Chapter 1
Towards a Transdisciplinary Ecological Economics: A Cognitive Approach

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an extractive economy is a terminal economy.
Thomas Berry

1.1 Introduction

It is clear that humankind and especially western civilization is in the middle of a multidimensional global crisis that involves all aspects of human living, including its own long-term survival (Max-Neef 2010; IPCC 2011). It is also clear that through the advance of environmental sciences in the last two centuries,[1] we have been able to clearly identify the main scientific causes of such crisis, and the technical solutions to escape from it. Moreover, the environmental sciences were able to predict the arrival of such global crisis with deep and accurate level of details since

[1]Malthus stated one of the first scientific critics to growth as a way of progress, with a simple mathematical demonstration of the demographic limits. After 220 years of its publication, his critic remains valid.

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at least 50 years ago.[2] In other words, the science developed until half a century ago was capable to:

- Predict the current global environmental crisis
- Understand the main causes of it
- Propose what kind of human behaviour (development) was necessary to resolve it

Therefore, we can claim that the global environmental crisis, and our capacity to manage it, is not due to a lack of scientific knowledge or unknown facts. Although the complexity of the natural world implies unpredictability in many processes and phenomena, the drivers and causes of such global change are known since long ago. In fact, in the last decades, the environmental sciences have not neglected the causes originally identified, but rather reinforce its validity through an ever-increasing stock of evidences. It is somehow frustrating to realize that most of the scientific work on environmental sciences in the last decades simply sum more evidences to what was already identified as the main causes of the environmental crisis. In other words, science has focussed on *knowing* more, but not necessary *understanding* more (Max-Neef 2005), perhaps because the main cause of the global crisis is not a scientific one and goes beyond the scope of natural sciences or sciences as a whole. This suggests that it would be incorrect to expect a solution for the crisis from the field of natural science and technology, as under our view the duty of science is already accomplished. That is, setting specific questions regarding the global crisis and proving with evidences the hypothesis that answer them.

As societies have not yet seriously tried to abolish those main drivers of the current crisis, identified long ago by natural sciences, the relevance of technology in proposing a concrete solution (e.g., renewable energies) is limited by the existence of discrete natural boundaries. In other words, technological solutions may move the frontiers of the feasibility, and therefore resolve the problem temporarily, but as long as, for example, an unlimited economic growth imperative exists, the system is determined to collapse. In other words, the civilization and its economy cannot run through "business as usual" if the main biophysical causes of the crisis have not been addressed.

Consequently, we identify a dramatic gap between what is *known* and what it is *done*. Therefore, the core of the environmental crisis lays not in a crisis of knowing (science), but in a *crisis of consciousness*, regarding our relationship with nature and ourselves, and our ability to detach from old patterns of behavior and to change according to what evidences, for so long and so clear, are telling us.

[2] Although there are many previous scientific works giving the same framework, "The Limits to Growth" (Meadows et al. 1972) of the Club of Rome addressed many problems that we are facing today.

1.2 Cognition

In this chapter, a background of cognitive science is used to deal with the problem of transdiscipline regarding the study of forests and nature in general, and its consequences in the way the rationality of neo-classical economics works. However, cognitive science is part of a broader set of disciplines and sciences that share a holistic, systemic, transdisciplinary and postmodern approach to knowledge. In these terms, many of the postulates in this article can be also expressed in other terms by those disciplines, that include phenomenology, systemic epistemology, second order cybernetics, quantum physics, to name a few. Also, this chapter is a very brief summary of referential concepts of cognitive science that is requested in the development of the next chapters.

Cognition is the science of the process of knowing. Since it has inputs from different disciplines (philosophy, neuroscience, semiotics), it is an "interdisciplinary discipline". Cognition can be considered "a promising starting point towards an appropriate and unifying paradigm" in relation to the needs of interdisciplinary approaches (Röling 2000: 5). Among different trends within the science of Cognition, the Santiago Theory of Cognition developed by Humberto Maturana and Francisco Varela provides for the first time a scientific theory that overcomes the Cartesian division of mind and matter (Capra 1997). One of the big insights of the theory is to resolve the crossroad about the relation between the brain and mind. For Maturana and Varela (1980) the relationship between mind and brain is simple and clear: the mind is not a thing, but a process, and the brain is a structure through which the mind is performed. In the same theory, life and the process of knowing are united. In other words, the central insight of the Santiago theory is the identification of cognition with the process of life (Capra 1997). The mental world is not separate from the physical process of living, but an intrinsic characteristic of this process, as living always entails knowing. In words of Maturana and Varela (1980) "Living systems are cognitive systems, and living as a process is a process of cognition. This statement is valid for all organisms, with or without a nervous system".

As cognition is a research field about knowledge, it is well related to the philosophical study of knowledge. *Epistemology* is that branch of philosophy that deals with the nature of knowledge and creation of new knowledge (Novak and Cañas 2008). This gives special relevance to the discussion of the role of language under a cognitive prospect, as philosophy and sciences are realized through language.

1.3 The Emergence of the Environment

Curiously, what we understand as the environment is ever changing, and the valorization of the environment also changes accordingly. This is so, because we as observers actually do not depend on our environment, but on our ecological niche.

The first is what is distinguished by an observer, and the second is where the domain of existence of any living being actually occurs (Maturana and Mpodozis 2000). For example, if we observe a tree, we can distinguish its environment simply by looking at the tree's surrounding. However, what we can see of the tree's surrounding is only what our senses allows us to see. Actually, the tree interacts and depends on many more features than those that we can distinguish for its process of living. We cannot see the underground interactions of millions of root radicals exchanging elements with the soil, nor can we see (but roughly infer) the gas exchange of its leaves with the atmosphere. The sum of all features of the environment is what sets the niche as the actual domain of living of the tree.

The same phenomenon happens to us in relation to our environment. Our environment is not an objective set of discrete resources, but an always changing perception as long as we can distinguish new elements of our niche. Here, a great paradox takes place: as long as we human species have an ever-increasing impact on the biosphere, new elements of the niche emerge from our alteration of it, setting new perceptions of our environment. For example, 200 years ago, we gave no attention to the electromagnetic environment, or to the air and water quality in most of the cities. The attention started when the original features of our niche started to be altered. Just as the French surgeon René Leriche (1879–1955) stated, that "*Health is life lived in the silence of the organs"* (Fantuzzi 2014), as we feel the organs just when they become ill, the new features of the environment frequently appear as a result of our modification of the natural features of our niche. Certainly, there is a coherence between this view and the classical economical view of demand and supply: as scarcer a resource becomes, it gets more expensive (ceteris paribus). So, why so many features of our environment have not been valued even until today by neoclassical economics, considering that some of them are essential for our survival? We will come back to this topic in the discussion of the quantitative focus of classical economics.

1.4 Distinctions and Objectivity

The operation of *distinction* is the basic operation that an observer performs in the praxis of living, through the specification of an entity by operationally cleaving it from a background (Maturana 1988). In the operation of distinction an observer brings forth an entity (a unity, a whole) as well as the medium in which the entity is distinguished and entails in this latter all the operational coherences that make the distinction of the unity possible in his or her praxis of living.

As the perception is determined by the structure of the nervous system, the observer can distinguish only what triggers in him or her a cognitive process that takes place and is defined by the characteristics of the nervous system as such. In this way, the perception is limited by the structure of the observer. As we cannot perceive what is out of our cognitive domain, the process of cognition is driven under a *Structural Determinism.*

The nervous system has an organization closed to the outside, and only operates realizing *senso-effector* internal correlations (Maturana 1989). This way, through our senses the environment triggers in us a cognitive process that takes place and is determined by the nervous system, in which such environment does not participate. Because of that, we cannot refer to an external reality independent of us (Maturana 1988).

In life, in the cosmos, in the existence in general everything is, directly or indirectly, related to everything else. As everything is moving, under certain scales of space and time every phenomenon has a connection with any other, and with the wholeness. Many of those relations are happening at every moment, although not fast or slow enough to be perceived by us, or simply not sensorially (materialistically) felt, just as gravity, synergy or empathy. We can measure some variables related to them, but actually not see them. We do not see the history of a person, although his/her history allows him/her to be there. We do not see the mining field from which a knife has come, although the mining place and the metal of the knife have been mutually transformed, so that there is a relation between the knife and how the mine looks today. Knife and mine are parts of one whole process, related to the history of culture (mining, cooking, etc.), to the process of tectonics that had made the iron emerged, to the history of the supernova in which the iron was made, to the origin of the universe. But in our experiences, those processes or the components of them seem to us as being different realities. Those realities appear from a physiological process that allows us to set boundaries of a phenomenon, so as to specify it as a unity and therefore allows us to see it as an individual experience.

Most probably, this fact played a role in the adaptation of organisms to environments, developing the capacity of differentiating events and developing skills accordingly, but also to become speaking organisms, as distinctions seem to be the base for the development of language. In fact, what we "name", that is, what we identify with a word (concept, idea), is commonly not a "thing" but a distinction, so that there is a strong relation between what we distinguish and what we specify linguistically.

First distinctions were probably sensorial encounters with nature, which explains why there is a correlation between ancient times and languages that are simple and resemble nature. As distinctions are recursive, that is, they can be configured from within previous distinctions, language and human life (culture) has gotten more and more complex (and less natural) building with time an "artificialized" society that has lost contact with the natural world.

The act of distinguishing happens to us as a cognitive process realized by our nervous system. If we cannot distinguish, we look, but we will not see; the process of distinction is at the core of our adaptation as living organisms. It takes place in ourselves, in our own nervous system, and not in the phenomena we are distinguishing. It is a dynamic internal experience that allows us to take contact with the world we live in. But as an internal process, it is not the world itself what we perceive, but only our human way to apprehend it. What we see is not a world independent of us, as the objectivity concept implies, but the result of the encounter of us with the world as perception is a process that results from this encounter.

Therefore, we are involved in what we perceive and distinguish. As perception is realized through the body, it is a personal experience, not sharable with others. We can *speak* to others about the experience, but not transfer our experience to others. Moreover, as different human groups (that is, different networks of conversations) follow different paths of interactions among them and with their environment, those different human groups frequently (if not ever) perform different distinctions, which explain why different cultures see the world so differently.

Deep in the origin of the western culture was the believe in the existence of a natural law that can be rationalized and comprehended. With arise of Enlightenment, the believe in the immanency of the physical reality, governed by hard incorruptible laws independent of us humans, set the core for believing in an objective reality. In fact, the very essence of the objectivity is the domain of a physical reality, as its root is the "object",[3] that is, what can be touched, felt by the senses. In this way, the objective world is essentially a materialistic world, as only counts what can be seen, accounted, quantified. However, objects are also not realities independent from who sees them. The very act of distinguishing an object entails a linguistic act and, therefore, it is dependent on a specific culture that sets the object as such.

In everyday life, objects appear to us as immanent realities. Somehow, they have become the symbol of an immanent reality independent of us, and likewise gave the name for that modern paradigm: the objectivity. As a difference observed by our visual perception is the basic process of distinction (i.e. setting different colors), entities that have visible boundaries are more universally distinguished, that is, the consensus among observers will be almost absolute (borders are visible to everybody). This particularity of "things" gave the study of objects (like in physics) such a robust degree of unquestionability. Additionally, objects are also *discrete unities*, which allow them to be *counted or numbered*. That opens the objects to be taken into "account" by the field of mathematics, which are then welcomed to modern natural sciences, that base most of its methods on a *quantitative* approach.

"Things", that we have called objects, are indeed specific distinctions configured by us as observers. Consequently, as those distinctions are useful, they began to pervade the linguistic domain (the domain of collective coordination) so that we name them and, in this way, objects start to become realities for us, ever more "solid" as more people and time are involved.

Hence, what western society has stated as objective knowledge is in fact knowledge that is consensual, consolidated as "truths" among human groups from a specific background in an specific age. That is why objective truths are ever changing through the history, as new knowledge changes the mainstream believes through different cultural processes (von Bertalanfy 1955; Popper 1959; Kuhn 1970). This way, according to Varela et al. (1991) what we named as objective is

[3]Etymology (https://www.etymonline.com/): from Medieval Latin objectum "thing put before" (literally "thrown against"). Late 14c., "tangible thing, something perceived or presented to the senses".

in fact an "intersubjective" phenomenon, as the subjective individual knowledge is consolidated through the collective consensus.

1.5 Distinctions and Language

Language made us become humans. Language is not simply a form of communication but is what has defined the human species as a social species that self organizes through linguistic interactions. As Maturana (1988) states, "whatever takes place in the praxis of living of the observer takes place as distinctions in language through languaging, and this is all that he or she can do as such". He also proposed (Maturana 1989):

(a) That language is a manner of living in recurrent consensual coordination of actions.
(b) That the human manner of living entails among other things, a braiding of languaging and emotioning that he calls conversation.
(c) That human beings arise in the history with the origin of language, and the constitution of a lineage defined by the conservation of an ontogenetic phenotype that includes conversations as part of it.
(d) That the magnitude of the involvement of the brain and anatomy of the larynx and face in speech as our main manner of languaging indicates that language cannot have arisen later than two to three million years ago.
(e) That rationality pertains to the operational coherences of languaging and that different rational domains are constituted by different basic notions that are accepted a priori, that is, on preference.
(f) That responsibility and freedom are a function of our awareness of the participation of our emotions (preferences) in the constitution of the rational domains in which we operate.

We do not perceive an objective reality independent of us but, instead, we perceive what reality triggers on us, mediated by the process of distinguishing that is performed and determined by our own nervous structure. Let us say again that our "reality" is built upon a set of distinctions instead of objects or discrete unities of information from the "outside world". Therefore, there is a deep relation between distinctions and language as a coordination process among our human groups. As relational processes, distinctions can be considered direct stimuli (like colors or shapes), or relations between those stimuli (like distinguishing a shape or color as an object), or relations that have no stimuli or sensual dimension (like any kind of non-material relation: observations of order, danger, similarity, justice, categories, etc.).

Language shares that relational nature. Words are far more correlated with distinctions than with physical "things", as words can have abstract or relational meanings, just as distinctions do. In other words, we propose that words are originated by distinctions that become common and then are shared within a human

group through a process of coordination of actions. That happens in the course of the collective use of such words that become consensual. Words are then not objective realities but refer to specific distinctions. However, although we become coordinated through language, experience is always personal. According to Maturana (1988):

> ... objectivity in parenthesis[4] entails the multiversa, entails that existence is constitutively dependent on the observer, and that there are as many domains of truths as domains of existence, she or he brings forth in her or his distinctions.

1.6 Language and Ideas

Ideas occur in language and, therefore, are strictly related to the nature of linguistic distinctions. That is why ideas can be communicated, have certain logic (coherence), and can be understood. In fact, any distinction in the linguistic domain is simultaneously an idea, including the concept of "reality" that takes place in language.[5] Mathematics is also a language that has its own validity codes and logic. As words, also numbers are distinctions, not objective realities.[6]

Commonly language operates within an internal rationality that gives language its coherence. In western societies, such structure is given by logic: a reality that is structured and through this logic structure behavior is able to be inducted, deducted and predicted, giving us the feeling of sense and the power of control of nature. In the words of Maturana and Varela (1980):

> Language does not transmit information and its functional role is the creation of a cooperative domain of interactions between speakers through the development of a common frame of reference, although each speaker acts exclusively within his cognitive domain where all ultimate truth is contingent to personal experience.

Language entails a rational mind, but there are other mental realms. These realms belong to the pre-linguistic or non-linguistic mind. If we use the term "non-linguistic" (or "non-rational"), we jump into a cognitive domain to which we cannot speak about directly, because obviously we can only speak through a linguistic interaction. With that we refer to a level of cognition that is not intermediate through the rational mind, as found in animals, pre-linguistic children, in a contemplative or life-in-danger experiences, that can also be achieved with meditation techniques. It is the state of mind in which reason is not operating. An experience can be non-linguistic, but it becomes linguistic as soon as we think or talk about it.

[4] With parenthesis is meant: Objectivity under question.

[5] *Reality* is a word, and therefore it is a linguistic construct and not an objective reality.

[6] In the logic and validity codes created by the language "mathematics" $1 + 1 = 2$ may be defined as a "reality".

1.7 Ideas and Culture

As words and ideas emerge in the collective interplay of social communication, they change with the evolution of such communication as another kind of biological process. In the process of being educated, we are taught to perform certain configurations of distinctions, so that such configurations end up being the way we perceive the world. The dominant ideas of every era configure the cultural background that sets the identity of every human group, community or country. In this way, the culture can be considered as a network of conversations (Maturana 1997). Any network of conversations entails a way to see and approach the world. As every network develops under its own environmental and social background, everyone develops a different view of reality.

1.8 Culture, Disciplines and Science

Defined as a closed network of conversations conserved through generations (Maturana 1997), cultures are any community of members related by a discrete (with boundaries) network of conversations, not only determined by countries or land-based groups. In this sense, any discipline, as it entails a community that shares a common tradition and specific knowledge, is a smaller network with operational closure, being simultaneously part of a culture. The etymology comes directly from the Latin "*disciplina*", (instruction given, teaching, learning, knowledge) which in turn comes from the word "*disciple*" (pupil, student, follower),[7] as followers of a master or a tradition regarding a specific knowledge. Just as any discipline, different sciences have their own different masters (or science founders) and are also defined by a common cultural background of history and ideas. In general, scientific disciplines roughly share the bases of scientific knowledge,[8] including the scientific method, the rationality and the prevalence of evidences over beliefs. However, every scientific discipline has its own way to describe reality which are commonly not transferable to another. This is precisely why every discipline is fairly closed in linguistic terms, that is, each person uses different logics, driven by different sets of distinctions (that is why they are focused on different problematics of reality).

There is only a thin line between disciplines and sciences, acknowledging science as a group of disciplines. In this way, a scientific truth is also a contextual consensus, situated in space and time and enclosed within the so called "scientific community".[9] Science is also a network of conversations that shares a common

[7] https://www.etymonline.com/.

[8] It is therefore very difficult to find a universal definition of science, and there is no universal consensus about a definition of science among the scientific world.

[9] In this context it is noteworthy that the former German health minister Ulla Schmidt in an official statement wrote that it was an "international consensus" that HIV caused AIDS (Schmidt 2004).

rationality. Contrary to the common belief that natural sciences were "hard" sciences in terms of their supposed objectivity, and social sciences were "soft" –as they would be subjective and impossible to prove and in which postulates would depend always on whom state them– natural sciences share the subjectivity with social sciences.

Science as just another set of human knowledge, is primarily a collective process. That is, it works through the exchange of ideas, the recognition of consolidated ideas that are taken as common base, and the exercise of demonstration or, in other words, a process in which a statement must be proven to the (scientific) community. The approval of a certain statement depends more on the time in history and place, than on an (supposed) inherent value of truth. In fact, there is no such thing as an imminent scientific truth, but an ever-changing set of assumptions that is evolving, built upon the preexisting knowledge and sometimes with radical changes (what then often is called "revolution"). This is what is at the core of the works of Popper (1959) and Kuhn (1970) with the context of paradigm, and that is coherent with the cognitive model that is being developed in this chapter. The sets and beliefs change through time, but they are not something without frame or just relative; at each time they seem to be solid, as every age has its own consolidated truths, just as many other sets of knowledge. For science the earth was flat 500 years ago, and now it is spherical. In both periods there were consensuses that defined the scientific truth of each one, just as the intersubjective nature of language as the main source of knowledge. As we have not arrived yet to the ultimate truth, we will always experience changes in the way we see and think the world in the future.

So, paradoxically natural science as a collective, linguistic and historical phenomenon is also a social process that follows what has been described by social sciences and not natural sciences. That is why social science abandoned the concept of objectivity much before natural sciences did. Seen from this cognitive perspective as a cultural phenomenon, the line that separates natural and social sciences –soft and hard sciences–, seems to be purposeless.

1.9 Science and Values

Values are like a bridge between rationality and emotions, as they integrate ideas, symbols and deep feelings of the community that affiliates to them. They are brought up by every individual community, inspired in the self-image of the group, in terms of how they perceive themselves, what is deeply proper of them, or what they would like to be. In this sense, values are rooted in emotions that drive those images, like expectancy, affection, yearnings, trusts, hope, or the believe in a positive nature of life and the community. Values determine what is important for each culture, and express the common preferences, configuring the bases for the political, legal and economic decision processes. From that prospect, values as guiding concepts are embedded in any culture, including science as a cultural phenomenon.

As any cultural process, science has its own set of basic beliefs, that have been obscured by the idea of objectivity or the belief that the scientific knowledge is a

universal, immanent truth (so that there is nothing to *believe*, only to *know*). The *leitmotivs* of sciences are the ideas of progress, and development, common good, well-being or contribution to society. Concepts like truth, knowledge (in contrast to ignorance) or so-called "natural laws"[10] can also be seen as values of science. Another value implicit in modern science, but not necessarily previous to modern era, is the foundational place of rationality in science. In other words, the belief that the world can be described, understood and predicted through reason. Much related to this is the search for prediction, that requires accuracy, revealing a natural affinity of science to certainty. This is a very important topic, as the search for certainty and the ability to predict have naturally pushed modern sciences towards the realm of quantitative approach and specialization. Yes, through this two facts science has indeed become more accurate in predictions but has left unattended a huge dimension of the living. In choosing quantities, current reductionist science has left the world of qualities. In choosing specialization, as a tool to get more details of the phenomena studied, science has gotten atomized and increasingly unable to resolve real-life problems.

Modern natural science, and coherently neoclassical economics, have chosen numbers as a practical solution to the problem of demonstration, but with that a huge portion of the human life has been cut off and set aside. This could be the cause of the lack of understanding of the current ecological and social crisis and, the lack of effectiveness in its solution (by applied sciences). Quantities are discrete distinctions that do not allow to deal with complex phenomena, which commonly imply the interplay of different disciplines that cannot interact under a paradigm of objectivity. Happiness, development, health, politics or the environment are matters that are not located in a specific discipline, and because of that no discipline has been able to entirely resolve such problems. Water, life or beauty do not belong to a scientific specialty, as their nature cannot be reduced to a discrete set of knowledge. Science has been dramatically successful in discovering new insights of the world but is far away to understand our existence. It is the other way around: the sense of life that every community sets for itself determines what sciences and disciplines it will study.

1.10 Neoclassical Economics, Science and Values

In its expectation to resembling a natural science (Smith and Max-Neef 2011), neoclassical economics took the way of a quantitative approach to study economic matters. In doing so, it has chosen to work with the quantifiable phenomena, primarily materialistic, as objects are easily accountable, like we have explained above. That approach has set apart most of the qualitative dimensions of human

[10]It has not been proven yet that the Universe behaves always in the same manner, an assumption that is implicit in the concept of natural law.

living. However, as stated above, many relevant bases of human culture are non-material and those bases have been, intentionally or not, neglected by neo-classical economics, evidencing its incapacity to deal with the real world.

As stated before, any discipline is set under a certain set of believes and preferences that are chosen a priori. In the case of neo-classical economics, there is a big remanence of the classical view, in which founders of the Enlightenment also developed a set of values. For example, for Bacon "the real and legitimate goal of sciences is the endowment of human life with new inventions and riches", as he believed that intangible, philosophical or spiritual approaches do not matter to human happiness (Freudenthal and McLaughlin 2009). Somehow, the relation of such mindset and the neoclassical approach, focused on materialism and consumerism, go hand in hand: as stated above, there is no such thing as value-free science and the same argument goes also for neoclassical economics. According to our perception, some values, assumptions or beliefs of neo-classical economics are:

- Human beings are predictable and can be studied as a physical phenomenon.
- Human beings are selfish and therefore competition as the driving force of the economy is natural.[11]
- Monetary wealth is something positive, and it is an indicator of personal success.
- Humanity has the right to appropriate any useful natural resource.
- Human development is about material things.
- Human happiness is about having money (or things), and the more the better.
- Regarding the long-dated critics to economic growth: natural sciences are not so relevant to be taken seriously.
- Regarding the use of GDP (Gross Domestic Product) as welfare indicator: past and future generations are irrelevant for the economy.
- Regarding enormous impacts on life and people from economic development initiatives: economists know the value of things better than other visions, and therefore economic arguments are enough (first priority) to justify them.[12]

Considering the latter, there are many facts that indicate that in the last decades, neoclassical economics has behaved as an isolated discipline that cannot be considered scientific at all. As stated in previous sections in this chapter, the main criteria of science are:

- To consider the scientific knowledge previously existing
- To openly discuss its ideas and being able to argument against eventual critics
- To support statements with logical reasoning coherent with the rationality of science

[11] A model of an economy in which neighbourly love instead of competition is the driving force of the economy has been described (Fuders 2017; Fuders and Nowak 2019).

[12] This assumption is especially relevant, as it implies that economists understand what is at stake with such environmental impacts.

- In the case of sciences based on mathematics, to be able to predict future scenarios
- To be able to demonstrate its hypotheses

Those criteria are definitively not fulfilled by neoclassical economics. Just the first criterion would be enough to let this discipline fall out of science. When the concept of (perpetual) economic growth is analyzed, a big contradiction with the first law of thermodynamics[13] is found. This is not just a banality; we are taking about what is considered one of the most robust and fundamental scientific laws of the traditionally considered the most robust science (physics). It is simply unimaginable to pretend that such law would not apply to economics. In simple terms, the economic growth as defined by neoclassical economics does not have a base on natural science. Even worse, this contradiction is known since at least four decades, but the economists of this approach have not taken such argument into account even until today. After decades of evidences against the expected function of the parameter, neoclassical economists and politicians still use and support indicators like GDP growth. To neglect critics is an option. As any idea, the GDP is a cultural construct that is chosen by will, and not by its objective essence, so that it is an option instead of a truth. As any option, there must be a reason to have chosen this option, such as ideology, convenience, etc.

In the face of a multidimensional global crisis, the society searches for a way to escape this crisis, debating solutions and assessing all the available methods to address the abundant set of problematics linked to this crisis. As we stated at the beginning of this chapter, we believe that science has the technical solutions for most of the current environmental problems since many decades. However, for a solution to become reality it must surpass a big gate: the economic feasibility.

We can clear most of the polluted waters on earth, replace most of the polluter energy sources by clean ones, reduce the discarded residual materials, reduce the extraction/exploitation of diminishing natural resources or endangered species, decrease substantially the waste of materials and energies, increase the amount and size of alternatives to the mainstream market products. Yes, there is enough knowledge and existing technological solutions to address these main global problematics. But society does not implement them. Why? Because it is economically not viable (see also Chap. 2 in this book).

Natural sciences have gained status as many of their achievements seem to be simply undebatable. That kind of power let people to think that if something is stated by science, it must be true. As most people assume that economics is a science, there is a tendency to accept the argument of "economical unviability" as something that must be true. Therefore, society accepts such argument as valid and considers it

[13] In brief, it states that energy (and matter) cannot be created nor destroyed, but only transformed. Related to the production of goods and services this means that they cannot be produced out of nothing. If real GDP increases, so has to increase the use of energy and material input, unless a purely qualitative transformation takes place. Obviously, that is not the case of a quantitatively driven science, like neo-classical economics.

superior to other arguments that can involve even the surviving of animals, people or entire ecosystems. But the evidence shows that the classical economic arguments are not objective realities nor scientific facts rooted in natural sciences. On the contrary, many of the economic rationale is in direct contradiction with the core of natural sciences, here especially the economic growth imperative, since nothing in nature grows forever.

1.11 Towards a Transdisciplinary Ecological Economics

Economics (from Greek "oikonomia") is the science of managing the "oikos", the scarce recourses of a household, in an efficient manner (Aristotle 1995). Applied to today's world this would involve the efficient use of natural and social capital of society. To fulfil its endeavor, it is essential for economics to include the new insights of sciences and disciplines, in order to find a new vision regarding human development and nature. To do so, it is essential to set bridges with other disciplines that can contribute to its understanding of the current world. The latter can happen under the exercise of a transdisciplinary work, which goes far beyond the concept of interdisciplinarity.

The essence of transdisciplinary work is overpassing the boundaries of individual disciplines in the construction of new linguistics that set the background for the emergence of new concepts and ideas that can better answer the challenges that the current and future exercise of economics so urgently demands. In this book, many of these concepts, like ecosystem services, are breaking the ground of traditional economics with new interesting proposals. Certainly, this chapter has set a critic against the neoclassical monodisciplinary economic approach. It would not be fair to say that all what this discipline has reached is worthless. In fact, the reason that this discipline is still so hegemonic may partially be owed to the immaturity of an alternative school of economics.

This chapter is an exercise to understand the roots of the global crisis, but it is also a proposal on how to set new roads for an alternative school of economics to run through it. Such economics should have also new tools to deal with the qualitative domain of human existence, and a strong emphasis in relational, holistic and non-materialistic phenomena of life as a whole. In the search of objectivity, science tries to step out of any subjective, emotional or spiritual matters, and so did neoclassical economics. However, we need a school of economics that dares to work with the different dimensions of human life or, to put it in the words of Theodor Roszak to introduce the book "Small is Beautiful" (Schumacher 2010) we need "a nobler economics that is not afraid to discuss spirit and conscience, moral purpose and the meaning of life, an economics that aims to educate and elevate people (. . .)".

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