

Working Paper Series

17/13

WHY DROUGHTS STARTED TO TURN INTO FAMINES IN THE LATE VICTORIAN PERIODS? A COMPLEX SYSTEM APPROACH

ELENA VALLINO



Why droughts started to turn into famines in the Late Victorian period? A complex system approach.

Elena Vallino*

Abstract

In this article complex system theories are used as interpretation framework for analyzing the strong famines which occurred in the Late Victorian age in many tropical countries. One leading explanation in the literature regarding these famines is that the so-called New Imperialism at the end of the nineteenth century together with the integration of the rural areas of tropical countries into the interconnected world economy led to an increase of the vulnerability of the population in these areas to climatic and economic shocks. This vulnerability converted rapidly the droughts between 1876 and 1902 into massive famines, diseases and starvations. The following questions are posed. Which contribution can complexity theory give to the understanding of these phenomena? If it is easy to conceive the process that leads to famines as complex, I wonder if a complexity approach is appropriate for representing and explaining the causal relations within the system that led to the emergence of famines. The complex system approach is extremely useful for analysing in detail the high degree of unpredictability of the system created by the interaction of phenomena which are very different among them, in nature, time and scale. Moreover, it is effective in analyzing the diversities in scale among causes and effects. However, I find the approach less useful when it is necessary to identify power relations and decision nodes among the elements of the system.

* This paper has been presented at the University of Modena and Reggio Emilia and at the VI Annual Conference of the Italian Association for the History of Political Economy (STOREP), Florence. I would like to thank David Lane and Silvana Dalmazzone for their useful ideas and comments. I am grateful to the STOREP Organizing Committee for the Young Researchers Contribution for the participation to the VI STOREP Conference in Florence, where I received valuable feedbacks to this paper. I appreciated useful remarks by students and Professors at University of Modena and Reggio Emilia, including Sander Van der Leeuw and Andrea Ginzburg. I thank also Edvin Zhllima and Enrico Bertacchini for fruitful discussions at a very early stage of this paper. This paper has been written in the framework of the PhD program in Economics at the University of Torino.

JEL classification: B59, F5, Q18

Key words: complexity theories, famines, Third World, colonialism, vulnerability

1.Introduction

In this work the strong famines which occurred in the Late Victorian age in many tropical countries are analyzed with the contribution given by complex system theories. The interpretation given by many authors regarding these famines is that the integration of the rural areas of tropical countries into the interconnected world economy, together with the so-called New Imperialism at the end of nineteenth century led to an increase of the vulnerability of the population in these areas to climatic and economic shocks (Davis 2002, Fraser 2007, Fraser et al. 2005, Ludden 1994, Bahtia 1963, Post 1974). This vulnerability converted rapidly the droughts between 1876 and 1902 into famines and massive starvations. The following questions are posed. Which contribution can complexity theory give to the understanding of these phenomena? If it is easy to conceive the system of famines as complex, I wonder if this main interpretation fits with a complexity approach in representing and explaining the causal relations of the system he deals with. The paper is organized as follows. First, I will give an overview of the state of food security nowadays. Second, I will present a review of the literature on famines from a socio-economic point of view. Third, I will briefly introduce complex systems theory. Fourth, Late Victorian famines will be described and the underlying dynamics presented. Fifth, I will analyze these famines through the framework of complex system theories.

2. Food security

A look at the data on production and availability of food worldwide offers a useful starting point in reasoning on the phenomena of famines. Regarding the situation of crops, from 1964 to 2004 the total output increased by 144% globally, with an average expansion of 2% per year. In Asia this growth has been even higher, of 3% a year since the 1960s, because of growing affluence, shifting dietary patterns, a growing feed market for livestock and aquaculture. In sub-Saharan Africa, while growth in overall crop output has been relatively high in the past twenty years, export-oriented production of beverage and fibre still represents a consistent share of crop production. This region remains the only area in which per capita food production has not had a continued increase over the period considered and has recently had a decline. This seems to be due to the food crop production growth rate in the African continent, which is lower than its population growth rate. In North Africa and in the Middle East, growth in crop production is moderate and erratic. In Latin America it has been stable over the last forty years, around 2.5%. Many middle-income and richer countries have faced a gradual decrease in the growth rate of crop output, although food intake has reached on average a sufficient level. In transition economies crop output has been stable during the 1980s and fell by 30% between 1990 and 1995 (MEA 2005: 214). The cereal sector is particularly important from several points of view. Cereals provide almost half of the calories consumed directly by human beings. They will remain the foundation of human food supply into the near future because of their high yields, nutrient density, and simplicity of cooking, transport, and storage with respect to other kinds of food. Moreover, cereal production represents almost the 60% the world's harvested crop area (MEA, 2005: 216). Cereal consumption and production patterns are influenced by three major, intertwined dynamics. The first one is an income effect: cereal consumption increases together with incomes as they both grow from low levels, but as incomes keep increasing cereal consumption starts to decrease. After this threshold, people tend to replace cereals with higher-value food. The second force is urbanization, which often brings a shift in diet habits toward wheat and rice from other kinds of cereals like sorghum and millet, and a decrease in the share of cereals in the diet. And the third phenomenon is the increasing role of coarse

grains (maize, sorghum, millet) and wheat as livestock feed. These dynamics, all with various patterns of evolution in different world regions, have led to a “net increase in per capita cereal consumption globally from 135 to 155 kilograms per year between 1961 and 2001, even though cereals now constitute a slightly lower proportion of total energy intake” (MEA 2005: 216).

2.1 Drivers of change in food provision.

Table 1 summarizes the factors that indirectly influence food provision worldwide, divided in factors regarding the demand side and those linked to the supply side. For millennia humans have transformed natural ecosystems in order to create the conditions for having access to reliable food to meet growing demands. Therefore, changes in food demands are tightly linked to drivers of food provision. The link between food consumption and ecosystem stress is different in different parts of the world. In subsistence-oriented food production systems there is strong geographical coincidence of food consumption and ecosystem stress. In the globalized commodity trade and food industry sectors, the influence of food production, which is consumption-driven, on ecosystems might be “several continents or oceans removed from the sites where consumption takes place” (MEA 2005: 222).

Among these direct and indirect factors influencing food availability I briefly underline the climatic issue, since later I will show the critical role that climate has into the emergence of famines phenomena. Although there is a wide literature on the potential impacts of long-term climate trends on food production (Rosenzweig and Parry 1996; Sombroek and Gommers 1996; Parry et al. 2004), clear evidence on this causal relation is relatively sparse. Although climate is a fundamental uncontrollable factor influencing crop production (in particular in regions of rain-fed agriculture), it is extremely complicated to isolate the influence of climate from other factors such as human intervention, the use of irrigation, fertilizer, pesticides, crop and land management, and the kind of seeds used (MEA 2005: 228). Besides standard climate indicators, like for example the rainfall rate, also global cyclical weather patterns strongly influence food production. This includes especially the El Niño-Southern Oscillation and the North Atlantic Oscillation. Several authors found evidence on the impact of these two

phenomena. A negative Southern Oscillation Index can result in a corn output that is 10% above the average line in the North American Corn Belt states (Carlson et al. 1996). Climate variability deriving from ENSO has been found to have significant impact on cereal yield in Indonesia (Naylor et al. 2002). The North Atlantic Oscillation apparently significantly correlates to crop productivity in northern Asia, with a very long lag time of one-and-a-half years (Wang and You 2004).

Table 1. Indirect drivers of food provision (MEA 2005: 223).

Drivers		Past 50 Years		Current Trends		Remarks/Examples
		Change	Relevance of Driver	Change	Relevance of Driver	
Demand factors						
Population growth and structure	In	+ / ++	med	- / +	low / med	Europe static/shrinking; North America still growing East Asia slow; SSA, WANA, SA highest growth rates
	Dg	+++	high	+ / +++	med / v. high	
Urbanization	In	++	med	- / +	low	70–80% urbanized 40% urbanized, 3%/yr growth, 80% of global urban total
	Dg	+++	med	+++ / +++	med / high	
Income growth	In	++	med / high	++	med / high	slow to medium long-term growth some negative, esp. SSA; strong growth: East Asia
	Dg	+ / +++	high	- / +++	high	
Food prices	In	--	med	- / o	low / med	well-integrated markets, productivity growth weaker markets, lower productivity growth
	Dg	-	high	- / +	med / high	
Food marketing: branding and advertising	In	++	med	+++	med	major diet changes are through switching brands/product less in poor rural areas, but increasing, e.g., radio, tv
	Dg	+	low	+ / +++	med	
Diet and health information	In	++	med	+++ / +++	med / high	increased information on the healthfulness or otherwise related to specific food types or food processing
	Dg	o / +	low	+ / ++	med	
Consumer concerns with production context	In	x	low	xx	low / med	concerns with environmental, food safety, child labor, equity, GMOs, animal welfare, etc. issues
	Dg	o / x	low	o / x	low	
Dietary (and lifestyle) preferences	In	o / x	low / med	o / x	low / med	largely consequence of marketing, diet, and health info largely consequence of urbanization and income growth
	Dg	x / xxx	med / high	xx	med / high	
Consumer demands for minimum produce grades, standards, labels	In	++	med / high	+++	high / v. high	most producers conform; contract farming on the rise major challenge to poor smallholders
	Dg	o / +	low	o / +++	med / v. high	
Supply factors						
Investments in infrastructure and institutions	In	++	med	+	med	industrial countries maintained investments in high stock developing countries often underinvesting in low stock
	Dg	- / +	high	- / +	very high	
Investments in science and technology	In	++	high	+ / ++	high	biotechnology: increasing, conventional: stable/decline widening gap between industrial and developing R&D
	Dg	o / +	high	- / +	very high	
Domestic price policies (e.g., producer subsidies, price controls)	In	++	med / high	+	med	powerful farm lobbies resist support reduction policies often favor urban consumer
	Dg	++	med / high	++	very high	
International trade regimes and regulations (e.g., WTO)	In	+	med	++	med	limited incentives for industrial-country concessions growing incentives developing countries to seek change
	Dg	o / +	low / med	+ / ++	high	
Regulatory environment for production practices	In	+	med	++	med / high	regulatory pressures on effluents, animal welfare, etc. less regulation/enforcement
	Dg	o / +	low	+ / ++	med	
Food industry integration and food retailing practices	In	+++	med	+ / ++	med	increased attention to on-farm standards and food safety increased incentives for smallholder collective marketing
	Dg	o / +	med	+ / ++	high	
Prices of produce and inputs	C/W	- - / +	high	o / ++	med / high	prices increasing with scarcity of wild food sources real prices declining; raise productivity to compete
	In/Dg	- / -	high	- / -	high / v. high	
Access to information, technology and credit, markets	In	++	high	++	very high	growing ICT role; weather/price forecasts, credit credit is a major constraint; ICT role growing fast
	Dg	o / +	high	+ / ++	very high	
Level of market access/integration	In	++	high / v. high	+	high	more mature and integrated; lower transactions costs often poor infrastructure, institutions; high costs
	Dg	- / +	high	- / ++	very high	
Insecurity and instability	In	o	very low	o	very low	not a significant issue; FSU a possible exception locally critical loss of assets, resources
	Dg	- / +	v. high (loc)	- / ++	v. high (loc)	

Key:

In – industrial-country grouping; Dg – developing-country grouping

Increases: + low; ++ medium; +++ high; decreases: – low, – – medium, – – – high; – / + indicates a range from – – to +

Change (no sign): x low, xx medium, xxx high, o no change.

C/W: cultivated/wild

ICT: information and communication technologies

Table 2. Direct drivers of food provision (MEA 2005: 224).

Drivers		Past 50 Years		Current Trends		Remarks/Examples
		Change	Relevance of Driver	Change	Relevance of Driver	
Increasing climate variability and long-term climate change	In	+	low	+	low/med	current and projected changes often low/positive apparent increases in variability/extremes; high/neg
	Dg	++	low/med	++	med/high	
Area expansion of cropland, pasture, fishing grounds	In	+	low/med	-/+	low	little available unexploited area; some are in decline forest/habitat loss, urban growth loss
	Dg	++	med/high	+/+	lmed/high	
Intensification of production (e.g., seeds, irrigation, fertilizers)	In	+++	med/high	++	med	main source of growth in food output mixed; sustainable increases critical for SSA
	Dg	+/+	high	+/+	very high	
Degradation of underpinning resource stocks	In	++	med	0/+	med	overfishing of marine fisheries; agrobiodiversity loss major impact on soil degradation, wild food sources
	Dg	---/+	very high	---/+	very high	
Pest and disease incidence and adaptation	In	0/+	med/high	-/+	med	extensive (regulated) pesticide use; GM crops (US) greater pressures, less regulation; IPM increasing
	Dg	0/++	high	0/++	high	

Key:

In – industrial-country grouping; Dg – developing-country grouping.

Increases: + low, ++ medium, +++ high; decreases: – low, -- medium, --- high; - /+ indicates a range from – to +

No change: 0

2.2 Distributional dimensions

In poor countries, most of which have a large share of agriculture in the economy and a high proportion of rural population, food production has influential distributional impacts in terms of income and of health inequalities. The importance and pattern of these impacts depend on several factors: the growth rate of agricultural and food production across regions and types of crops, the share of agriculture in the economy, the proportion of rural population, land and asset distribution, infrastructure in rural areas, the functioning of markets, availability of agricultural inputs and credit in remote areas, and research and extension services. In turn, all these factors have of course a decisive impact on food productivity. The results of these mutual causal relations is the persistent food distribution inequalities despite the global increasing trend of food production per capita. Increased local food production remains crucial to reducing poverty and creating the conditions for food security.

In general, research on the experience of the last few decades shows interesting relations. The higher the agricultural output, the more equal the land distribution, the more effective the

small farmer's access to inputs and markets, the more positive is the impact on income and consumption distribution, poverty reduction, and food security for the poor (MEA 2005: 238).

2.3 Food provision and human well being

There are several attributes of food that have a major impact on human well being: quantity, price, diversity, quality, and safety. The actual impact of food depends on local food availability and the ability of people to obtain access to it and suitably consume it. The dimensions of food availability, access, and utilization compose the notion of food security, defined as "access by all people at all times to enough food for an active, healthy life" (Reutlinger and van Holst Pellekan 1986). For the poor, food prices, together with the access to wild sources of food, are crucial in determining the real value of incomes; for such people the relationship between wage rates and food prices is a key determinant of well-being and safety. It is established that a productive food and agricultural sector decisively contributes to economic growth (Mellor 1995; Hazell and Ramasamy 1991).

2.4 Undernutrition

Some information about undernutrition worldwide is also relevant for this work. Undernutrition can be broadly categorized into protein energy undernutrition, which represents the result of a diet lacking enough protein and calorie sources, and specific micronutrient deficiencies (Habicht 1992). FAO estimates that 852 million people worldwide lacked enough food to meet their basic daily energy needs in 2000-02. 9 million are in industrial countries, 28 million in transition countries, and 815 million in developing countries (FAO 2004a). In Asia and the Pacific, and in sub-Saharan Africa, live about 60% and 24% respectively of the global total of undernourished people (FAO 2004a). The latest hunger estimates signal a disappointing reversal of trends reported since the 1970s of a gradual decline in both hunger incidence and the absolute number of hungry people. Between the 1970s and the 1990s the absolute number of undernourished people in developing countries had fallen from around 959 million to 780 million people. During the period 1995-97 to 2000-02, however, the number of hungry increased by some 18 million people to a total of 815

million. The progress in hunger reduction in the early 1990s occurred predominantly in China and India. But in the second half of the decade, progress in China reduced and in India inverted, while in the Near East and Central Africa the numbers of hungry increased throughout the 1990s (Wang and Taniguchi 2003).

The Millennium Ecosystem Assessment (2005: 211) summarizes key issues regarding trends of food production and consumption worldwide. First, although food production per capita has been increasing globally, major distributional inequalities exist. Second, local food production is fundamental for alleviating food insecurity and promoting rural development in areas where the poor do not have the possibility to purchase food from the market. Third, government policies are important drivers of food production and consumption patterns, both at a local and at a global scale. Investments in rural roads, credit systems, irrigation and agricultural research and extension are critical to stimulate food production. Access to input and export markets improves productivity. Possibilities of access to international markets are conditioned by international trade and food safety regulations and moreover by tariff and non-tariff barriers. Selective production and export subsidies stimulate overproduction of many food crops. This in turn leads to relatively cheap food exports which is in favour of international consumers at the expense of domestic taxpayers and has often disturbed the ability of food producers in many poorer countries to enter international food markets (MEA 2005: 211).

3. Famines theories: a review

We now turn to a quick review of theories about the causes of famines. The concept of famine is defined in different ways in the literature, depending on which factor is considered crucial for its inception. According to climate theories and to demographic theories, a famine is a food shortage leading to widespread death by starvation. Climate theories state that natural disasters, like floods or droughts, or processes of climate change, trigger famines because they lead to diminished crops or to damaged assets, like livestock, and consequently to food prices increases. Murton (1984) reports many studies following this approach. Demographic theories refer to the Malthusian approach: population increases indefinitely, but land is strictly limited. Consequently, the demand for food will eventually exceed potential food production and, in the long term, famine acts as a “natural check” on population growth. Both

theories identify the so called “food availability decline” (FAD) as the primary cause of famines and starvation, seeing either crops decline or population growth as causes of FAD (Bowbrick 1986). This school of thought received many critiques for different reasons. First, Malthus failed to foresee the agriculture, the industrial and the transport revolutions, as well as the demographic transition (Devereux 1993). Second, the theory does not address the issue of vulnerability – which categories of people are more likely to be affected by the famine (Watts and Bohle 1993). Third, it does not explain famines that actually occurred without food shortage. In the 1980’s, the Nobel Amartya Sen introduced the entitlement approach, which became very popular in the literature and strengthened the idea that famines are human made and not nature made. In his popular book *Poverty and famine* (1981), Sen affirms that “starvation is the characteristic of some people not having enough food to eat. It is not the characteristic of there being not enough food to eat” (p. 1) and that “a person's ability to command food — indeed, to command any commodity he wishes to acquire or retain — depends on the entitlement relations that govern possession and use in that society. It depends on what he owns, what exchange possibilities are offered to him, what is given to him free, and what is taken away from him” (p. 54). Therefore, we identify four types of entitlements: production-based, trade-based, own-labour based and transfer-based. In Sen’s view the crisis of exchange of these attributions leads to famines, rather than merely the decline of food supply. This approach received a lot of appreciation (Desai 1988, Watts 1983, Arnold 1988, Bebbington 1999) but generated also high-pitched debates (Sen 1986, Bowbrick 1986, Allen 1986). Devereux (2001) highlights some of the main limitations emerging in Sen’s approach. The following issues needs further explanation than the sole entitlement theory: starvation by choice, disease-driven rather than starvation-driven mortality, ambiguities in entitlement specification and extra-legal entitlement transfers. Sen’s methodological individualism privileges economic aspects of famines, above socio-political determinants. Further analysis must acknowledge the importance of non-market institutions in determining entitlements, famines as a social process (as a *sequence* of failures of different kinds of entitlements) and epidemiological crisis, and violations of entitlement rules in the complex emergencies that typify famines. Complex emergencies consist in a vicious mixture of different elements, such as decline in food production, destruction or appropriation of food stocks, fragmentation of local trade and of the local economy, destabilization of the community strategies for coping with food decline, interruption of government services, creation of refugees (Devereux 2001, Chakrabarti 2004, Albala-Bertrand 2000, de Waal 1990,

Duffield 1994). Watts and Bohle (1993) highlight as well the necessity to take into account the structural properties of the political economy that trigger entitlement crises. Relatively new directions in famine thinking explain the phenomenon with the lack of an “anti-famine” social contract. Various authors compare India and Africa, highlighting that the unique history of India led nowadays to the consideration of famine prevention as a right, upon which political legitimacy is founded (Drèze and Sen 1991). On the contrary, freedom from famine never became a right in Africa, where public anti-famine systems raised and declined, fluctuating together with the domestic political accountability towards famine prevention. This explains why famines have disappeared from contemporary India but not from Africa (de Waal 2007, Devereux 2009).

The school of the political ecology is also relevant for the aim of understanding famines. This stream of thoughts analyzes the political and economic structure of a society, which makes certain groups of people more vulnerable than others to environmental shocks (Fraser et al. 2005). Vulnerability is thus defined as “the state of individuals, groups or communities in terms of their ability to cope with and adapt to any external stress placed on their livelihoods and well-being. It is determined by the availability of resources and, crucially, by the entitlement of individuals and groups to call on these resources”(Davis 2002: 30).²

4.The complex system approach

One of the traditional definitions of complex systems is a system which can not be decomposed and linearly re-composed (Terna et al. 2006: 20).³ A more articulate definition explains that a complex system⁴ is composed by heterogeneous agents interacting with each

² For a classification of vulnerability definitions and theories see Füssel (2007).

³In the explanation of the concept of complex system I will follow mainly, but not only, the approach of the Santa Fe Institute, New Mexico, USA (Anderson 1988).

⁴ “A ‘system’ may be defined as a set of components which interact much more with each other than with their ‘neighbours’, whether by human design or natural happenstance. A system also includes boundaries and one or more processes by which the components [a] interact with each other, [b] interact with neighbours and [c] transform inputs into outputs. Each process typically leaves one or more ‘tracks in the sands of time’ (orbits, time series, trajectories.) Systems may be dynamical: state space and position of the system in that space change with time. If they are dynamical, they may be sporadic (earthquake), unimodal (pendulum) or multimodal (chaotic, random or complex). They are chameleon: the track of one may imitate at least one of the behaviour patterns generated by another” (Smith 2007: 153).

other with different non linear dynamics, generating at least one output. The action of the constituent agents – which operate and interact individually, following simple communication and coordination rules – produces aggregate effects which are far from the simple sum of individual behaviours. An immediate example is that of ants and their anthill (Smith 2007, Terna et al. 2006).

It is interesting to distinguish complex systems from complicated ones. A complicated system can be deconstructed and re-constructed. We are able to understand precisely how it works and how each sub-part intervenes in the whole system. If one part does not work anymore, this may affect the functioning of the whole system. One example is the internal combustion engine. In the case of a complex system, the exact functioning is difficult to understand. The investigation of its isolated parts tells us less about the role of each of them and about the mechanic of the system. The system is robust to the malfunctioning of some of its part. In order to understand the whole, it is necessary to study simultaneously the components and the deriving aggregate system. The level of predictability gets lower as we run more detailed analysis (Terna 2006: 24).

In complex systems, entities exist at different levels. Each level has a spatio-temporal scale. The magnitude of the scale increases as we ascend to higher levels. Each entity interacts directly with entities at the same level, and indirectly, through processes of upward and downward causation, with the levels immediately above and below its own. However, any level could be considered “autonomous”. According to Simon (1969), it is possible to study processes at each level in isolation. Processes at higher level are sufficiently slow that they can be considered as constant, while lower level processes are so fast in comparison that they “reach equilibrium”. Levels tend to cluster into weakly interacting sub-systems. The sub-systems interact with one other on an input-output basis, so their internal structure and dynamics can change, without inducing system-wide cascades of change as long as they remain functionally equivalent – that is, able to produce the same output from the same set of inputs (Lane 2006).

According to many authors, what distinguishes complexity from any environment with some interdependence is the presence of the following aggregate properties.

(a) Emergent properties. These properties of a system exist at a higher level of aggregation than the original description of a system. By this definition, ice is an emergent property of water. The property of being ice describes how water molecules are collectively aligned, not one molecule in isolation. Holland (1988) speaks about emergence as persistent aggregate- or global-level regularities displayed by “interesting” systems generated by simple rules. Anderson (1988) explains that, through the mechanism of emergence, quantitative change (more entities) becomes qualitative, like water which becomes steam after the achievement of the boiling temperature. The new organizations present “rigidities”, in the sense that for the entities of the system it is energetically more favourable to maintain certain fixed relationships with each other, and the body tends to respond as a whole to external forces. Because of this rigidity, the whole becomes not only more, but very different from the sum of its parts (Lane 2006). Adam Smith’s “invisible hand” is a classic example of an emergent property, including those frequent cases where a market does not meet standards for equilibrium and Pareto optimality (Smith 2007). Different patterns of social behaviour may arise as side-effects from interaction with the physical or social environment instead of arising from specific behavioural rules (Hemelrijk 2002, Terna 2002).

(b) Path dependence. Complex systems have irreversible histories. Both in natural and in social phenomena, each event is the unique product of entities’ actions under given time and space (Fontana 2010).

(c) Self-reinforcement. The same elements are both cause and effect and there may be no distinction between induction and deduction. We find processes of cumulative causation and mutual causality such as virtuous and vicious circles (Arthur 1988: 10). Positive, reinforcing feedback drives change, while negative, balancing feedback maintains stability in a system (Mitleton-Kerry 2003).

(d) The butterfly effect. The connection between the dimensions of an event and the magnitude of its consequences is not mechanical and regular. A shock at one point in time affects the long-run state of the system (Ormerod 2003, Durlauf 2005).

(e) A complex system is likely to spend more time out of equilibrium than in it or near it. As a result, multiple equilibria or none at all are possible (Smith 2007).

(f) Connectivity and Interdependence: Complex behavior arises from the interrelationships, interactions, and inter-connectivity of elements with a system and between a system and its environment (Mitleton-Kelly 2003).

(g) Universality. A property is universal if its presence is robust to alternative specifications of the microstructure of the system. In physics, magnetisation is universal in the sense that its presence in iron occurs for a range of different specifications of the interdependence of spins between individual atoms (Durlauf 2005).

(h) As a result of the above, it is impossible to predict the immediate future. However we can see some autoregulation of the system in the long run (Ormerod 2003).

Theories of complex systems have been applied to economics for fifteen years, in order to address questions such as (Anderson 1988):

- Economic development as a complex system, as a pattern problem. Are there many equivalent states? Can one model the diffusion of development as a reaction-diffusion front? Is political input a damping /enhancing factor in development?
- Regional economies differences: is there a tendency to polarization?
- Possibilities of lock-in: is it possible that policies or spontaneous actions of the economic system for removing harmful lock-in?
- The global economy and links among nations as well as over time. Monetary and real magnitudes in international flows. Changes in regime (gold standard, fixed exchange rates, floating rates, emergence of business cycles).
- Why increasing returns occur (traditional theory assumes diminishing returns on the margin)?

Holland (1988) makes some interesting considerations about the linkages between the global economy and complex systems, which will turn out to be useful for this work. The overall direction of the global economy is determined by the interaction of many dispersed units acting in parallel. The action of any given unit depends upon the state and actions of a limited number of other units. There are rarely any global controls on interactions, but only competitions and coordination between units. The economy has many levels of organization and interaction. The overall organization is more than hierarchical, with all sorts of tangling

interactions (associations, channels of communication) across levels. The system adapts: the building blocks are recombined continually after the system accumulates experience.

5. Late Victorian famines

I chose to concentrate on the famines that occurred in this particular historical period because they have been the first which have been extensively documented and because their occurrence coincides with the emergence of the so-called Third World, bringing a reorganization of the world economy and politics. "(...) what marks the famines during Queen Victoria's reign as different from ones in previous generations is that these droughts occurred at a period of massive economic transformation. In the process of colonizing remote area, the European empires hurt traditional communities and damaged traditional ways of coping with environmental irregularities. So, even though the famines were triggered by highly irregular weather patterns, social and economic forces seem to have played a role in creating situations especially vulnerable to weather related shocks" (Fraser 2007: 502).

5.1 The facts

From 1876 to 1879 the lack of monsoons in Asia causes a tremendous drought, which has a deep impact on the rural society (Billig 1992). The same happens also in Brazil as well in southern and northern Africa and in northern China. Up to that time, nobody would have thought that extreme climatic phenomena could be simultaneous in the whole area of tropical monsoons, in northern China and Africa. Moreover, before this date, famines in such remote zones of the globe had never been extensively documented (Davis 2002: 11). Between 1889 and 1891 monsoons lack again in India, Russia, Brazil, Korea, Ethiopia and Sudan: drought, food shortages and epidemic diseases kill almost one third of the population of these countries (Grove 1989). The same patterns repeat between 1896 and 1902, after a period of good precipitations and crops. Summing together the three events, it has been calculated that from 31.7 to 61.3 millions people died. Such huge disaster is comparable only to the Tai Ping riot in China (1851-64) in terms of loss of human lives (idib.: 17). This constitutes one of the "darkest secrets" (ibid.: 17) of the Victorian Age.

5.2 An interpretation of Late Victorian famines.

Different authors interpret Late Victorian famines in the following way: the integration of the rural areas of such remote countries into the interconnected economic world together with the so-called New Imperialism lead to an increase in the vulnerability of the local population to climatic and economic shocks (Davis 2002, Fraser 2007, Fraser et al. 2005, Ludden 1994, Bahtia 1963, Post 1974). This vulnerability converts rapidly the droughts into famines and massive starvations. Davis (2002: 316) states: "I argue that *ecological poverty* — defined as the depletion or loss of entitlement to the natural resource base of traditional agriculture — constituted a causal triangle with increasing *household poverty* and *state decapitation* in explaining both the emergence of a 'third-world' and its vulnerability to extreme climate events". Consequently, what we call today Third World is the result of imbalances of income and wealth, which emerge during the last quarter of the nineteenth century, when the extra-European rural masses have been employed in the world economy.

The colonialist transformation of local production systems modifies the way in which the climatic factors exercise their influence. The famines are seen as "engines of historical transformation" (Arnold 1988, quoted by Davis 2002: 25). They have been the genesis and the accelerators of the same socio-economic forces that favoured their existence. Hence, the general tendency to pauperization increases the vulnerability to droughts, which in turn of course facilitates the pauperization.

The enhanced vulnerability has been the result of the peculiar interaction among three "gears" (ibid.: 22) and each of them is in turn the result of the interaction of many factors. Firstly, the climate has extreme behaviours in 1876-79, 1889-91, 1896-1902, with strong droughts or floods in many different tropical countries. In the 1960's the ENSO (*El Niño-Southern Oscillation*) has been explained. The Pacific Ocean at the Equator is able to influence the precipitations of the whole tropical area of the world and to some extent even the rains in the temperate areas. When it rapidly warms (*El Niño* phenomenon) there are weak monsoons and simultaneous droughts in large areas of Asia, Africa and Latin America. When the equatorial Pacific is unusually cold (*La Niña* phenomenon), in these regions we find anomalous precipitations and floods. These regions of the world are called teleconnected (Davis 2002).

Secondly, the integration of rural areas of Asia, Africa and Latin America into the world economy has unexpected consequences. Until 1870's, these areas were not sufficiently integrated in the world economy to give or receive repercussions to or from the rest of the world. From the 1870's, many factors contribute to the augmented vulnerability of rural population in tropical countries, "decide who had to die" (ibid: 25) and shape the "political ecology of hunger" (Watts 1983, quoted by Davis 2002: 285). There are short term factors, such as the end of the boom of the cotton and the world-wide trade recession, and long term factors: the expansion of cash crops and the decline of the food crops, the consequences of colonial settlements, the new Gold Standard, the decline of traditional irrigation systems, the informal colonialism, like the case of Brazil.

Thirdly, the New Imperialism. Every global drought has been a 'green traffic light' for new colonial expansions.⁵

The results of the interaction among these three factors are new vicious circles. The international market of cereals intertwines climatic perturbations with prices turbulences. "Suddenly the value of wheat in Liverpool and the precipitations in Madras became variables of the same colossal equation of human surviving" (Ibid.: 22).

It is important to notice that famines and starvation increase in a precise historic period (1870-1914) in countries which are not marginalized, but well integrated and fundamental for the world politics and economy gravitating around London. Such a high number of rural people died during the golden age of liberal capitalism, and for reasons that contradict the classical economic theories of the nineteenth century, like, for example, that of the gains from trade.

Critical factors for the spread of famines in those tropical countries has been the free market of wheat and the fall of local households' incomes. Karl Polanyi (1944: 159-60, quoted by Davis 2002: 19) adds as important reason the "cultural degeneration": the destruction of socio-economic structures of communities at village levels. All these elements are strictly linked to colonialist policies. However, while Polanyi describes free markets as something that spontaneously emerges, Davis (2002) argues that markets are always intentionally created by some precise agents, and therefore they have also a political history, beside the pure economic one. The use of the direct or indirect violence plays then a very central role in the determination of economic and social performance of "markets".

⁵ For example, Great Britain in southern Africa in 1877, Italy in Ethiopia in 1889-91, Germany in northern China and USA in the Philippines at the end of the 1890's.

5.3 Some definitions

Drought is defined as the interaction between the variability of precipitations (meteorological drought) and the hydraulic defences of the agricultural sector (hydrological drought) (Davis 2002). The first is the percentage deficit of rains relatively to the yearly average for a given geographical area. However, for agriculture the distribution of rains over longer cycles is much more important than the total quantity of precipitations in a given period. Therefore, a meteorological drought alone is not automatically source of bad crops or food shortage. The hydrological drought is referred to natural (rivers, lakes, water-bearing strata) and artificial (channels, wells, irrigation systems) water tanks. They are often independent from the local climate. For instance, in northern India, the rivers are refilled by very far glaciers, which may not be affected by a drought occurring along some parts of the rivers' course. Moreover, the hydrological drought has always a social history. Artificial irrigations systems depends on human investments. Natural ones are affected by human practices, such as deforestation and overexploitation of the land.

Famine has a more articulate definition: it is the non-linear interaction among social factors that leads from drought and lack of crops to famines and determines which parts of the society will suffer in case of famines (Davis 2002). Sen (1984) and Desai (1988) argue that famines represent a crisis of exchange attributions, which are defined as legal rights which are economically effective and which allow the access to the crucial resources for the control of the food. Such a crisis may be independent from the quantity of the crop and may be originated by different factors – climate, economic depressions, conflicts, even development policies – or, more probably, by the convergence of many of them together.

Regarding the magnitude, or even the existence of a famine, we can again observe different approaches. The Malthusian definition of famine would be “massive starvation”. The African definition conceives famine as starvation together with poverty, diseases, social collapse (De Waal 1989). The British authorities already in 1866 wrote that mortality caused by hunger and that caused by disease are not epistemologically differentiable (Davis 2002: 31). Moreover, an initial malnutrition and deficit in the immune system increase mortality derived from both hunger and diseases. In addition, refugees' camps increase infections and contagion. Finally, in India a peculiar mix of modernity (transport of persons and of food commodities with railways which had been recently introduced) and underdevelopment

(poverty, malnutrition, basically bad health conditions) may have led to a higher mortality than what would have occurred otherwise.

6. Why and how rural people became vulnerable to shocks

Before explaining how the whole famine phenomena could be regarded as a complex system, it is interesting to explain how each of the three mechanisms which led to higher vulnerability is complex in itself.

6.1 The ENSO

The 1960s' scientific explanations of the ENSO (*El Niño Southern Oscillation*) cycles raised hopes that these cycles could become predictable. However, later on it has been discovered that final climatic outcomes depend on the interaction of the ENSO with other independent climatic variables (circulation regimes and periodic variables). The result is a system which has all the characteristics of complexity. The causal direction of such interactions is not unique. The pattern of interaction is each time particular and may amplify or diminish the ENSO intensity. Feedback processes bring the system towards the extremes. The ENSO and the other variables have very different time scales. All this brings to high unpredictability, leading to the conclusion that a human society should prevent the impact of climatic shocks and invest in food security. According to some authors, this has been done by pre-colonial States, but it has not been done by colonial authorities (India, Africa) or by modern States after the globalization of the world economy (Brazil) in the late Victorian Period (Davis 2002, Fraser 2007, Fraser et al. 2005). Clues of ENSO presence in our period of interest are well evident in all tropical states (Davis 2002: 249-74). Thus, climatic shocks occurred, but they have not been the only source of famines. Their interaction with other two mechanisms gave this outcome.

6.2 The world economy

In the late Victorian period we find patterns of development that lead to the emergence of industrialized countries and to the decline of those tropical countries, which will be called “Third World”. Some advanced economies of 1700, as China and India, have not been able to adapt their economic structure and manufactures to the new conditions of production and competition in 1800.

This can be seen as one emergent property at the world economy level of that period.

One traditional explanation of this fact is the “Malthusian” overpopulation and the “chains of the tradition” in such countries which hampered productivity and output growth. However, there are reasons to think that there are other important factors concurring to this result. First, of course, war and colonials occupancies. Second, trade policies explicitly conducted in favour of leading countries. In the second half of 1800 Great Britain faces economic imbalances due to a fall in productivity growth and to an increase in imports. Trade and tariff policies with India and China are able to maintain the world trade balance. While colonial India is forced to absorb massive quantities of British exports of manufactures, Great Britain actively prevents the creation of an autonomous industrial structure in India. The investments in railways follow the same patterns. Moreover, Great Britain forces India to export opium and manufactured cotton to China. Third, in India and China military expenses increase massively, the first because England searches territorial expansion in Asia, and the second because China fears for its sovereignty along the coasts and in order to face internal revolts due to instability after the two “opium wars”. Fourth, the new established Gold Standard leads to strong currency depreciation in countries, like India and China, that do not adopt it. This reduces the monetary stability of the country, reduces the governmental autonomy for fiscal policies (in China the Qing must raise taxes, spreading dissatisfaction among the population) and diminishes the purchasing power for essential imports. Fifth, the terms of trade start to decline for raw materials producers in tropical countries. Tropical agricultural products are given less value relatively to those coming from temperate areas. The purchasing power of tropical countries for buying international raw materials decreases. All these factors together lead to a situation of underproduction, more than to one of Malthusian overpopulation. Of course, these factors are linked together, and perhaps they would not have even existed one without the other. Each of them is cause and consequence of the other (Ludden 1994).

If we look at the country level, we notice that, differently than before, the world economic perturbations reach poor rural populations of tropical countries which are formally or informally colonized. This may be seen as the emergent property of the socio economic systems at the country levels.

Many factors concur to this result. First, in the late 1870's the cereal market becomes global. Because of adverse climate Great Britain has bad wheat crops and increases massively imports from the colonies. New territories are colonized in different continents and railways bring modernity and extensive cereals cultivation to new lands from Canada to Argentina. The Association for Trade of Wheat in Liverpool and the stock market for cereals in Chicago leads to the creation of a unique global market of subsistence goods. Second, the impact of *El Niño* drought is amplified by the worse global economic recession of the nineteenth century. In Wall street the prices of cotton, rice, tobacco and sugar fall. Thirdly, due to the construction of the Suez Channel, distances shorten. These three factors lead to increased competition at the global level in the food market. The global wheat market guarantees that climatic shocks and consequent crops deficits translate into price shocks that cross the continents at a telegraphic speed. For local peasants the origins of economic perturbations are as far as the sources of climatic ones (Davis 2002: 72).

Other factors contribute to the fall of profits in rural areas in tropical countries, and consequently to the fall of rural incomes. As we have seen, the deterioration of terms of trade for tropical agricultural products leads to diminished profits in this field. Moreover, droughts and famines offer to foreign creditors, allied with local money lenders, new occasions for augmenting the controls on rural economies through debts and expropriations. Further, the increase of export demand of wheat leads to the extensive expansion of this cultivation to less fertile lands and to the change of the equilibrium among different crops (like maize and sorghum), resulting in a fast impoverishment of soils (Ibid: 129). The same consequences are given by the massive cultivation of cash crops, like cotton, tobacco sugar, with the addition of the problem of land subtraction for subsistence crops. The choice of shifting from food crops to cash crops is in turn given, according to Davis, more by deep subsistence difficulties (high taxes, chronic indebtedness, lack of agricultural surface, dissolution of patrimonial linkages at village level), than not by an entrepreneurial choice. Moreover often this choice was imposed, with more or less force, by colonial authorities and by merchants. Enclosures and railways contribute to deforestation, soil erosion and alteration of traditional equilibrium between

agriculture and pasture. Commercialization is thus linked to pauperization, in both cases when local peasants produce directly for the international market, or for the domestic market which is suddenly involved in the international competition, because the shock absorbers of technical progress or agrarian capitalism are missing (Fraser 2007). “The marginal subsistence producers are devoured, and not benefited, by the market” (Ibid: 295).

The last important factor of the collapse of traditional irrigations systems must be mentioned. The colonial system and the deterioration of village social rules lead to impoverishment of traditional irrigation schemes and infrastructures.⁶ High taxes on land does not leave surpluses for the maintenance of such infrastructures. Moreover public investment in this sector falls dramatically, in India because of choices of colonial government, in China and in Brazil because of diminished fiscal and political capacity of the state⁷, which is menaced by foreign powers with real or commercial wars.

As we can see, none of these factors is left isolated, nor it just appears and concurs together with other to some final output. Every single factor is in turn generated by others, although the simple sum of all of them is considered by many historians and economists the source of underdevelopment and emerging of the Third World. Far from being just complicated, the system is indeed complex, because the direction of causation is not unique, the dynamic is not linear and not regular, the spatial and temporal scales vary.

6.3 The New Imperialism

The emergent property of this mechanism consists in the impossibility for tropical countries to manage politically the interaction with the global market exactly at the time in which its mass subsistence depends always more on attributions for food which must be obtained on this global market. On the one hand, this happens as direct consequence of colonial dominance, like in India. On the other hand this is the result of unequal debt and trade relations with Great Britain which is the dominant global power at the time, like in Brazil and

⁶ Davis (2002: 302) reports many studies which argue that traditional irrigation schemes were better than colonial ones: they were more efficient in terms of energy, capital and natural resources consumption. They were more stable in the long term, more equal in terms of distribution of opportunities, benefits, risks. They contributed to prevention of malaria and soil salinization.

⁷ In China the maintenance of the irrigation structure was one of the explicit tasks of the emperor, together with the preservation of the “always normal granaries”.

China. States that are powerful in 1700 become periphery of a global economy which rotates around London. The official and not-official imperialism together with the Gold Standard confiscate the local fiscal autonomy and they obstacle the investments for development. These disadvantages are not compensated by the construction of railways and channels. The “gains from trade” do not return to the mass of small farmers, neither as household income, nor as social capital, nor as governmental investment. This situation contributes to the increase of the vulnerability of local populations. In turn, in both nations which are still independent, and those which are already under colonial power, famines attract new imperialist and colonialist waves.⁸ Again, we find imperialism which makes these regions of the world vulnerable to economic, political and climatic shocks, turning drought into famines. In turn, when famines come, they make the countries weaker, and this attract new colonial conquests. The same factors are both cause and effect. The result is a polarization of the world: a new economic boom in Europe (*Belle époque* 1896 - 1914) versus the weakening of tropical countries. New Imperialism may be seen as the mechanism that allows the reinforcement of this bifurcation pattern (Ludden 1994, Post 1974).

6.4 The management of famines

In almost every country in which the simultaneous drought occurs, there are areas with lack of water and consequently of crops, but other areas with surpluses of cereals. Metaphorically speaking, between these areas there are the new free markets of raw materials and the new price speculations. Moreover, the capacity of the States to cope with the famine differs. For example in India a high quantity of wheat is available, but is exported to Great Britain, and there is a lack of governmental willingness to intervene massively against the famine. On the contrary, in Ethiopia the emperor Menelik II wants to intervene for facing the emergency but lacks resources (Davis 2002).

In India approximately the same patterns occur during the two big droughts of 1876-78 and 1896-1901. In some regions the monsoon lacks, causing bad crops and consequently the

⁸ In many cases we find millenarist local revolts, where indigenous population pretend to see a clear and unavoidable correlation between foreign conquerors and climatic catastrophes. Examples are in Korea, against Japan; in Vietnam, against France; in Oriental India, against Holland; in the Philippines, against Spain (Davis 2002: 99 and 147).

increase of wheat prices and revolts among the rural population. Although the production of rice and wheat is above the average in other Indian districts, the consistent surpluses are exported to Great Britain. Among the reasons for this there is also the compensation for the bad crops in Europe, due to adverse climate - floods, excessive rains - which is another manifestation of the ENSO cycle. Great Britain refuses to apply a control on food prices and, consequently, merchants speculate significantly. Modern railways are used by merchants to transport rice and cereals from affected districts to the deposits in order to store them, because prices are high and are expected to rise further. The telegraph guarantees that rises in prices are synchronized in every part of the country, independently from the situation of the local reserves. Poor rural population lacks money for buying the food transported from other parts of the country that are less affected by the drought. Even a newspaper of that time affirms: "The famine has been more a shortage of money and labour force, than of food" (The Nineteenth Century 1877, quoted in Davis 2002: 37). Moreover, the silver Indian Rupiah is depreciating massively, due to the new international Gold Standard and the prices for imports raise, lowering the purchasing power of Indian rural population. Massive unemployment and high rice prices bring the famine even into the districts that are not affected by drought. Taxes are not reduced for affected districts, and even militarized campaigns are conducted to collect the duties in arrears during the drought.

Great Britain hardly organizes some reactions to these emergencies. The central British government of India organizes work camps, hiring malnourished people with low salary. The government is against the free distribution of food and more in favour of selling it in affected districts. The reasons for this restrictive approach are various. Great Britain is concentrating on attacking Afghanistan from India in order to contrast Russia in Central Asia. England believes in the orthodox economics of Adam Smith's *laissez faire*, therefore is against the control of wheat prices and believes that the market will smoothly find a solution to the crisis. The budget of India has to be maintained in equilibrium. There is the Malthusian belief that overpopulation is the source of the crisis. If the British authorities demonstrate to be too accommodative, there is the fear that the poor Indian population would regularly expect free aid even when the famine is over (Ibid.: 43). At the end it is calculated that between 5.5 and 12 millions people die during the two droughts, despite the presence of modern railways and the millions of tonnes of wheat and rice put in circulation through national and international trade (Ibid.: 44). Some unexpected correlation has even been found between higher rates of mortality and presence of railways in the district. In the *Report on the famine in Bombay*

Presidency 1899-1902 it is admitted that it would have been possible to mitigate the mortality if free aids had been distributed from the beginning of the famine. However, the report affirms that this would have had costs that no State would have been willing to bear (Fraser 2007).

In China the story is slightly different, as there is no formal colonialism. However, from the 1850's China suffers from an increasing pressure from foreign powers, in the form of wars (the two so-called Opium Wars: 1839-42 and 1856-60), influence areas (in 1898 the British-German treaty is stipulated for the division of the areas of influences in China), unequal commercial treaties and proliferation of European Christian missionaries. At the end of the century, internal revolts spread in the country, as, among other reasons, expression of frustration towards foreign presence. This situation coincides with an enormous increase in mortality rates following droughts or floods, if compared with the same calamities in 1700. Davis argues that the foreign pressure causes a "distraction" and a limitation of capacities of public Chinese authorities from their traditional mission of hydrological system and food security management. In turn, the weakness of China during famines and diseases facilitates the foreign pressure and intrusion.

In Brazil droughts turn into famine because of high deforestation rates due to increasing extensions of cotton cultivation. Another reason is the end of the cotton boom which leaves many people unemployed. Despite the establishment of a free market of cereals, the country is not able to import cereals or to transport them into the countryside. The emergency approach of the British India is adopted: food for work, but people are malnourished and these measures are not effective.

In the African continent the increasing intrusion of European powers into agriculture, trade and society creates a tense situation that the droughts in 1876 and the following ones lead to explosion. Again the weakening of the African countries give an occasion to Europeans for formal and violent colonialist conquests. States in Northern Africa become unable to pay debts to France and England, and the latter in response take over the control of fiscal revenues respectively in Morocco and in Egypt. Approximately in the same periods of intensive droughts in tropical countries, we find excessive precipitations and floods in other areas of the globe, like in Great Britain and USA, due to the ENSO cycle. The resulting destruction of crops has important consequences on trade policies of such countries, which become highly dependent on imports.

After the description of famines at the end of nineteenth century, Davis (2002) also analyses how drought's consequences have been managed in 1700 in China and India. The Chinese Qing dynasty had to face the intense drought of 1743-44. The Qing had the political willingness, the efficient administration, and the technology to move through the country massive quantities of wheat in order to face the drought. Moreover, they invested in prevention of famines, keeping the granaries "always normal" (ibid., p. 103), investing in irrigation and in transport on water. They explicitly imposed controls on wheat prices in order to guarantee food security for the Chinese peasants, which was considered one of the missions (*ming-sheng*) of the sovereign. In the same period in Europe States were completely unable both to prevent and to manage famines and the mortality after bad crops was higher than in China.

In India the Moghul dynasty invested as well in the prevention of famines, with investments in hydraulic conservation, flexible legislation which was sensible to climatic variation, taxes varying according to the real crops, public lands available for the poor. The aim was as well the preservation of food security. Moreover, before the creation of a national market of wheat, the food reserves in villages were higher, patrimonial wealth more diffuse and wheat prices in surplus areas were isolated from speculations. The colonialism did not face back-worded societies enveloped in vicious circles of poverty. As we have seen, one of the consequence of the unique market has been the export of the famine through inflation to poor peasants of districts with surplus of crops.

7. How complex system theory helps in understanding famines.

The whole phenomenon of famines can now be analysed in terms of complex systems. We have three different mechanisms. Each of them is on its own complex. The first is the ENSO (*El Niño Southern Oscillation*) pure climatic phenomenon, which brings strong droughts or floods simultaneously in different areas of the globe. The second is the integration of tropical countries in the global economy during the Late Victorian Period. The third is the New Imperialism. The second and the third mechanisms are strictly related and linked in a pattern of mutual reinforcement. The first influences the other two in the sense that each drought,

which turns into famine thanks to the whole system, gives a “green traffic light” for new colonial or commercial expansions of European countries in tropical countries.

The whole system of the consequences of droughts in tropical countries may be described in the following way, as shown in Figure 1. ENSO brings droughts and floods, leading to bad crops and lack of food in some areas. The interaction of the second and the third mechanism produces an enhanced poverty in rural areas of tropical countries. This poverty can be decomposed in three main elements: ecological poverty, lower household incomes, and diminished capacity of the State to prevent and face climatic and economic shocks. This poverty leads simultaneously to diminished food crops and to diminished attributions for food, even without droughts. However, if drought comes because of El Niño, it hits an already impoverished society. This fact, together with a bad management of the emergency by the competent authorities, turns rapidly the drought into famine and epidemic diseases, which reinforce mutually as well and cause tremendously high mortality rates. The famine weakens the country both at the village and at the national level. This diminishes its ability to maintain political and economic autonomy and it favours its integration in the world economy on an unequal basis. In this way famines give positive and reinforcing feedbacks to the second (integration into the global economy) and to the third (New Imperialism) mechanisms. One emergent property of the whole system is the enhanced vulnerability of rural populations in tropical countries to climatic and economic shocks,⁹ which contribute to explain the incredibly high mortality rate during the three big droughts at the end of nineteenth century. Another property is the emergence of the so-called Third World and its departure from the western development path.

⁹ Also in the work of Fuessel (2007) vulnerability definitely appears as an emerging property of complex systems, where elements located at different scales interact. This happens particularly in the “integrated approach” (ibid.), which combines the internal factors of a vulnerable system with its exposure to external hazards.

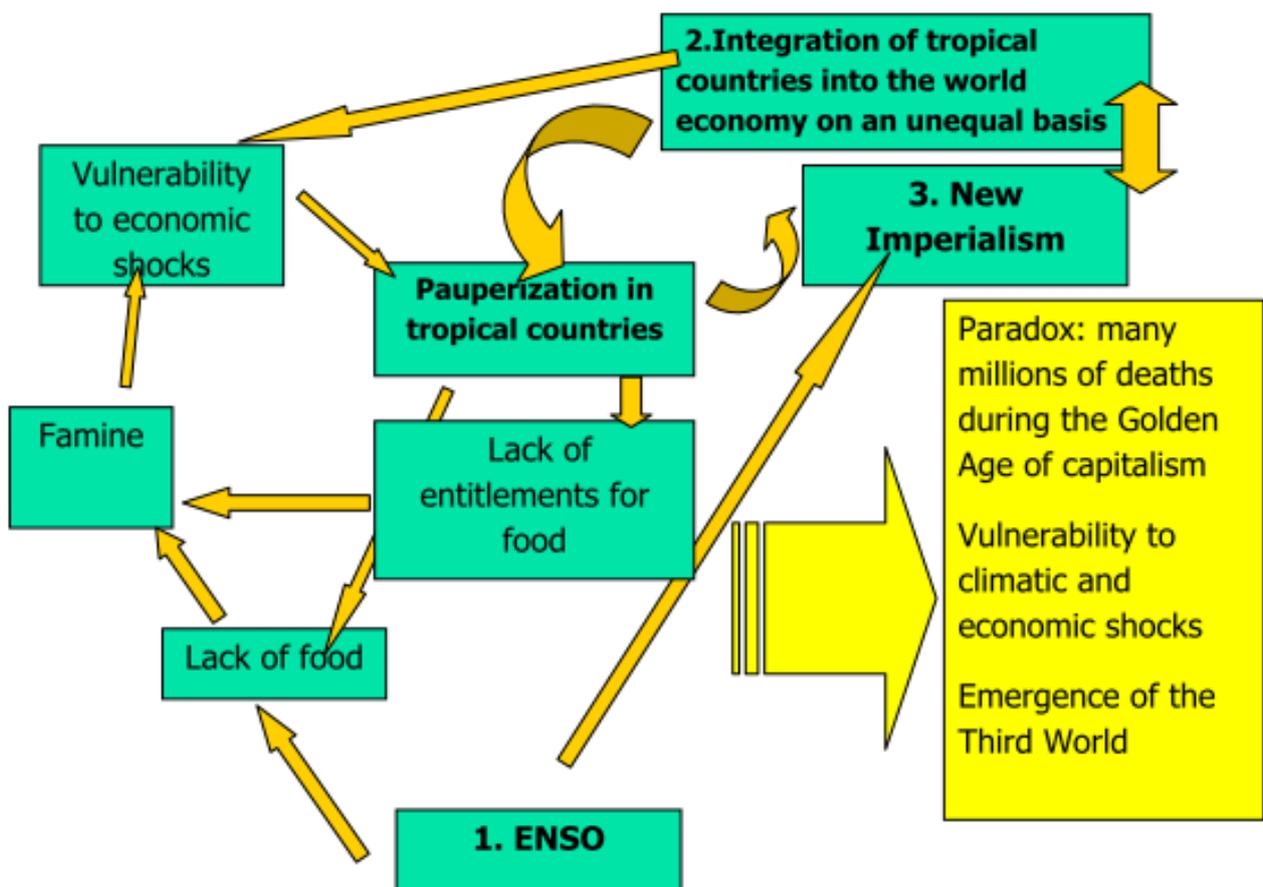


Figure 1. The mechanism of conversion of droughts into famines (own elaboration).

Let us check whether the characteristics and properties of complex systems hold for the explanation of the phenomenon of such strong famines and high mortality in tropical countries in a particular period of high development of the world economy.

First, each of the three mechanisms on its own and the interaction among the three form a complex system, and not just a complicated one. It is very difficult at an intellectual level to decompose and recompose it in a linear way, without making very restrictive assumptions. The causal links among the different factors do not have a unique direction; some of them occur simultaneously in both directions and others occur at very different time and spatial scales.

Second, there is definitely no regular connection between the dimension of an event and the magnitude of its consequences. For example, as we have seen, some speculation in the cereal stock market in the USA may suddenly seriously affect the subsistence of many people on the

other side of the globe, thanks to the enhanced density of connections (institutions, railways, formal and informal power relations, technology, in one word, more perfect information).

Third, we find emerging properties in every of the three mechanisms and in the interaction of the three. These properties are to some extent unexpected. Global trade would allow the convergence of the different economies, and not to a self-reinforcing polarization along two different ways of development.¹⁰ Railways should have been helpful in facing food emergency, and not just a tool for increasing speculations on cereals.¹¹

Fourth, self-reinforcing and lock-in processes are everywhere. The best example is how the new economic and political configuration of tropical countries, dependent and linked to the world economy, make them vulnerable to climatic shocks more than in previous times. This vulnerability in turn makes these countries more adapt for further exploitation from the world economy, until the next drought comes. Or we find self reinforcement at local level: cash crops prevail over food crops and this impoverishes soils. Food crops are as well shifted to less fertile soils, which are much more vulnerable to drought. The impact of ENSO is thus higher, requiring people to spend more money for food. Consequently people will have more incentive (or necessity) to shift to cash crops and the pattern of soil erosion and food security decline will continue.

Fifth, complex systems may have no equilibrium, or many. Before the introduction of a national market of cereals in India, linked to the international market, the different districts of the country were more isolated and each local market of wheat and rice was more stable. As we have seen before, an increase in physical and institutional connections (that is to say the creation of a unique national market, with high density of monetized exchange) led to high instability in people purchasing power and thus in food consumption. The results have been the convergence of wheat price increases in every districts (one equilibrium) and the collapse of food security in many areas (everything but equilibrium between supply and demand).

We can find other ways in which the complexity theory may help us understand the story. As we can see, the factors that have been enumerated are grouped into different levels, leading

¹⁰ Another parallel between this portion of history and complex thinking may be found in the French Regulationist School, which interestingly allows for high instability and for emergencies of norms in dealing with global capitalism. It argues about the paradox of how capitalism has both a tendency towards crisis, change and instability as well as an ability to stabilize institutions, rules and norms (Lipietz 1997).

¹¹ In some areas of India mortality rates have been higher in proximity of railways. This surprising result may come from the fact that sometimes railways brought wheat from other districts which were affected by highly contagious diseases.

our mind to the concepts of level hierarchies of Lane, Simon and Holland (Lane 2006). I would say that each of the three described mechanisms is developed on different levels. Each level has a spatial-temporal scale. The ENSO is a global phenomenon. The New Imperialism has its decision centre in Europe. Famines have been (badly) managed at a country level. The inability of rural households to purchase food happens at a village and regional level. Regarding the time scale, we can notice that droughts come when the rural society is already impoverished by the previous interaction of the second and third mechanisms. Economic recessions or shocks in wheat prices occur rapidly and are quickly geographically transmitted. Trade policies and modified configurations of the world economic relations are indeed slow processes. We find upward and downward causations between factors at different levels of the same mechanism. However, Simon argues that it is possible to study each level in isolation (Lane 2006), and this is what Davis did, in the different chapters of his book. For example, in explaining famines, Davis combines the clarification of why the food availability decline is in the economy (FAD approach) and why the availability decline is in the market (entitlement approach).

Moreover, Simon says that processes at different levels may be considered either as constant, or as equilibrium points, depending on whether they occurs slowly or rapidly. For instance one can consider the structure of the world trade in the Late Victorian Period as in equilibrium, if watched from a wide perspective, and the transmission of prices shocks from London to Calcutta as an efficient mechanism for balance. The stock market for cereals, telegraph and railways guarantee for sure a better level of information (although not perfect) than before. However, we have seen how this process results in a polarization of effects, bringing masses of people into poverty and famine, and other societies to increase their wealth.

The property of universality – the characteristics of emergent properties are robust to different specifications – (Durlauf 2005) holds as well in our system. The same inputs (three mechanisms at work) give the same output (famine and high mortality) in different States, like India, China, Brazil. The internal dynamics vary (China and Brazil are not even formally colonized), but the result is the same enhanced vulnerability of rural masses and the decline of the State. Or, another way for justifying that universality holds is that in our and Davis' description of the system, the building blocks are grouped and put in a particular structure. But this is just one way of representing the story. We could have identified a different number

of mechanisms or different causal, spatial or temporal relations. In any way we would have the same set of outputs from the same input.

In conclusion, the approach analyzed in this work (Davis 2002, Fraser 2007) argues that the relation between Imperialism and enhanced vulnerability of rural people in the “new” Third World exists. We can see that this relation is not linear, the direction of causation is not unique and the result comes from the interaction of many heterogeneous factors at different levels. Between these inputs and these outputs there is a complex system.

However, this approach tends to identify a precise, linear, “guilty” relationship between inputs and outputs. The questions that rise are: to what extent were agents aware of the long term consequences of their decisions? Were the creators of the global market of cereals conscious about its deep impact on rural households in tropical countries? Is it correct to attribute so much direct responsibility to every agent? Is it not the final result just the unpleasant outcome of a complex interaction among many factors, such as climate together with technology and creation of integrated markets? Another limit of this approach is its consideration of every pre-colonial system as stable and efficient in terms of prevention and management of the impact of climatic perturbations. It is always risky to compare situations which are similar, but plugged in completely different environments (i. e. droughts of 1700 and those of the end of 1800), especially if the quantity of information available for one of them is very limited in comparison with the other.

We can also find some reasons for which complexity theory does not completely fit the explanation of this portion of human history. Some relationships, for example, may turn out to be more linear and direct than complexity theory suggests. First, the theory of complex systems assumes a high degree of imperfect information. However, reports clearly prove that British authorities in India had information about the ongoing famine which was probably sufficient to take decisions which would have diminished the catastrophic consequences of the drought (Davis 2002).

Second, colonialism was only one of many events which influenced the enhanced vulnerability of rural populations to climatic shocks. Complex theory suggests that small events may lead to very large outcomes. However, in my opinion the colonialism event is pretty “large”, for sure not a “butterfly”. In both formal and informal colonialism there was with certainty an explicit willingness to exploit the resources of tropical countries, which had been deprived of the political and economic power to respond effectively to the changing situation.

Third, to what extent can we say that the emergent properties of the system are unpredictable and have not been planned by precise agents? Authorities took decisions that went in precise directions on how to manage the emergency situations. The British central government for India consciously chose restrictive measures that affected millions of people. Such measures did not just happen as a result of some spontaneous interactions among system's components (Marks 2001). The same consideration holds for the configuration of trade policies. Ants do not have the perception of the functioning of their anthill. Nations signing trade treaties do have the perception of the immediate consequences of their agreements, because this is exactly the reason why they are taking the accord. If there is the explicit political willingness to do an action, if the conditions allow it, the action is done, without many elements of complexity in the process.

A fourth consideration is about the issue of interconnections. One should be cautious in applying the complexity vision too literally to socio-ecological systems (Fraser 2003). For example, although strongly connected ecosystems are often the most vulnerable, some researches show that it is unconnected or isolated human communities that are far more vulnerable to shocks derived by droughts or floods because they do not have access to the social networks that help people overcome such difficulty (Pretty and Ward 2001, Fraser 2007).

As a conclusion, we could say that complexity theory applied to socio-economic systems should make room for speaking about economic and historical responsibility of some (or every) agent. As Anderson affirmed (1988: 269): "Economics differs from biology in that foresight and game-playing exist. For instance a whole collection of actors can suddenly and simultaneously switch strategies. Also, government action and regulation exist to correct or control lock-in."

References

- Albala-Bertrand J.M. (2000) Complex emergencies versus natural disasters: an analytical comparison of causes and effects, *Oxford Development Studies*, 28(2): 187 – 204.
- Allen G. (1986) Famines: the Bowbrick-Sen dispute and some related issues, *Food Policy*, 11(3), pp. 259-263.
- Anderson P.W. (1988) A physicist looks at the economics. In Anderson P.W., Arrow K., and Pines D., *The economy as an evolving complex system*, Addison-Wesley Pub. Co., Santa Fe Institute, Santa Fe, New Mexico.
- Arnold D. (1988) *Famine: social crisis and historical change*, B. Blackwell, London.
- Arthur W. B (1988) Self-reinforcing mechanisms in economics. In Anderson P.W., Arrow K. and Pines, D., *The economy as an evolving complex system*, Addison-Wesley Pub. Co., Santa Fe Institute, Santa Fe, New Mexico.
- Arthur W.B. (1999) Complexity and the economy, *Science*, 284 (5411): 107-109.
- Bebbington A. (1999) Capitals and capabilities: a framework for analyzing peasant viability, rural livelihoods and poverty, *World Development*, 27(12): 2021-2044.
- Bhatia B. (1963) *Famines in India – 1850–1945*, Konark Publishers, Delhi.
- Billig M. (1992). Sweet reason: the rationality of growing sugar on Negros, *Philippine Studies* 40: 153-182.
- Bowbrick, P. (1986) The causes of famine. A refutation of Professor Sen's theory. *Food Policy* 11(2), pp. 105-124.

- Carlson R.E. Todey D.P. and Taylor S.E. (1996) Midwestern corn yield and weather in relation to extremes of the Southern Oscillation, *Agronomy Journal/ Production Agriculture*, 9: 347-352.
- Chakrabarti M. (2004) *The famine of 1896-1897 in Bengal: availability or entitlement crisis?* Orient Blackswan, New Delhi, India.
- Colander D. (2000) *The complexity vision and the teaching of economics*, E. Elgar, Northampton.
- Cottrell C. (2003) Review of the book: Late Victorian holocausts: El Niño famines and the making of the Third World, by Mike Davis, *Journal of World History*, 14(4): 577-579.
- Cowan G.A. and Mc Cormick A. (1988) Summary of meeting on International finance as a complex system at the Rancho Encantado, Tesuque, New Mexico, August 6-7 1986. In Anderson P.W., Arrow K., and Pines D., *The economy as an evolving complex system*, Addison-Wesley Pub. Co., Santa Fe Institute, Santa Fe, New Mexico.
- Davis, M. (2001), Late Victorian holocausts: El Niño famines and the making of the Third World, London-New York. (2002) *Olocausti tardovittoriani: El Niño, le carestie e la nascita del Terzo Mondo*, Feltrinelli, Milano, Italian translation by G. Carlotti.
- de Waal A. (1989) *Famine that kills: Darfur, Sudan, 1984-1985*. Oxford University Press.
- de Waal A. (1990) Re-assessment of entitlement theory in the light of recent famines in Africa, *Development and Change*, 24: 587-96.
- de Waal A. (2007) Social contract and deterring famine: first thoughts, *Disasters*, 20(3): 194-205.
- Desai M. (1988) The economics of famine. In Harrison G. (ed.) (1988) *Famine*, Oxford University Press.
- Devereux S. (1993) *Theories of famine*, Hemel Hempstead, Harvester Wheatsheaf.
- Devereux S. (2001) Sen's entitlement approach: critiques and counter-critiques, *Oxford Development Studies* 29(3): 245-263.
- Devereux S. (2009) Why does famine persist in Africa?, *Food security* 1(1): 25-35.

- Drèze and Sen (1991) *Hunger and public action*, Oxford University Press.
- Duffield M. (1994) Complex emergencies and the crisis of developmentalism, *IDS Bulletin* 25(4), Institute of Development Studies, Oxford.
- Durlauf S.N. (2005) Complexity and empirical economics, *The Economic Journal*, 115: F225-F243.
- FAO (2004): *The State of Food Insecurity in the World. Monitoring Progress towards the World Food Summit and Millennium Development Goals*, Food and Agriculture Organization, Rome.
- Fontana M. (2010) Can neoclassical economics handle complexity? The fallacy of the oil spot dynamic. *Journal of Economic Behavior & Organization*, 76(3): 584-596.
- Fraser E. (2003) Social vulnerability and ecological fragility: building bridges between social and natural sciences using the Irish potato famine as a case study, *Conservation Ecology*, 7.
- Fraser E., Mabee W., Figge F. (2005) A framework for assessing the vulnerability of food systems to future shocks, *Futures*, 37: 465-479.
- Füssel H.-M. (2007) Vulnerability: a generally applicable conceptual framework for climate change research, *Global Environmental Change*, 17: 155-167.
- Goklany I. M. (2003) Review of the book: Late Victorian holocausts: El Niño famines and the making of the Third World, by Mike Davis, *Environmental History*, 8(3).
- Grove R. (1989) Scottish missionaries, evangelical discourses and the origins of conservation thinking in Southern Africa 1820-1900, *Journal of Southern African Studies*, 15(2): 163-187.
- Habicht J.P. (1992) Discussion: mortality, malnutrition and synergies: determinants and interventions. In: Hill K., *Child health priorities for the 90's*. The Johns Hopkins University, Baltimore, MD.
- Hazell P.B.R. and Ramasamy C., (eds.) (1991): *The Green Revolution reconsidered: the impact of high yielding rice varieties in South India*. Johns Hopkins University Press, Baltimore, MD.

- Hemelrijk C.K. (2002) Understanding social behaviour with the help of complexity science, *Ethology*, 108: 655-671.
- Holland J.H. (1988) The global economy as an adaptive process. In Anderson P.W., Arrow K. and Pines D. *The economy as an evolving complex system*, Addison-Wesley Pub. Co., Santa Fe Institute, Santa Fe, New Mexico.
- Jones T. (2002) Review of the book: Late Victorian holocausts: El Niño famines and the making of the Third World, by Mike Davis, *Technology and culture*: 43.
- Lane D. (2006) *Hierarchy, complexity, society*. In Pumain D. Hierarchy in natural and social sciences, Springer Netherlands.
- Lipietz A. (1997) The Post fordist world: labor relations, international hierarchy and global ecology, *Review of International Political Economy* 4(1): 1-41.
- Ludden D. (1994) *Agricultural production and Indian history*. Oxford University Press.
- Marks B. R. (2001) Review of the book: Late Victorian holocausts: El Niño famines and the making of the Third World, by Mike Davis, *The Journal of Economic History*, 61(3): 871-872.
- Mellor J.W. (ed.) (1995) *Agriculture on the road to industrialization*. Johns Hopkins University Press, Baltimore, MD.
- Millennium Ecosystem Assessment, (2005), *Ecosystems and Human Well-being: Current State and Trends, Volume 1*, Island Press, Washington D.C., USA.
- Mitleton-Kelly E. (2003) Ten principles of complexity and enabling infrastructures. In Mitleton-Kelly E. (ed.) *Complex systems and evolutionary perspectives of organisations: the application of complexity theory to organizations*, Elsevier Press, London.
- Murton B. (1984) Spatial and temporal patterns of famines in Southern India before the Famines Codes. In Currey B. and Hugo G. (eds.) *Famine as a geographical phenomenon*, D Reidal Publishing Company, Dordrecht.
- Naylor R., Goldberg R., Primavera J., Kautsky N., Beveridge M., et al. (2000) Effect of aquaculture on world fish supplies, *Nature*, 405: 1017-1024.

- Ormerod P. (1998) *Butterfly economics: a new general theory of social and economic behaviour*, Pantheon Books, London. (2003) *L'economia della farfalla: società, mercato, comportamento*, Instar Libri, Torino, Italian translation by E. Griseri.
- Parry M.L., Rosenzweig C., Iglesias A., Lovemore M., and Fishcher G. (2004) Effects of climate change on global food production under SRES emissions and socio-economic scenarios, *Global Environmental Change*, 14: 53–67.
- Post J. (1974) A study in meteorological and trade cycle history: the economic crisis following the Napoleonic war, *Journal of Economic History*, 34: 315–349.
- Pretty J. and Ward H. (2001) Social capital and the environment, *World Development*, 29: 209–227.
- Rangasami A. (1985) “Failure of exchange entitlements” theory on famine: a response, *Economic and Political Weekly*, 20(41).
- Reutlinger S. and van Holst Pellekan J. (1986) *Poverty and hunger: issues and options for food security in developing countries*, World Bank, Washington DC.
- Rosenzweig C. and Parry M. (1996) Potential impact of climate change on world food supply, *Nature*, 367: 133–138.
- Sen A.K. (1986) The causes of famines. A reply, *Food Policy* 11(2): 125-132.
- Sen, A. K. (1981) *Poverty and famines: an essay on entitlement and deprivation*. Oxford University Press.
- Simon H. A. (1969). The architecture of complexity. In Simon H.A. (ed.) *The sciences of the artificial*, MIT Press, Cambridge, MA: 192-229.
- Smith L.L. (2007) Complexity meets development – a felicitous encounter on the road of life, *Interdisciplinary description of Complex Systems* 5(2): 151-160.
- Sombroek W.G. and Gommers R. (1996) The climate change-agriculture conundrum. In Bazzaz F. and Sombroek W.G. (eds.) *Global Climate Change and Agricultural Production*, West Sussex, Wiley.
- Terna P., Boero R., Morini M., and Sonnessa M. (eds.) (2006) *Modelli per la complessità. La simulazione ad agenti nell'economia*, Il Mulino, Bologna.

- Wang X. and Taniguchi K. (2003) Does better nutrition enhance economic growth? The economic cost of hunger. In Taniguchi K. and Wang X. (eds.), *Nutrition intake and economic growth. Studies on the cost of hunger*. FAO, Rome.
- Wang G. and You L. (2004): Delayed impact of the North Atlantic Oscillation on biosphere productivity in Asia, *Geophysical Research Letters*, 31(12).
- Watts M. J. (1983) *Silent violence: food, famine and peasantry in northern Nigeria*. University of California Press, Berkeley.
- Watts M. J. and Bohle H.G. (1993) Hunger, famine and the space of vulnerability, *GeoJournal* 30(2): 117-125.