 1.

In order to better understand the concept of territory and its variables, some equations have been developed, in text and in graphic format; for the graphic format some pictograms have been created with its own meaning. (Fig. 20) Each pictogram can be used separately or in combinations to visualise aspects of environmental, social and economical territoriality. The purpose of the pictograms in equation format is to show that they give a coherent framework to territory.





















	environment	$\Sigma$	summation	-1	contrary	$\lessgtr$	energy
$\rightarrow$	sustained		time	\$	economic		power
$\oplus$	Earth	$\infty$	infinite	$\int$	integrated	e	final
$\varepsilon$	limited	$\neq$	diverse	$\in$	member		work
	load		ecosystem	$\sqsubset$	part hood	l	imaginary
$\Omega$	resistance		society		economy	$\Downarrow$	synergy
	people/human	@	development	$\Pi$	production		symbiosis
	footprint	$\mu$	friction	$\eta$	efficiency		soil
	territory		target		governance		vocation
	chain	$\star^o$	quality		identity		connection
%	rate		countryside				

Fig. 20 Pictograms and meaning used for graphic representation of territory.

$$Tt = (Hc \times Cg) + \frac{Cc}{Hf} + (Sv \times Pc)$$

- by
- $Tt$  = Territory
  - $Hc$  = Human capability
  - $Cg$  = Community governance
  - $Cc$  = Carrying capacity
  - $Hf$  = Human footprint
  - $Sv$  = Soil vocation
  - $Pc$  = Productive chain

$$\text{Territory} = (\text{Human capability}) (\text{Community governance}) + \frac{(\text{Carrying capacity})}{(\text{Human footprint})} + (\text{Soil vocation}) (\text{Productive chain})$$

$$Tt = (Hc \times Cg) + \frac{Cc}{Hf} + (Sv \times Pc)$$

(1) Basic territory equation



### 3.5 Territorial Cohesion

By definition, cohesion is the act or state of sticking together tightly. (Merriam-Webster Online Dictionary, 2009 ) Territorial cohesion, consequently, is the act that keeps together a territory.

For the European Union, territorial cohesion is “The reinforcing power of a territory’s spatial qualities and synergies”; (European Council of Space Planners, 2008) (Vogelij, 2008) and “having a sense of solidarity between different territories and putting this into practice so that no region feels seriously disadvantaged or neglected.” (European Communities, 2008)

Therefore, territorial cohesion has two dimensions, one internal, which is the state of sticking together the social, environmental and economical unit of a settlement and its surrounding area; and one external, which is the consolidation of interests and responsibilities, in the spirit of cooperation, between territories belonging to the same region. In both cases, cohesion is a unifying force to fully develop, in a sustainable way, the potentials of a determined area.

Three components of Territorial Cohesion have been identified: (Camagni, 2002) 1) Territorial Quality: intended economically as innovation, environmentally as natural values, and socially as quality of life. 2) Territorial Efficiency: intended economically as production growth, environmentally as minimal use natural resources, and socially as services and infrastructure accessibility. 3) Territorial Identity: intended economically as specialization, environmentally as landscape entity, and socially as cultural and historical assets.

In order to establish a territorial cohesion there are four key factors to be considered: 1) Synergies: the cooperation between independent elements of the territory to achieve a common goal. 2) Symbiosis: the interactive exchange between independent elements of the territory to improve their functions and results. 3) Connectivity: the capacity to open communication channels between the elements of the territory to create an intranet. 4) Effectiveness: the efficient functioning of the network to potentiate the productivity of the different elements of the territory.

Territorial cohesion can be formulated as the product of the three components multiplied by the four factors. As shown in equation 2.

$$Tc = T(q + e + i)(Sg)(Sb)(C)(E)$$

by	$Tc$	=	Territorial cohesion
	$Tq$	=	Territorial quality
	$Te$	=	Territorial efficiency
	$Ti$	=	Territorial identity
	$Sg$	=	Synergies
	$Sb$	=	Symbiosis
	$C$	=	Connectivity
	$E$	=	Effectiveness

$$\text{⊙} \mu^{-1} = \text{⊙} (\star^{\circ} + \eta + \text{|||||}) (\updownarrow) (\text{↻}) (\text{⚡}) (\text{🎯} \%)$$

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*Territorial cohesion = Territory (Quality + Efficiency + Identity) (Synergy) (Symbiosis) (Connectivity) (Effectiveness)*

(2) Basic territorial cohesion equation

### 3.6 Parameters

The Footprint theory (Wackernagel, 1995) confirms that at the present time the ecological footprint of each person around the globe is bigger than the per capita Earth's carrying capacity. This situation results in an unsustainable current situation of -31% of global environment deficit. An unsustainable environment means not having enough physical support to fulfil man's biological needs; which leads to economic exclusion based on purchasing power principles, deriving in social unsustainability. The combination of these factors is the background of the rural-urban migration and the urban scenario of the big cities in developing countries. A sustainable countryside would balance the urban and agrarian worlds, and stop the migration flux to the cities. To achieve this goal it is necessary to establish strategies to redistribute the population, and to increase the productivity and carrying capacity of the rural areas, which is the cornerstone of rural sustainability.

Following the bionic approach of this research, rural sustainability can fit in the statement that any living organism in nature has its own vital bio-space, with whom it develops an intimate symbiosis, on which depends its survival and the sustainability of the space itself. The inspiring example from nature, in the case of the small territorial town, is the ant; which has the ability to establish several symbiotic associations with different species, including other ant species, other insects, plants, and fungi. The analogy between ants and peasants, and anti-hills and rural settlements is almost inevitable. The ants are very efficient and

laborious farmers that carefully cultivate and fertilise, with its own faecal material, their fungi crops; devoting they entire behaviour and lifecycle to their symbiotic associations. (Martin, 1970) Ants form colonies which sizes vary from a few dozen individuals to millions of individuals, and their organisation can be from very simple to very sophisticated. In any case, each colony occupies a defined territory where they develop their activities; and create a network of food-trails from the ant-hill to the crops in order to secure their provisions. (Oster GF, 1978) On the other hand, the ant-hills are built with the surrounding earth material where the colony is established, emerging from the landscape as part of it.

The relationship between a sustainable small territorial town and its territory is framed within the principles of natural symbiosis, in particular mutualistic symbiosis, including commensalism as a second option but excluding parasitism. Mutualism is a biological interaction between two organisms, where each individual obtains a fitness benefit, which usually increases growth and survivorship to both organisms. (Bronstein, 1994) Mutualism can be figured as a "biological barter", (Ollerton, 2006) in which the organisms trade resources and services; having different combinations of exchange: resources-resources, resources-services and services-services. In nature, mutualism is the key element to reach a climax community, the idealised endpoint of ecological succession. (Cowles, 1899) The climax point is when the community stabilises, attaining a state of equilibrium, which is possible through biodiversity. While biodiversity is the base of an efficient ecosystem or climax community, mutualism is the mechanism or interacting tissue that permits biodiversity to exist. Biodiversity provides scattered organisms that mutualism stick together; nourishing each other in an interdependent existence. (Rose, 1997)

#### **4. Conclusions**

Rural sustainability is not an isolated and spontaneous state resulting from an intrinsic economical agrarian process. Sustainable countryside is the complex of economic, social and environmental interrelations of the rural world that makes it viable, in all its aspects, throughout time. The two traditional approaches, the industrial urban centric vs. the agrarian rural-eccentric, are unidirectional; they ignore the interconnections between the urban and the agrarian worlds, and do not respond to a holistic concept of rural sustainability.

Rural sustainability in developing countries can be achieved through networks of small territorial towns integrated under a bioregional perspective. (Fig. 21) This means that the location, size, character and function of the territorial towns will depend on the vocation, capacity and potential of their surrounding territory. Territorial cohesion, internal and external, should be established from the very beginning of the planning process, in order to activate the symbiosis and synergies necessary to achieve a comprehensive climax community, based on diversity involving the society, the environment and the economy.

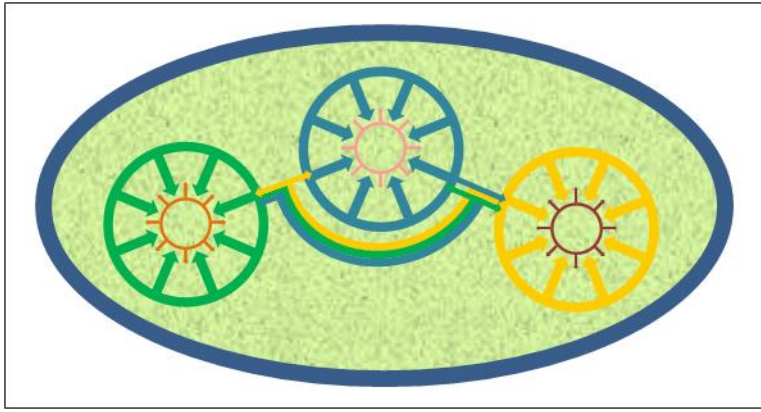


Fig. 21 Rural sustainability network

Rural sustainability can be formulated as the addition of the territories multiplied by territorial cohesion. As shown in equations 3 and 4.

$$Cts_{\infty} = (\sum Tt) (Tc)$$

by  $Cts_{\infty}$  = Countryside sustained infinitely

$\Sigma$  = Summation

$Tt$  = Territory

$Tc$  = Territorial cohesion

$$\text{Icon} \rightarrow \infty = (\sum \text{Gear}) (\text{Gear} \mu^{-1}) \quad \text{©}$$

***Countryside sustained infinitely = (Total Territories) (Territorial Cohesion)***

(3) Basic rural sustainability equation

$$Cts_{\infty} = \sum \left[ (Hc \times Cg) + \frac{Cc}{Hf} + (Sv \times Pc) \right] [T(q + e + i)(Sg)(Sb)(C)(E)]$$

by  $Cts_{\infty}$  = Countryside sustained infinitely

$\Sigma$  = Summation

$Hc$  = Human capability

$Cg$  = Community governance

$Cc$  = Carrying capacity

$Hf$  = Human footprint

$Sv$  = Soil vocation

- $Pc$  = Productive chain
- $Tq$  = Territorial quality
- $Te$  = Territorial efficiency
- $Ti$  = Territorial identity
- $Sg$  = Synergies
- $Sb$  = Symbiosis
- $C$  = Connectivity
- $E$  = Effectiveness

$$\text{⊕} \rightarrow \infty = \Sigma \left[ \left( \text{⊗} \right) \left( \text{⊗} \right) \left( \text{⊗} \right) + \frac{\left( \text{⊕} \right) \left( \text{⊗} \right)}{\left( \text{⊗} \right)} + \left( \text{⊗} \right) \left( \text{⊗} \right) \right] \left[ \left( \text{⊗} \right) \left( \text{★}^\circ + \eta + \text{⊗} \right) \left( \text{⊗} \right) \left( \text{⊗} \right) \left( \text{⊗} \right) \right]$$

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(4) Complex rural sustainability equation

$$\text{Rural Sustainability} = \text{Total} \left[ \left( \text{Human capability} \right) \left( \text{Community governance} \right) + \frac{\left( \text{Carrying capacity} \right)}{\left( \text{Human footprint} \right)} + \left( \text{Soil vocation} \right) \left( \text{Productive chain} \right) \right] \left[ \text{Territory} \left( \text{Quality} + \text{Efficiency} + \text{Identity} \right) \left( \text{Synergy} \right) \left( \text{Symbiosis} \right) \left( \text{Connectivity} \right) \left( \text{Effectiveness} \right) \right]$$

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