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*Capital-Value-Decision : a Trialectic Measure of Solidarity ?  
Keys for a freedom fields wave-model of interactions*

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*Abstract*

Starting from the hypothesis that the principles of solidarity follow the laws of environmental and social adaptation, we will try to model the complex systems of human interaction, through three modes of observation, ontological, phenomenological and genetical. By reinterpreting the case study of the historical 2012 drought in the United States, we consider that resilience of this event can be decrypted through multiple interactions between decisions and actions of the territorial actors fighting against this hazard.

Following the systemic analysis of the decisional and axiological interactions designed to cope with this climatic event, solidarity operators are modeled as feedback loops corresponding to the disaster and resilience phases that occurred during this event. These operators are interpreted as "interaction controllers", whose cyclical behavior makes it possible to act on specified regulatory domains in the context of sustainable development: economic, social and environmental. As a function of mechanical, pragmatic or organic solidarity natures, their cyclic dynamics will then be questioned within the framework of evolutionary systems.

*KeyWords* : Interaction System, Social Capital, Freedom Fields, Wave Model, Solidarity Measure.

*Introduction*

Faced with the present prevalence of individualism and unrestrained competition, our vision of intelligence is part of cooperation, transcendence, empathy and communication. Leaving from our modes of representation shaped by the notions of human capital, which corresponds to a reality of the "homo œconomicus", the notion of "social capital" defines the human on criteria basically inscribed in its insertion in the socio-eco-environmental system, privileging the transmission and the mutual enrichment. The collective dimension thus allows to go beyond individualism (the "brains in society"). Social Capital thus develops on two dimensions which constitute its conditions of existence: networks and trust (Fukuyama, 1995).

By proposing a compromise between human development and economic development priorities in an ecosystemic context, this "new capital paradigm" is the basis of solidarity, networks and trust, thus constituting its facilitators.

In this work, we hypothesize that the three dimensions of solidarity, *mechanic, pragmatic and organic*, can be assessed on the basis of socio-economic, socio-cultural and socio-environmental capital measurements. Solidarity index, formulated as a parametric function of these three components, can then be considered as an indicator of a turbulence regime specific to the transition periods of the eco-socio-environmental system, whose signal amplitudes reveals the cultural upheavals risk and wealth aggressive redistribution, traduced as conflictual crisis.

*Theoretical background : three Towns, three Men, three Views*

« Over the course of the last 30 years there has evolved at the Massachusetts Institute of Technology a new method for understanding the dynamic behavior of complex systems. The method is called System Dynamics. The basis of the method is the recognition that the structure of any system--the many circular, interlocking, sometimes time-delayed relationships among its components--is often just as important in determining its behavior as the individual components themselves. » (Meadows and alii, 1972 ).

*The General System theory: from cartesianism to complexity*

Jean-Louis Le Moigne (1990) and Edgar Morin (2007) both define new constructivist sciences, also called complexity sciences, on the basis of transdisciplinarity and the rejection of disciplinary boundaries. In quantum physics as well as in human and social sciences, the observer is here considered as an interaction actor, whether it is a scientist, an engineer, a human, or even a nonhuman. As he constructs by his action his own representation of the world, this last is in return immediately modified. Understanding to do and doing to understand constitutes here a Janus dimensioning of multi-dimensional realities facing to acknowledge, thus founding methodological assets for an anarchist theory of sciences (Feyerabend, 1979).

Within his General System theory, Le Moigne (1990) proposes to replace the “Discourse of the Method” of Descartes with defining a new systemic paradigm: the General System. The main precepts of Descartes, to receive for real only what one knows for such, to divide difficulties in simpler parts to solve, to study a problem starting by the simplest, is then traduced in the teleological system precept, project or purpose, through the principle of aggregativity.

Thus, General System theory articulates an organized structure around the three main modalities, *genetical*, as a construct from historical evolution, answering the question: “From where are we and what do we BECOME ?” *ontological*, as an ethical/scientific characterization of the system object, lying on the nature of the object do define : “What can it BE ?” and *functional*, thus defining praxeological or experiential dimension of systemic interrelationships : “What can we DO ?”.

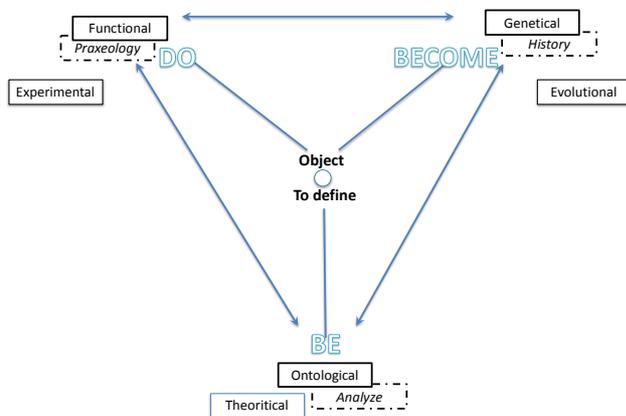


Fig.1: The three modalities of the General System theory, from (source: Le Moigne, 1990)

Moreover, the General System, by interrelations of its components and the goals assigned to it, is then self-organized, having the capacity to define new relationships and new elements. It thus allows to specify the concept of *processors network* which has been originally the base of the structure of a system, and which will base the present research model.

### ***Freedom Fields and ActionScapes: A Man’s Project***

In Strasbourg, A. Moles’ first works devoted to acoustics leads him to focus on the concept of object as a communication support. He therefore proposes to bridge the disciplinary fields of psychology, information and communication, through the lens of engineering sciences (Moles, 1990 ).

His working hypothesis enlightened the basic notion of vicarial experience, or "vicarious correspondence" in the viability theory (Aubin, 1991), argues that the change of information state of a system or subsystem can be evaluated on the basis of a strategy to characterize the cognitive structure of its interaction with the environment. In this hypothesis, the integration of the information is made by jumps from one fragment to another, by constructions. and deconstructions of associative recursive networks of ideas and nested information units, all falling within the discontinuous temporality of the mechanism of the imprint, or "impression". These impressions which are organized and memorized in "scenes", succeeding each other in the consciousness, passing from a continuous information flow to discrete structured impressions, are named “ideoscenes” by Barker (1957) then by Moles (1995).

Landscape of action, “ActionScapes”, was conceptually developed within this context: this notion tries to lighten how the individual will interact following his phenomenal being, interactive action and teleological projection through managing his freedom fields.

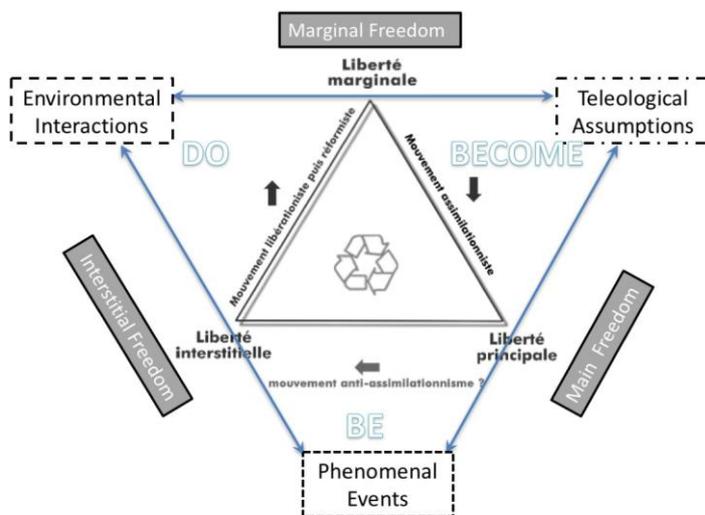
The term "freedom" is here taken in its rational and mechanistic sense, the notion of "degree of freedom" refers to a number of parameters (in our paradigm, the three "freedom classes" above), which define the system. The hypothesis formulated here of the reduction of human behavior in interactions is based on the structural modeling of this multidimensional freedom fields between its principal, marginal and interstitial dimensional fields (Moles, 1966).

The freedom field thus defined represents the hyperspace in which the individual moves, constrained in a plural way to physico-biological laws, imposing the limits of the human body in its material environment, the social and / or moral limits, namely the boundaries of human behavior in society which, associated with probabilistic laws, habits or behaviors more or less predictable, allow to schematize this hyper-volume of interactions in which he is inserted.

The *main freedom field* is framed by the limits of the law: the behavioral excursion outside this field then constituting the illegal act, offense, or crime. Classes of these excursions also answer the anomic classification, implying an inverse entropy (rarity of the act) to the excursion gravity: if offenses are numerous, criminal acts remains exceptional ...

*Marginal freedom*, on the other hand, extends the field of freedom of the individual by a form of elasticization of the frontiers of the main freedom, by ethical or ideological constructions. This freedom extension has the effect of relaxing the social or societal counter-reaction to the act of transgression: it thus constitutes a form of "modulation" of this last, which absolute value is the opposite of the rigidity of the political framework in place.

Finally, *interstitial freedom* is defined as the "quasi-juxtaposition" of the limits imposed by the law in complex situations. The example of the tax optimization strategies of multinational companies is enligning this fact: this freedom exploits the gaps, the "cracks" of the legislative devices framing the laws. In this sense, financial legislation seems particularly relevant to this dimension, insofar as it systematically explores the spaces of interstitial freedom between the constraint blocks, in order to control (increase) its potential excursion in the system.



*Freedom Fields and Action Scapes (source : Moles, 1966)*

### ***From Solidarity to Solidarities: the social link***

In Bordeaux, Emile Durkheim (1893) prefigured a systemic thought of the social fact, considering society as a *sui generis*: reality, which means a complex system, can't be reducible to its constitutive parts, all has to deal with interactions, one time again...

Following this chart, solidarity notion should be defined through three " faces ", or dimensions, mechanical, organical and pragmatcal :

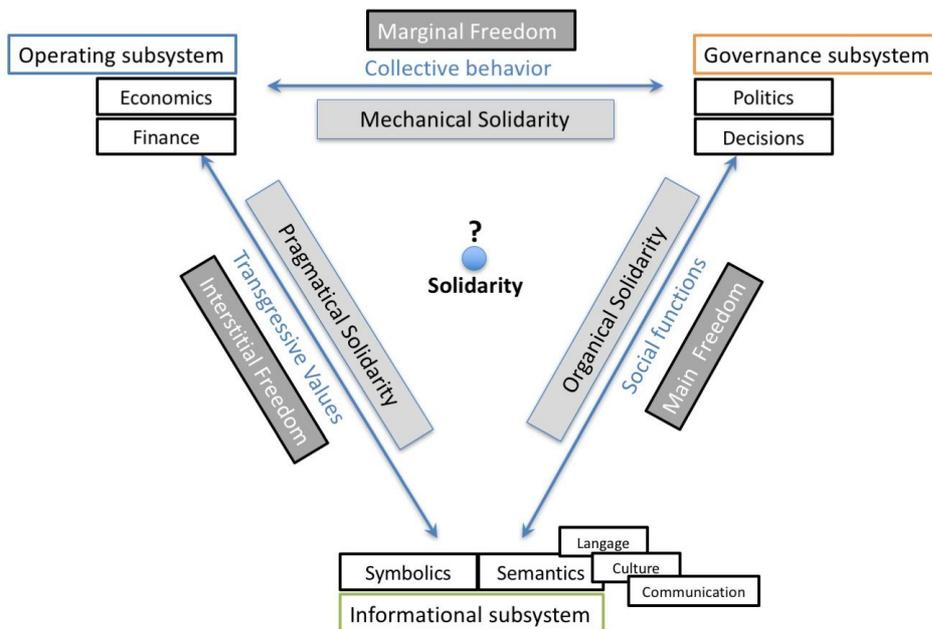
- Mechanical solidarity involves collective behavior and weakly differentiated production activities. It is also based on proximity, resemblance and common history and values sharing during the interaction act.

- Organical dimension of solidarity is defined by a social function between human beings, interdependence and complementarity. It constitutes the “ interaction capacitance” of the relevant society.
- A complementary dimension, as Pragmatical solidarity, was claimed by Proudhon (1840) as a transgressive value, refuses any interaction with the political sphere. This defines it as a “ regulation part ” of the solidarity system.

From the social link theory of E. Durkheim (1893), the solidarities allow the exercise of the main fields of freedom, articulating all three the principles of emergence of this "new economy".

In fact, solidarity economy is an extension of the social economy, which is returning to the political dimension, into a form of "economic democracy". However, solidarities also constitute a factor of wealth production, which is the basis of one of the ontological bases of social economy. If *mechanical solidarity*, involving collective behaviors and weakly differentiated production activities is based on proximity, resemblance and the sharing of common values, *organic solidarity* is defined by the social functions of interdependence and complementarity (Durkheim, 1893).

*Pragmatic solidarity*, for its part, refuses any interaction with the political sphere, thus positioning this dimension of solidarity as a transgressive value. It represents the contribution of "scientific socialism" (Bakounine, 1911) actors, where volunteers or professionals play a key role in mediation with social authorities.



Sub-Systems of Freedom Fields: A Solidarity System Design (source : Anonymous).

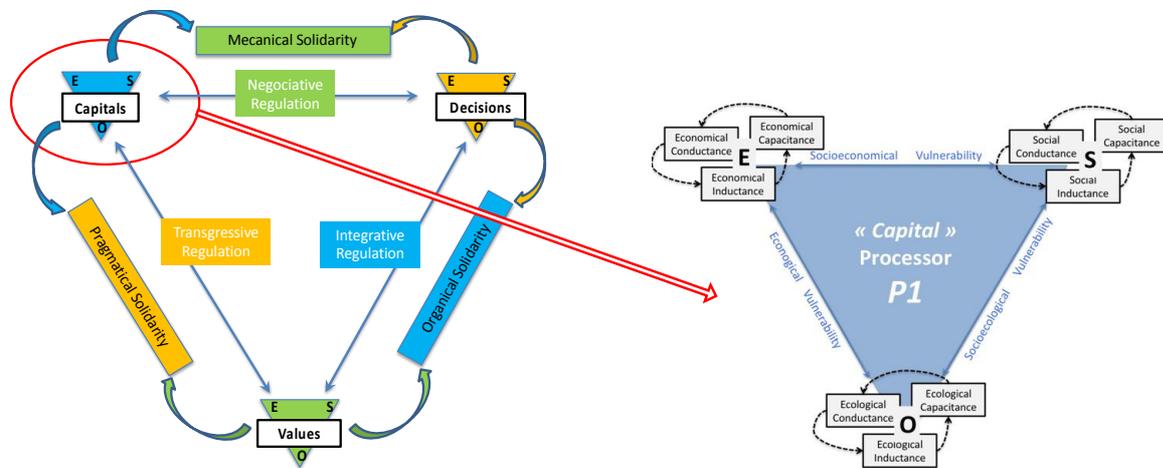
Considering freedom fields as a subsystem of solidarity, mechanical solidarity is relevant from marginal freedom, as well as organical solidarity constitutes freedom main's dimension, while pragmatical solidarity is based on interstitial freedom.

***A multidimensional transduction principle : Eco-politico-symbolic co-regulation of interaction flows***

With taking the symbolic, economic and political exchanges into account (Figure 1), freedom fields allow the individual to interact between the spheres of the symbolic, economic and political to satisfy his project by the levers of values, capitals and decisions.

These solidarities transduction of the freedom fields are organized on three complementary regulation subsystems:

- The so-called "integrative" regulation lays the user rights driven by traditional governance structures, particularly legislative ones. In doing so, it organizes the so-called "organic" solidarity defined by the social functions of the distribution of values, by guaranteeing the main freedom of the concerned user.
- Complementary to the integrative regulation, the so-called "negotiating" regulation of the interaction flow exchanges responds to a principle of "social promotion", thus balancing access and exclusion, through negotiation between political and economic sphere. This type of regulation is therefore part of a "lateral" exchange mode, on the operative schema of cooperation or co-construction.
- Finally, the last type of regulation, which we named "transgressive", is based on "small arrangements" between governance structures and specific interests. By breaking free from the "political" order, it is the place of plasticity between structural organizations and (inter-) individual action, which is currently constituted mainly by groups that mobilize lobbying processes. This type of regulation is more and more broken down by politicians and citizens, but represents a so-called "interstitial" field of freedom, whose seat of "pragmatic" solidarity remains useful for the regulation of the system, extended to the marginal part of the economic sphere.



(Capitals-Decisions-Values) co-regulation structure and the Capitals subsystem – processor (source : Anonymous).

### **Sub-System Interactions Processors: E-S-O inductive workflow**

Every sub system can then be considered as a processor, which responds to the inductive work-flow model which has been developed in the aim of resilience dynamics studies (Anonymous, Quenault, 2013), quickly presented thereafter.

With taking Capitals processor P1 into account, converting capital stocks into service flows in the three dimensions of sustainable development, involves stocks notion, here understood as the "capacitance" property of the system, as "flows" constitute its conductance, leading to capital stocks growing or declining<sup>1</sup>. This system evolution describes the "inductive" effect of the (stock/flow) conversion process. Generalizing this principle within each (Capitals – Values – Decisions) processor leads us to define the three dynamical notions of a general theory of social-eco-environmental entropy,

<sup>1</sup> In the science of physical mechanics, potential energy is associated with a physical property called elasticity or stiffness, and can be therefore represented by a stretched spring. In electronic science, potential energy is stored in a capacitor instead of a spring, which property is called capacitance. Second passive component, kinetic energy, is associated with a physical property called inertia or mass, and can be represented by a flywheel in motion. In electronic science, kinetic energy is stored in an inductor, a magnetic field, which property is called inductance. Endly, energy dissipation is associated with a physical property called friction or resistance, thus converting energy into heat.

also called "generalized social energy": capacitance, conductance and inductance. Thus, sustainable co-evolution of environmentalized systems answer to those complementary potential, dissipative and cinetic processes constitute the ESO IT collaborative model (Dumas, Anonymous, 2012), involving economic, social and ecologic inductances as illustrated figure 2:

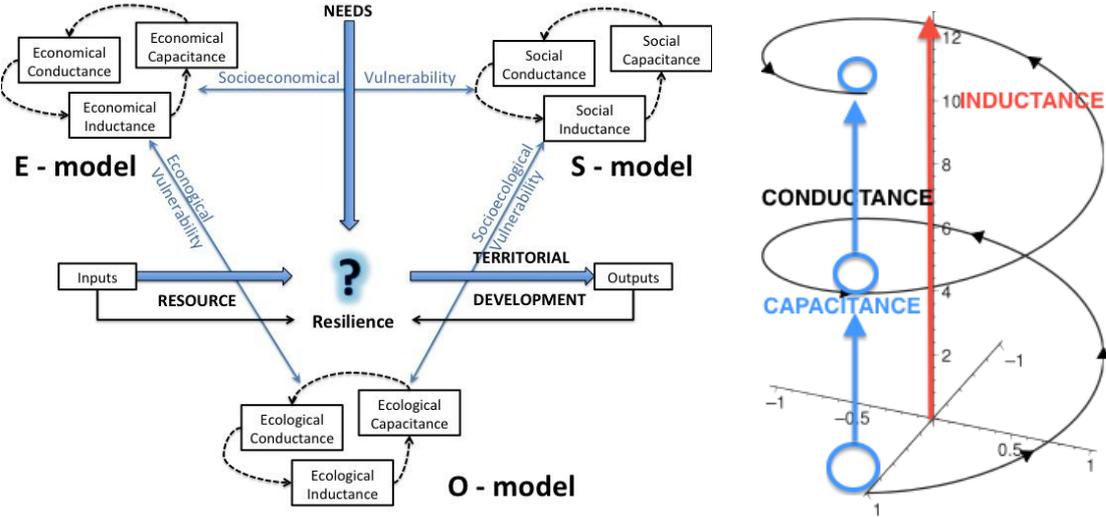


Fig 2: Subsystem open-analogical model and inertial inductance behaviour (source : Anonymous, 2012)

Economic inductance (E-Model) can thus be understood as an analogy with an electrical inductor: this last has an electric current as its primary phenomenon and a magnetic field as its secondary phenomenon. Analogic view of this process describes an economic inductor as a complex flow driving, constituted by economic value as its primary phenomenon and population behavior as its secondary field phenomenon of inertia. Social Inductance (S-Model) considers social implying cooperation action as primary phenomenon and environmental integration process as secondary field phenomenon. Last but not least, ecologic/organic Inductance (O-Model) implies ecological management as primary phenomenon and ecosystemic interactions between air (athmosphere), water (hydrosphere), ground (litosphere) and life (biosphere), or environmental benefits/losts, as secondary inertial field inductive phenomenon.

This paradigmatic change of the process leads us to consider this model as a thermodynamic approach of open-living systems, instead of mechanical-closed systems: stability key of those lasts closed systems, retroaction or feedback, is here considered as the open-systems evolution source.

Property (Entropy class)	Economical (Model E)	Social (Model S)	Ecological - Organic (Model O)
<b>Capacitance (Potential)</b>	Capital (stocks) Money-Infrastructures Skills-Trust	Cultures, Social capital (actors & networks...)	Ecological capital Bio-hydro-litho-atmo-spheres
<b>Conductance (Dissipative)</b>	Flux (Goods) Services production Financiary outcomes	Networking Cultural action Cooperation	Eco-actions Ecologic management Nature valuation
<b>Inductance (Kynetical)</b>	Resultance (Added / Lost Value...) Long-term benefits	Integration - differentiation Wellbeing	Ecosystemic interactions Fertilization-Desertification Amenity outcomes

Fig 3: The three passive components of the sustainability pillars (source : Woloszyn, 2012)

Defining the *stocks* of a community's capital that generate enough *flows* for community wellbeing provides here an econologic view of resilience: a rise (or fall) in a community's wellbeing can be explained by increases (or decreases) in its stocks of capital. In case of disfunction between capacitance level and conductance process, inductance should exceed capacitance, and a leading power factor is produced, driving community to uncontrolled economic/social flows driving. As an illustrative example, this induced effect generated the 2008's crisis, due to excessive financial flows resulting from american subprimes system, which has led to a "savage" inductance process, traduced by financial crash & social crisis. Harmonic problems of eco/socio/environmental inductive interactions have then emerged, so that the dissipative system disrupted its equilibrium between the sustainable dimensions of the development process. Inductance process will be illustrated thereafter through 2012 U.S. drought event case study (Anonymous, 2012).

### ***Processors specifications***

This framework fosters operational qualities and levels of each subsystem to be computed, capitals, values and decisions, will then help to understand which response has to be brought to face environmental changes.

« The word "capital" should be understood to mean service, industrial, and agricultural capital combined. Thus the most basic definition of the state of global equilibrium is that population and capital are essentially stable, with the forces tending to increase or decrease them in a carefully controlled balance. » (Meadows and alii, 1972).

With social-economical-ecological (organical) dimensioning of each subsystem, we'll try to enlight their own requirements and properties, leading them to be defined as specific processors.

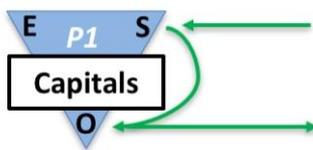
### ***« Capitals » subsystem – Inductive processor***

- **S social-cultural capital.** Pierre Bourdieu defines Social Capital as « the sum of resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition » (Bourdieu, Wacquant, 1992). In this acceptance, social capital shares a productive dimension with the economical system : « Social capital is defined by its function. Like other forms of capital, social capital is productive, making possible the achievement of certain ends that would not be attainable in its absence » (Coleman, 1990). Thus, social capital manifestation includes norms and values which facilitate exchanges, reduce information and transaction cost, permits trade in the absence of contracts, encourage citizenship responsibility, and, therefore, the collective management of resources (Fukuyama, 1995). This notion incorporates social shared values as knowledge, skills, attachments, cultural knowledge, education, training, co-operation networks, shared trusts and values of the population. Social capital is thus treated as a mediating variable, shaped by public and private institutions, which strategy combination has important impacts of development outcomes. It can also be a powertrade for cooperative action, through policies participation or collaborative intelligence : « Social capital refers to features of social organization, such as trust, norms, and networks, that can improve the efficiency of society by facilitating coordinated actions » (Putnam, 1993).

- **E economical capital.** It is sometimes separately considered as *financial* capital, which refers to the funds that are available to individuals and groups in a community. This form of capital can generate a flow of income to support the holder's immediate wellbeing, such as money, machinery and infrastructure providing physical assets of businesses and households, as well as public or community physical infrastructures. Community wellbeing is then produced by converting *stocks* ("inputs") to "outputs" such as *flows* of services; *economical capital* can also be converted into some other form of

capital contributing to community wellbeing.

- **O ecological (organic) capital.** This recovers goods and services items such as exploitation or transformation of natural resources, specific land-use and settlement patterns, biodiversity management, nature valuation, landscape preservation, sustainable farming and food production. Hence, the ecological stock represents objectified and accumulated labour (Bourdieu, Passeron, 1990) and context-related knowledge describes the interrelations between natural resources and amenity production: in one word, effective adjustments in land-use to reconnect nature with society (Swagemakers, 2008). As neo-classical economics stated a separate organisation from environment and a total freedom from biophysical constraints, economical think-tank interested with natural resources and environment introduced *ecological (organic) capital* notion to refer to the limited natural resources stocks, through considering economy as an open-growing totally dependant subsystem of a closed, non-growing finite ecosphere system. Thus, ecological capital dimensioning introduce a highly-ordered dynamic system governed by the second law of thermodynamics, its entropy being directly in- and out-putting to ecosphere energy/matter equilibrium (Rees, 2003).



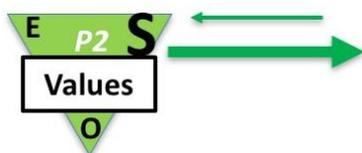
Capitals subsystem processor (source : Author).

Within this frame, Capitals (P1) works as an inductive processor, able to proceed to recursion operations. It works as a « information flow » I-O switch within its three dimensions, social-cultural, economic-financial or organic-ecologic.

« Values » subsystem – Scaling processor

The previous three kinds of capital, when combined, generate a wide range of "outputs", or wellbeing attributes, that are important in terms of community valuation. As a complex combination between economic, environmental and social life values, outputs that people may need or seek in order to maintain their wellbeing involve complex forms of capital that are the result of joined eco/socio/environmental inputs. So, communities can be considered as complex systems that provide economic, social-cultural, and environmental goods and services that contribute to societal amenities, produced by converting *stocks* of various forms of *capital* ("inputs") into *flows* of services, or common amenity attributes, or values ("outputs").

Therefore, a community resilience can be defined as a function of the capability to extent its available capitals in the three (social/ economical/ environmental) dimensions of sustainable development values.

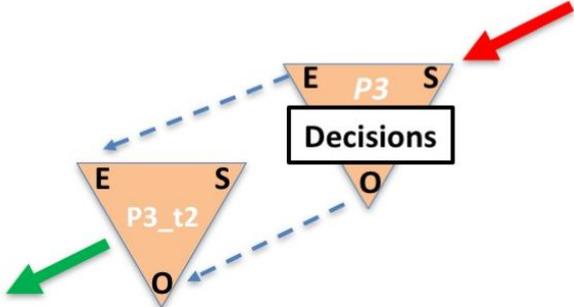


Values subsystem processor (source : Author).

Thus, values (P2) works as a scaling processor through an affinity transformation. It drives the sustainability priorities, acting on the « stock-flows » fluxus to enable economic, social or environmental (organic) valuation.

« Decisions » subsystem – Oscillating processor

Some forms of capital might be emerging while others become obsolete, so that equilibrium between social, economic, environmental value dimensions is subject to change with environmental conditions. Consequently, it is important to determine practices and policies for the decision making and political directions to follow sustainability laws time evolutions. Thus, decision-making should develop and adapt these previous capitals structure in function of value characterization during production/ consumption/ exchange processes between economy, society and environment.



Decisions subsystem processor (source : Author)

As a consequence, decisions (P3) works as an alternance processor, operating a phase set-up at every cycle of the system dynamics. It's a time processor, able to switch feedbacks from negative to positive values, or reciprocal.

*An application : the solidarity system during the 2012 drought in United States*

The United States is grappling with a widespread drought summer 2012 as severe as the historic drought of the 1950s. The US Department of Agriculture (USDA) reported that 55 percent of the pasture and rangeland was in very poor condition. On July 25, the USDA designated even more drought disaster areas, bringing the total for the 2012 crop year to 1369 counties in 31 states (Figure 3).

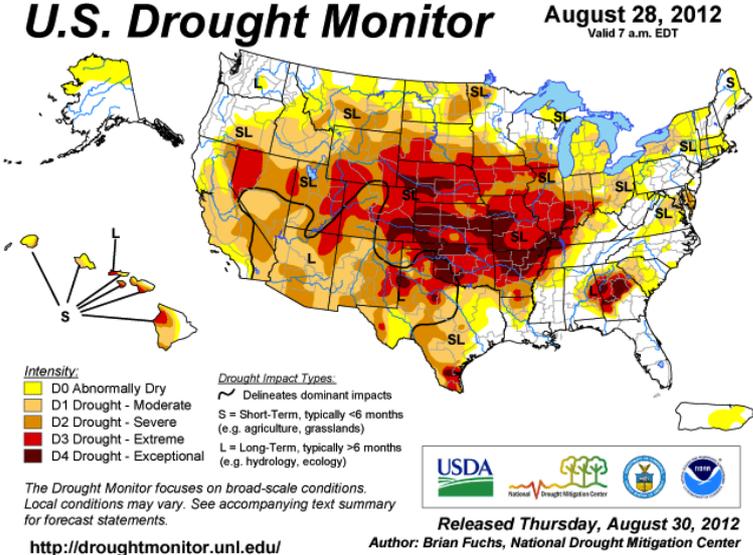


Figure 3: U.S. Drought Monitor (source : Reuters, 2012)

With more than 40% of US agricultural land now in extreme or exceptional drought, “Prices of both corn and soybeans soared to all-time highs, with corn climbing more than 50 percent in the past four weeks alone due to the worsening drought, squeezing livestock producer margins.” (Reuters, 2012-1).

As said Bruce Williams, Kansas-Phillipsburg agricultural cooperative director: "since 31 years doing this business, I never saw such prices fluctuations" (Reuters, 2012-2), it is not the price level that borrows producers, but their fluctuation periods, which have passed from seasonal (between summer and winter, namely) to daily frequency, which causes market uncertainty by unpredictable price variations. Thus, entropy of the whole E S O system is collapsing, implying a global crisis risk in agri-food sector as well.

*Negative Feedbacks : the drought crisis in three phases*

Severe drought of United States has immediately impacted the agricultural prices, with an increasing of +26% for corn and +41% for wheat at the international market.

Property (Entropy class)	Economical (Model E)	Social (Model S)	Ecological (Model O)
<b>Capacitance (Potential)</b>	Stocks decreasing Price Uncertainty	Governance failure	Climate stability/ change
<b>Conductance (Dissipative)</b>	<b>+26% for corn and +41% for wheat prices</b>	Hunger Line Powerty	US Severe Drought <b>40% of US agricultural land</b>
<b>Inductance (Kynetical)</b>	Market deregulation	Social risk perception	High temperatures Lack of water

Figure 4: The three passive components of the U.S. climate event (source : Woloszyn, 2012).

With the ongoing drought expected to destroy or damage a portion of the field corn crop in a number of states, increase in the farm price of corn affects the price of other crops, such as soybeans, and other inputs in the food supply such as animal feed.

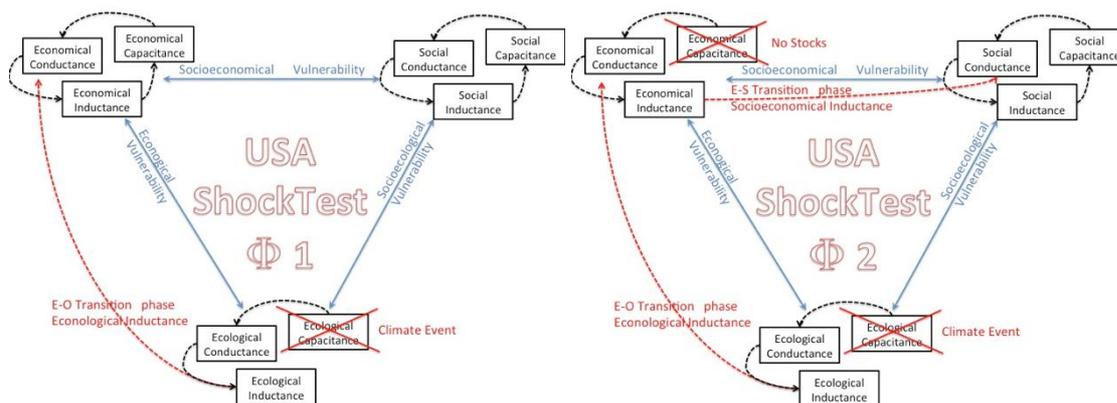
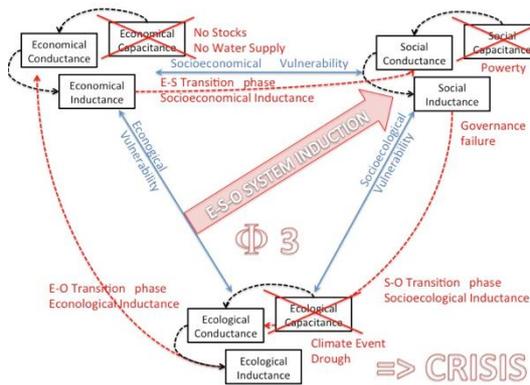


Figure 6: First (Organic-Economic) induction effect: phases 1&2 (source : Woloszyn, 2012).

This first (Organic-Economic) induction effect shown in figure 6 will then be followed with a second (Economic-Social) induction effect (Figure 7), thus squaring the vulnerability-sustainability triangle to enter a first induction phase leading to global crisis emergence.

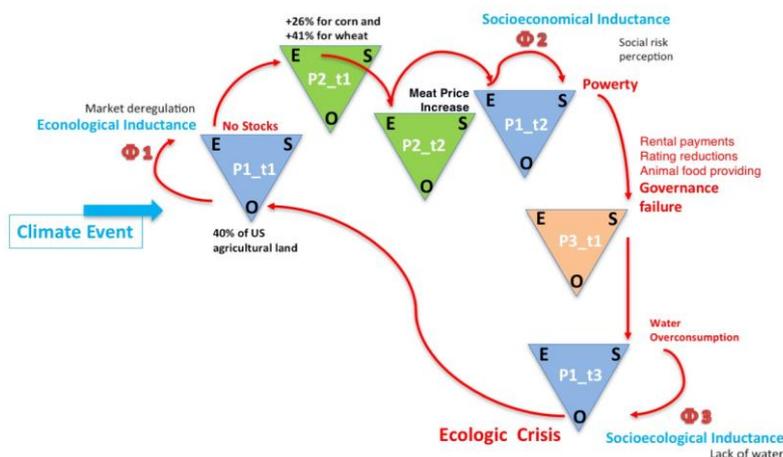


**Figure 7:** . Runaway and system crisis: phase 3, induced effect E-S, "Economic-Social" (source : Woloszyn, 2012).

While drought planning and mitigation responsibilities lie largely at the state and local level, the federal government also provides some drought planning assistance. But let us first analyse this crisis at (Capitals-Values-Decisions) subsystems interaction scale.

### Matrix Temporal Analysis of Crisis Interactions

Temporal analysis of negative induction effects on the interactions system shows three phases or distinctive temporalities to be described, following figure :



Cumulative negative induction effects as a global feedback loop between (P1-P2-P3) subsystems (source : Author).

- Ecological inductance (t1) : First phase deals with ecological lack of capacity to renew the “natural feeding” of cereals destined to human food and cattle feed. End of ecological capacitance.
- Socioeconomical inductance (t2) : Second phase of the crisis traduces the impossibility to answer the lack of cereals with an economical response. This implies the economical capacitance break.
- Socioecological inductance (t3) : Third phase returns to social impact of the two first phases on the farmer’s socio-economic situation, poverty and impossibility to maintain their livestocks. It’s the turn to social capacitance to fall...

During this process, each interaction subsystem is achieved, each one in a different manner :

Capital subsystem (P1) fails during the three phases, first through the cereal market deregulation (t1 : Organic-Economic interaction), second with the social risk perception (t2 : Economic-Social interaction), and third according to drastic lack of water (t3 : Social-environmental/Organic interaction)...

t1	P1	P2	P3	t2	P1	P2	P3	t3	P1	P2	P3
P1	O-E	E	S	P1	E-S	E	S	P1	S-O		
P2	E	E	E	P2	E			P2			
P3	S	E		P3	S			P3			END

Global interaction subsystems achieving (source : Author).

Value subsystem (P2) evolution is operating between phase t1 and phase t2, with the cereals and meat prices fluctuations, which causes market uncertainty.

Decision subsystem (P3) is here traduced by the federal governance failure between phase t2 and phase t3, with territorial unadapted decisions leading to the environmental impact of the farmer's socio-economical fail (impossibility to water cereals).

*Positive Feedbacks : Resilience as a responses to crisis*

As illustrated figure 7, when a drought is declared for a locality or region, U.S. Secretary of Agriculture sets in motion a series of alerts, recommendations, activities, and possible restrictions at the local, regional, or state level, depending on the drought length and severity. Ultimately, a multi-year severe drought could initiate a federal response and transfer of federal dollars to the affected area.

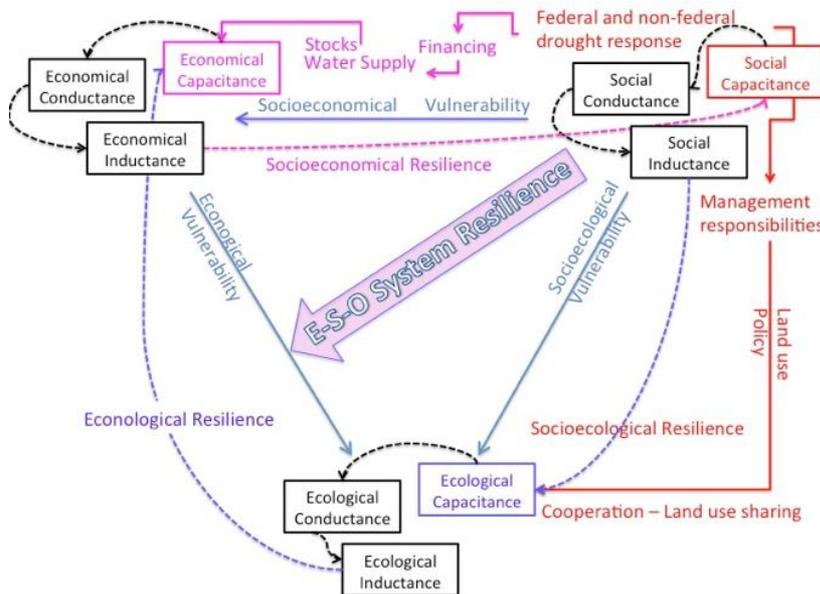


Figure 8: E S O System Resilience applied to U.S. 2012 Drought (source : Woloszyn, 2012).

In response to the 2012 drought, USDA agriculture federal department also has taken a variety of administrative actions. For example, it reduced the interest rate for emergency loans from 3.75% to 2.25%, a smaller reduction (10% instead of 25%) on rental payments, or the purchase of up to \$170 million in livestock and fish products to help ease the financial effects of drought on meat and catfish producers. (Shields, 2012). Congress may evaluate whether current federal practices could be supplemented with actions to coordination, and respond to the unpredictable but inevitable occurrence of drought. In passing the National Drought Policy Act of 1998 (The National Drought Policy Act of 1998, P.L. 105-199), U.S. Congress found an increasing need at the federal level to emphasize risk management, albeit unpredictability, of severe drought occurring (Leggett, 2012). It also may consider

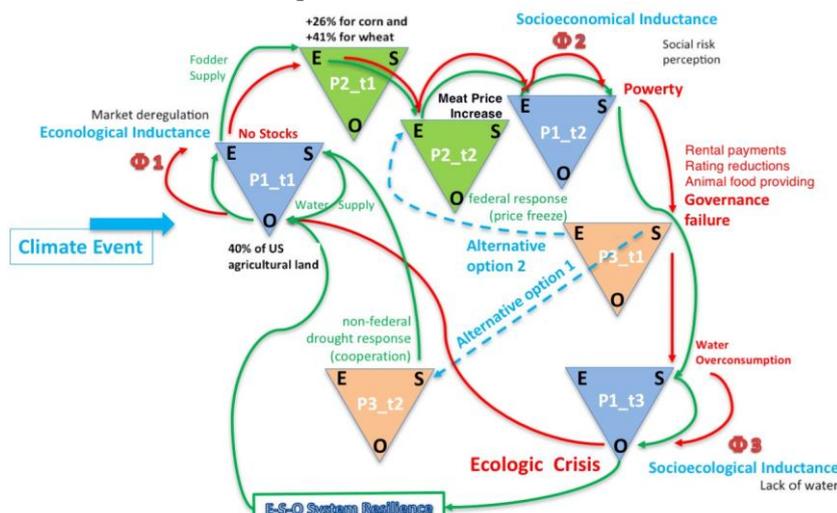
proposals to manage drought impacts, such as assisting localities, industries, and agriculture with developing or augmenting water supplies (Folger and alii., 2012).

By increasing economical capacitance of agricultural product units (farms), the federal government enable socioeconomical resilience to increase social capacitance, and therefore, to avoid social risks due to insufficient feeding supply. If this governance action increase the inductive fields of socioeconomical actions, this short-term federal response has to be completed with long-term policy rules concerning land use, pollutant emissions, and environmental preservation, in order to enable socioecological resilience to "square" the whole E S O system resilience.

### Solidarities Interactions Analysis

Temporal analysis of resilient positive induction effects on the interactions system is here described during its three phases :

- Socioeconomical resilience (t1) : Ecological lack of capacity to renew the “natural feeding” of cereals is here thwarted by solidarity between farmers : it consists here into cooperation about hay for livestock and complementary water supply for cereals culture. This can be assimilated to mechanical solidarity (relied with marginal freedom field), where social capital is replacing non-federal response.
- Socioecological resilience (t2) : Second phase of resilience implies pragmatismal solidarity (relied with interstitial freedom field), which consists into costless fields lend between farmers, thus overriding federal laws concerning land use sharing and supply valuation.
- Ecological resilience (t3) : Third phase organizes the organical solidarity (corresponding to the main freedom field), where the federal government takes back the hand with proposing new land use policies, supply price freezing and rating reductions, in order to avoid future socio-economical consequences of climatic events...



Cumulative negative and positive induction effects as antagonists global feedback loops (source : Author).

During this process, each interaction subsystem is sought in the following ways:

Capital subsystem (P1) is sought during the three phases, first with the cooperation between farmers, providing stocks of furniture in order to avoid (or repair) the capital capacitance, secondly through land use sharing, and third when the federal government organizes new land use policies.

Value subsystem (P2) evolution is essentially operating between phase t2 and phase t3, with regulating the cereals and meat prices fluctuations through the federal government act, in order to renormalize the food market.

Decision subsystem (P3) is here traduced by two alternatives, cooperative in a first time (relevant to the mechanical and pragmatismal solidarities between phases t1 and t2) and federal (relevant to the organical solidarity between phases t2 and t3) with adapted decisions, local (cooperative) and global (federal), thus leading to the socio-economical recovering of the food market.

Global interaction subsystems achieving is resumed on the following table, showing the main types of interactions between sustainable developments pillars.

Solidarities	Main Regulation Domain	Hybrid Evolution Laws	Freedom fields
<b>Pragmatical</b> Solidarity as a transgressive value	<i>Economic (Financial)</i>	<i>Inductive-scaling</i> 	<i>Interstitial</i>
<b>Mechanical</b> Solidarity as collective behavior	<i>Environmental (Ecological)</i>	<i>Inductive-alternance</i> 	<i>Marginal</i>
<b>Organical</b> Solidarity as a social function	<i>Social (Cultural)</i>	<i>Scaling-alternance</i> 	<i>Main</i>

Functional equations involving the three (capital-value-decision) subsystems (source : Author).

As economic (financial) interactions are relevant from Pragmatical solidarity, ecologic (environmental) interactions from Mechanical solidarity, and social (cultural) interactions from organical solidarity, this last describes the following behaviour :

- Pragmatical Solidarity, allowing economical regulation of the interaction system, follows inductive-scaling laws under Interstitial degrees of Freedom
- Mechanical Solidarity, allowing environmental regulation, follows inductive-alternance laws under Marginal degrees of Freedom
- Organical Solidarity, allowing social regulation, follows scaling-alternance laws, under Main degrees of Freedom

The result of this multidimensional solidarity resilience is the stabilisation of the market price of water, cereals and meat, passing from a short-time fluctuation signal to a quasi-asymptote at daily scales. Here, resilience acts as a “damping factor” of the whole exchange system.

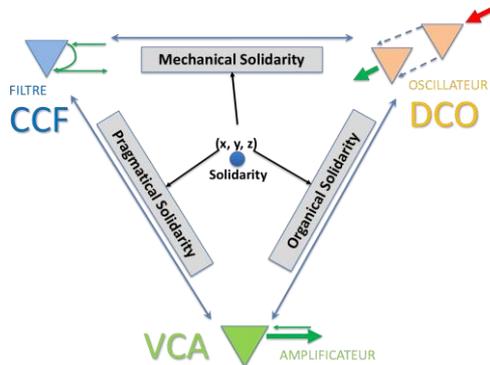
This confirms that territorial resilience can be conceived as a hybrid process located at the intersection of several spatiotemporal dynamic trajectories that interfere each other. These trajectories imply very uneven times of realization and spaces of expression between the social, economic and ecological frameworks of sustainable development, which resilience dynamics acts on intricate time scales.

Adaptive capacity of a population to face a crisis is here understood as a solidarity-driven resilience inductive process within the decision-action space. Achieving sustainability goals through effective economic, social and ecological reforms as a route to the sustainability transition may propose societal anticipation and socio-cultural response to environmental transitions. Based on an analysis of trade-offs between social, ecologic and economic development priorities in ecosystemic context, we propose therefore a framework for temporal evolution modeling of the main factors of territorial solidarity leading to resilience.

Now, we'll try to built an analogy between (Capitals-Values-Decisions) subsystems, and oscillating-filtering-scaling operations, linking actions to be decided with environmental observations, first through the shape of a feedback loop between decision making and Capitals building<sup>2</sup>.

<sup>2</sup> Main used in electronic music, sound synthetis involves periodic electric signals that can be converted into sound by amplifying them. The more classical way to do this is to start with geometric waves (square, sawtooth, triangle...), which are rich in harmonic content, and

## From decision to action



Capitals-Values-Decisions subsystems: a sound synthetis analogy (source : Author)

The differential inertia associated with (P1, P2, P3) subsystems is parameterizable by the "slope" of temporal evolution of the successive levels of the system state entropy<sup>3</sup>: it is thus a modelizable evolution in sinusoidal form whose maximas and minima represent the entropy peak levels, the "pulse width" retranscribing inertia level of each subsystem, which defines the time behavior of the associated signal.

Concerning the « decision » P3 subsystem, let's consider a Decision Controlled Oscillator emitting an information flux  $\Phi$ , under an oscillating regime producing running waves trains.

Therefore, DCO alternation processor phase shift of the signal gives :  $F(\Phi) = \sin e^{2\pi t}$ , where  $\pi$  represents the inertia frequency of the decision system.

Filtering operation of this train waves is then proceed by CCF (Capitals Controlled Filter), which controls the envelope of the structured information, the frequencies of the decisions oscillator can thus be whittled into axiologic harmonic structures.

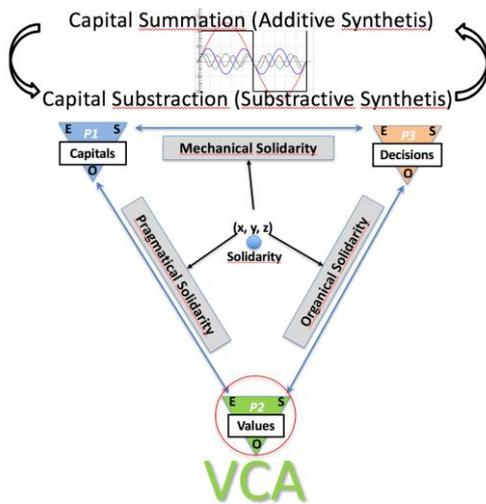
Outputs of the the Capital subsystem filter, also called Capital Controlled Filter (CCF), is then back-modulated by the Decisions Control Oscillator (DCO), thus creating an information treatment loop, combining information wave filtering and modulation by Capitals subsystem processor. This loop operates a symbolic construction from observations of the environment, considering it as an inference mechanism formulating hypotheses to compare gradually with the perception of the environment. This "behavioral internalization"<sup>4</sup> of environmental data allows permanent adaptation of the system to the evolving environment, by successive jumps, constituting loops of feedback between information input (decision) and output (action).

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filter the harmonics to produce a new sound- *subtractive synthesis*. Another way is to simply add various amplitudes of the harmonics of a chosen pitch until the desired timbre is obtained, called *additive synthesis*. Usually associated with FM Synthesis, employing a modulator oscillator that varies the frequency of the sound signal to produce new harmonics, generated signal is also filtered and amplified.

<sup>3</sup> By measuring the average value of information in messages, entropy is a measure of the uncertainty of this information associated with a random variable. Shannon's theorem gives one of the possible interpretations of the latter: the average number of symbols necessary to code the values of the signal, which expresses the quantity of indeterminacy according to what is known about the statistical structure of the source of the signal.

<sup>4</sup> Used in artificial intelligence systems, these inference mechanisms determine the evolution of the cognitive system by the permanent adaptation of its sensorimotor system to its context

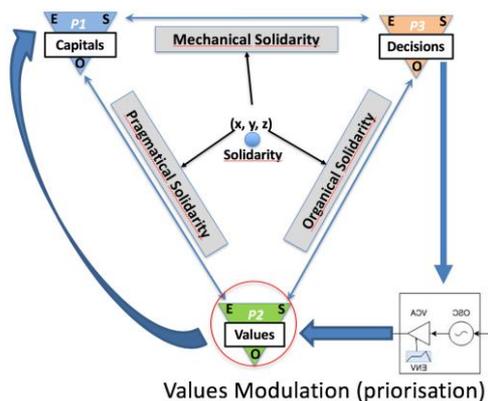


Information treatment loop between DCO and CCF (source : Author).

These feedback loops are here described by the temporal sine function of autocorrelation, as the decision act infers the present state to the estimation of the future modification of this state. Measured by entropy, the transmission dynamics of information then constitutes an adaptive function which asymptote corresponds to the coincidence of the repertoires of the interacting subsystems, equilibrium. So, this "informational impedance adaptation" directly influences the information coding from (DCO-CCF) to VCA. The regulated system thus apply this adaptive function by operating a symbolic construction from observations of the environment (Moles 1990).

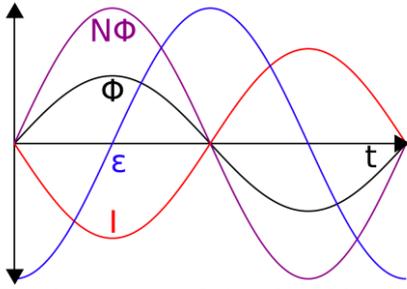
DCO-CCF subsystems loop operations then acts as a modulator of the incoming information wave signal, measured by its entropy, with specific evolutionary forms, mainly as tensors components. Loop combination of subtractive and additive synthetis between decision subsystem (DCO) and capital subsystem filtering (CCF) is then a function of the exchange values, VCA (Values Controlled Amplifier), modeled by a decision « envelop » which controls the global timing scale of the output axiologic process.

The VCA is thus considered as a scaling processor, modifying the information flux circuit according to :  $N\Phi = \sin N\omega t$



VCA information treatment (source : Author)

Resulting DCO signal, N-factor scaled through VCA envelope, and modulated through DCO-CCF loop constitutes the complex decision-action process of the solidarity system. Decisions becomes action.

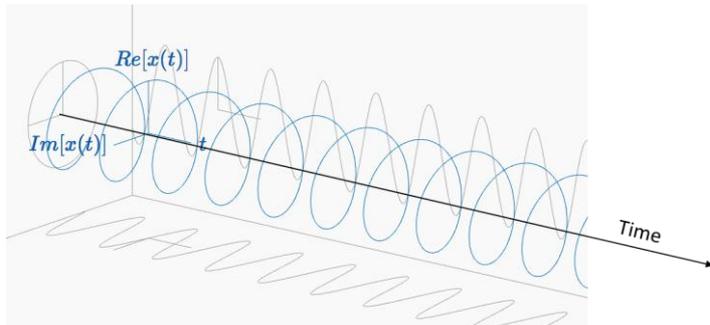


The three types of signal within the solidarity system : DCO emitting signal  $\Phi$ , N-factor amplified signal through VCA, and modulated phase shift signal loop (DCO-CCF) (source : Author).

*Inductive output of the model*

Thus, the harmonic character of a generated axiologic waveform depends of the three processors (DCO- CCF-VCO) interactions, between decisions emission, capitals filtering and values modulation. The output of the system can thus be represented by a complex exponential of frequency f:  $x(t) = \exp(j2\pi ft) = \cos(2\pi ft) + j\sin(2\pi ft)$  where  $j0$ , inductive reactance of the whole system, can be represented by the complex number such that  $j0^2 = -1$

The complex exponential is here described on the three subsystems planes P1-P2-P3: we will notice that two of these projections P1 (Capitals operator) and P2 (Values operator) are a cosine and a sine signal, which respective operations with the decisions subsystem P3 represents real and imaginary parts of the dynamical output of the system.



Complex output of the system (source : Author).

Resulting entropic inductance signal  $K_p$  is given as a temporal sine function of autocorrelation, which varies in cylindrical coordinates as  $\Phi = \sin \omega t / \omega t = \sin 2\pi ft / 2\pi ft$ , which can be represented by a tree-dimensional tensor that rotates the reference frame of a three-element vector as a DQO or DQZ transform<sup>5</sup>.

$$K_P = \begin{bmatrix} \cos(\theta) & \sin(\theta) & 0 \\ -\sin(\theta) & \cos(\theta) & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

Rotation matrix of the P1, P2, P3 subsystems (source : Author).

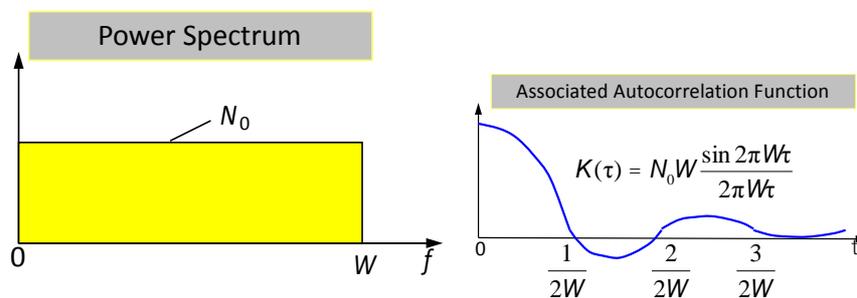
The transformation projection of the three separate sinusoidal phase quantities constitutes a geometric interpretation of the imaginary part of the working frequency  $j0$  (inductive reactance) of the complex output of the axiologic system.

*Damping time patterns of global evolutionary systems*

<sup>5</sup> Direct-quadrature-zero (DQZ or DQO) transformation transformation is a tensor that rotates the reference frame of a three-element vector or a three-by-three element matrix

By quantifying the entropy of the information exchange levels by time step, we are therefore able to evaluate the variability of the transmission flows during the interaction sequence between the involved subsystems. This sort of "axiological impedance" constitutes the transmission capacity of the realizable information under the condition of mutual (P1 P2 P3) subsystems evolution. This impedance therefore defines the axiological transfer functions of the transmission from the generator subsystem (P3) in the form of filtering (P1) and / or amplification at the output (P2). The output of the system then constitutes an affine multiscale signal (with the shape of a complex wave form) whose information dimension is quantified by the temporal evolution of its entropy level, transcribing the regularities of the solidarity system.

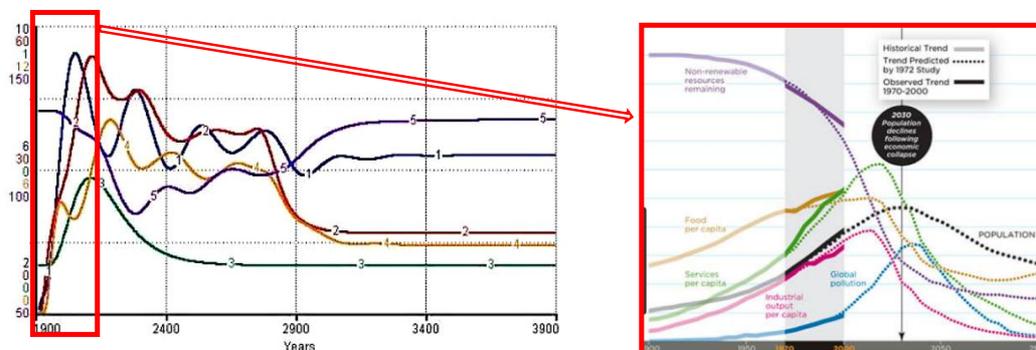
The axiological impedance of the (Decisions-Capitals-Values) subsystems thus defines resilience as a form of "damping factor" of the whole solidarity system. As a consequence, resilience constitutes the main variable of the transfer function that moves the system from one state to another, and determines both intensity and duration of the solidarity axiological exchanges signal during a transition phase. This train of temporal fluctuations can thus be quantized by its "Power Spectrum", which "probability density" of solidarity system events is approximated by the entropy level time evolving, as an "Autocorrelation Function" of the system as following:



"Power Spectrum" and "Autocorrelation function" of the interaction system (source : Author).

Autocorrelation Function thus constitutes a sine-function of information flow entropy evolution during the interaction time, signed by the maxima and minima values of the entropy periodic sine signal, describing a system of oscillations of decreasing amplitude of "sinx / x" type. Those evolution modes alternating peaks, oscillations and stabilizations reveal a turbulence regime specific to the transition periods of an evolving system, whose signal amplitudes reveal the long-term decreasing character of the sustainable development system. This intermittent signal is typical of dynamic modes of transition systems behavior, as the evolutionary models of human development.

In long time evolution patterns, following evolutionary models of human development shows damped oscillations as the result of phase shifts between the short and longer term panarchic evolutions of each social, economic and ecological dimensions of development, as seen next figure:



Compared simulations of world changes between - on the right side - Meadows World model (Meadows and alii, 1972) and - on the left side - SDSIM model (Jackson et Senker, 2013) showing evolutions of world population (1), gross industrial production (2), energy availability (3), average per capita consumption (4), and trends in Social cohesion or "solidarity index" (5).

This “long time evolution” model can also be interpreted as an extrapolation of Meadows “World Dynamic Model”, showing a collapse of the global system, namely the world population, after accelerated growth and resource exploitation. Within evolutionary models of human development, Meadows collapsing previsions can be interpreted as a first phase of a global evolutionary model of development, involving damping time patterns of environmental system long-term transitions, showing decreasing amplitude oscillations of the "sinx / x" type. This global autocorrelation function of man-environment interactions is particularly noteworthy in the evolution of population growth (population / GDP ratio-per capita consumption of material goods and services), the rate of consumption of resources (presenting a "peak of dependence" on fossil fuels and then addressing a long decline, namely the "Oil Peak" described by Jeremy Rifkin, 2012), and the solidarity index<sup>6</sup>.

### ***Conclusions***

To solve climate-related problems, the way people act together through coordinated cooperative actions is primordial for eco-social capacitance long-term increasing, and therefore, resilience induction.

As resilience can be considered as the adaptative capacity of the population to manage solidarities cooperations in the three dimensions of freedoms fields, complex output of the interaction system allows us to obtain a functional and dynamic reading of the balance between solidarities, depending on how the social-ecological system organizes itself in response to management actions.

Therefore, this adaptative capacity is here understood as a solidarity-driven resilience inductive process within the decision-action space. Thus, achieving sustainability goals through effective economic, social and ecological reforms as a route to sustainability transitions may propose societal anticipations and economical response to environmental brutal changes.

Thus, solidarity system dynamics, as a function of the temporality of its (decision, capitals, values) processors can be described by a complex wave mechanics model whose temporality is a function of the articulation of the three freedom fields.

A resilient community should then be able to extent its available capitals through the corresponding solidarity modes dimensions, in order to find a viable sustainable way for territorial development, even within crisis conditions.

Solidarity can then be thought as a hybrid process located at the intersection of several spatio-temporal dynamic trajectories of interfering systems and subsystems. These trajectories coexist in the cybernetic cycle of communicational inference, the ontological basis of the decision-action process. Formalized by the temporal signature of interactions, they illustrate the temporality of the transition from the decision state to the action one.

This model takes part of the emergency message from scientists to be sent to the nation’s consciousness, to enable convergence between decision-making and cooperation action within sustainable development, in order to take care of our common biosphere, and to make our planet livable again.

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<sup>6</sup> Solidarity index is defined here as a non-linear function of human population and consumption in relation to the sustainability of resource use

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