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ROLE OF THE VIRTUAL STAKEHOLDERS IN THE SEARCH OF A BALANCE BETWEEN ENVIRONMENT, ECONOMY AND SOCIETY IN THE POLICY CHOICES MANAGEMENT

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“Don't play what's there; play what's not there.”

Miles Davis

1. Introduction

"- […] mi sapresti dire quante siano le vocali?
- […] le Vocali son cinque, A, E, I, O, U.
- Bene! Sei un Salomone ma come si fa che nell'alfabeto di ogni lingua l'"A" sia prima, e l'"E" sia dopo? […]"
(Perché) "in questo misero mondo chi "à" "è", e chi non "à" non "è". […]"

"- […]Can you tell me how many vowels are there?
- […] The vowels are five, A, E, I, O, U.
- Fine! You are a Solomon but how is it that in all alphabets the "A" is before, and "E" is after? […]"
(Because) "in this miserable world who "has" "is," and who "has" not "is" not. [...]

"Le vocali ossia la prima lezione di mio padre"
Vincenzo Padula 1819 - 1893 (Padula, 1950)

1.1 The invisible welfare

"[...] even if we act to erase material poverty, there is another greater task, it is to confront the poverty of satisfaction - purpose and dignity - that afflicts us all. Too much and for too long, we seemed to have surrendered personal excellence and community values in the mere accumulation of material things. Our Gross National Product, now, is over $800 billion dollars a year, but that Gross National Product – if we judge the United States of America by that – that Gross National Product counts air pollution and cigarette advertising, and ambulances to clear our highways of carnage. It counts special locks for our doors and the jails for the people who break them. It counts the destruction of the redwood and the loss of our natural wonder in chaotic sprawl. It counts napalm and counts nuclear warheads and armored cars for the police to fight the riots in our cities. It counts Whitman's rifle and Speck's knife, and the television programs which glorify violence in order to sell toys to our children. Yet the gross national product does not allow for the health of our children, the quality of their education or the joy of their play. It does not include the beauty of our poetry or the strength of our marriages, the intelligence of our public debate or the integrity of our public officials. It measures neither our wit nor our courage, neither our wisdom nor our learning, neither our compassion nor our devotion to our country, it measures everything in short, except that which makes life worthwhile. And

it can tell us everything about America except why we are proud that we are Americans. If this is true here at home, so it is true elsewhere in world [...]". Robert F. Kennedy speech at the University of Kansas, March 18 (1968).

Two observations come to mind by analysing this famous speech:

- first, its content is a criticism of the vision that policy had of the *Res publica* management at that time, *i.e.* a given policy is judged positive only if it is able to increase the GNP which means that politics is losing its aims, the contact with reality and with humanity;
- the second observation is that some information (which are important topics for all governments) are not taken into account in the GNP calculation. The motivation may be found in the quote: "It would be nice if all of the data which sociologists require could be enumerated because then we could run them through IBM machines and draw charts as the economists do. However, not everything that can be counted counts, and not everything that counts can be counted.", very famous and wrongly attributed to Albert Einstein, coming from a document written only five years before that speech (Cameron, 1963).

There is a third observation, which can be made explicit only after a brief introduction to the historical context which has been developing before 1968 (the year of this speech) until today about the use made by politics of the *Gross National Product* (GNP) and its successor (from 1991) the *Gross Domestic Product* (GDP) (U.S. Department of Commerce, 1991).

1.1.1 National accounting: the (never)ending story?

In 1995, an interesting article was published: *If the GDP is up, why is America down?* (Cobb *et al.*, 1995). This article describes with a certain detail the history of GDP, which it is not easy to find even if the number of articles talking about the "economic growth" have had a significant increase from 1930 to 2010, as it is possible to derive from Figure 1.

Cobb *et al.* try to explain why the citizens "didn't feel better, even though economist said they should". The authors emphasize the fact that, in the past, when the Western economies transformed from agriculture to manufacturing, finance and services, the way of measure their health and progress generally evolved accordingly. These days, the market economy is constantly evolving, but even if this evolution has undergone a radical and accelerated change, the way to measure economic health and progress has been frozen.

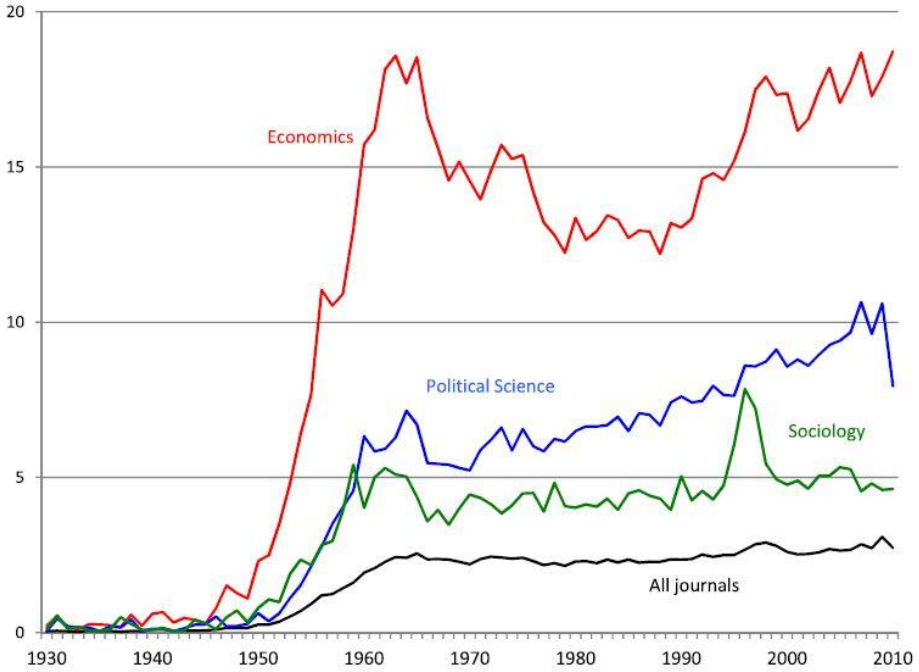

Figure 1 - Percentage of articles published in all academic journals in the JSTOR database that contain the term “economic growth”, by discipline, 1930–2010. (Schmelzer, 2015)

Everything started in the 1665, when the first national account was carried out in England by William Petty with the aim to ascertain the taxable capacity of the nation. In France the Physiocratic theory maintained that agriculture was the true source of a nation's wealth but in the more industrialised England, Adam Smith articulated a broader theory of national wealth that included the whole swath of manufactures as well. Smith excluded entertainment and services (including government and lawyers) because as "unproductive of any value" they didn't give rise to a tangible product. Actually, Smith was asking a crucial question, one that has pretty much disappeared from economic thoughts: "is there a difference between mere monetary transactions and genuine addition to a nation's well being?".

By the end of 19th century with the shifting of England's economy from manufacturing to trade and finance, Alfred Marshall (the father of the neoclassical economy) declared that the true standard of production and wealth was the "utility" in the place of "tangibility": "[...] an abstracted commercial economy, were essentially no different from sacks of potatoes or carloads of iron. The economic significance of a thing lay not in its nature but simply in its market price."

This change in the aims of national accounting brought to the exclusion of everything without a market price, letting out, for example, the ecosystem services. The axiom is: environment is considered to provide an infinite supply of resources and an infinite capacity to absorb any amount of waste.

In 1932 the US Senate, tired of reflagging national accounts on the basis of market evolution, asked Simon Kuznets to develop an uniform set of national accounts. The Gross National Account was born (Kuznets, 1934), replaced only in 1991 by the GDP. The year 1934 could be identified as the "year zero" of the economic history and, from that moment, all has been classified in terms of "b.K." (before Kuznets) and "a.K." (After Kuznets). Indeed, Kuznets won the Nobel Prize in 1971 "for his empirically founded interpretation of economic growth which has led to new and deepened insight into the economic and social structure and process of development"[1]. Abramovitz (1986) said in his article that Kuznets made a decisive contribution to the transformation of economics into an empirical science and to the formation of "quantitative economic history".

According to Cobb *et al.* there are a number of observable consequences in the "a.K." period. A relevant one is the following: "economists became the ultimate authorities on American public policy. Before the war, economists were rarely quoted in news stories except in some official capacity. Now their opinions were sought and cited as canonical truth.". Another consequence of the authority gained by economical sciences was and is the decreasing relevance of humanistic studies, *i.e.* those very subjects which deal with topics usually not included in the national accounting methodology developed by Kuznets.

In 1991 GDP replaced GNP. The difference between the two is important, in that in GNP, the earnings of a multinational company were attributed to the country where the firm had its owners. With GDP the profits are attributed to the country where the multinational is located. However, no fundamental change in the methodology was done.

[1] http://www.nobelprize.org/nobel_prizes/economic-sciences/laureates/1971/

What the two indicators of "wellbeing" share is the methodology of accounting which "[...] assumes that everything produced is by definition a "good" and it does not distinguish between costs and benefits, between productive and destructive, or between sustainable and unsustainable activities. The nation's central measure of well being works like a calculating machine that adds but cannot subtract." According to Cobb *et al*. "by the curious standard of the GDP, the nation's economic hero is a terminal cancer patient who is going through a costly divorce. The happiest event is an earthquake or a hurricane. The most desirable habitat is a multibillion-dollar Superfund site".

Despite this, GDP is frequently used as an indicator to compare quality of life in different countries (Costanza *et al.*, 2009) (Figure 2 and Table 1).

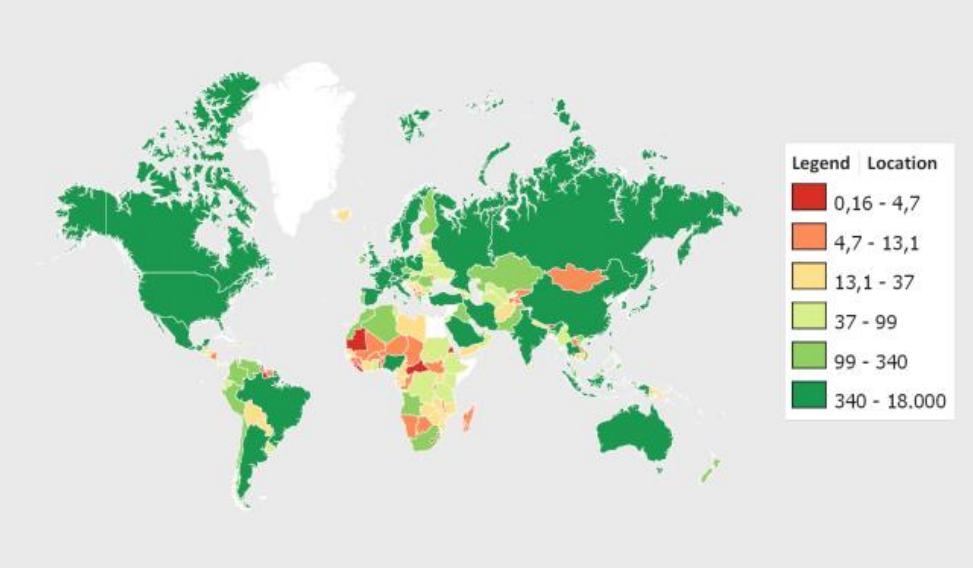

Figure 2 - World ranking distribution maps by GDP current prices of year 2015 (U.S. billion dollars)[2].

[2] Source: International Monetary Fund, original data from the website: http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/download.aspx

Rank	Country Name	U.S. $ (10^9)	Rank	Country Name	U.S. $ (10^9)	Rank	Country Name	U.S. $ (10^9)	Rank	Country Name	U.S. $ (10^9)
1	United States	17968.195	51	Peru	179.911	101	Uganda	24.943	151	Swaziland	4.305
2	China	11384.763	52	Algeria	175.077	102	Zambia	24.466	152	Sierra Leone	4.266
3	Japan	4116.242	53	Romania	174.922	103	Estonia	22.934	153	Eritrea	4.256
4	Germany	3371.003	54	New Zealand	170.59	104	Nepal	21.356	154	Timor-Leste	4.231
5	United Kingdom	2864.903	55	Iraq	165.057	105	Honduras	19.941	155	Togo	4.152
6	France	2422.649	56	Venezuela	131.855	106	Afghanistan	19.681	156	Montenegro	3.985
7	India	2182.577	57	Kuwait	123.228	107	Cyprus	19.383	157	Guyana	3.203
8	Italy	1819.047	58	Hungary	118.49	108	Papua New Guinea	17.995	158	Maldives	3.031
9	Brazil	1799.612	59	Morocco	103.075	109	Cambodia	17.714	159	Burundi	2.97
10	Canada	1572.781	60	Angola	102.011	110	Mozambique	16.985	160	Bhutan	2.209
11	Korea	1392.952	61	Ecuador	98.925	111	Iceland	16.738	161	Lesotho	2.035
12	Australia	1240.803	62	Ukraine	90.138	112	Bosnia - Herzegovina	15.568	162	Liberia	2.015
13	Russia	1235.858	63	Slovak Republic	86.198	113	Senegal	13.988	163	Belize	1.763
14	Spain	1221.387	64	Sudan	84.331	114	Zimbabwe	13.905	164	Djibouti	1.743
15	Mexico	1161.483	65	Sri Lanka	79.524	115	Jamaica	13.823	165	Cape Verde	1.641
16	Indonesia	872.615	66	Dominican Republic	66.575	116	Gabon	13.8	166	Central African Republic	1.624
17	Netherlands	750.782	67	Uzbekistan	65.953	117	Georgia	13.753	167	San Marino	1.543
18	Turkey	722.219	68	Myanmar	65.775	118	Botswana	13.091	168	St. Lucia	1.438
19	Switzerland	676.979	69	Azerbaijan	63.983	119	South Sudan	12.882	169	Seychelles	1.375
20	Saudi Arabia	632.073	70	Guatemala	63.218	120	Namibia	12.855	170	Antigua and Barbuda	1.285
21	Argentina	578.705	71	Kenya	63.121	121	Lao P.D.R.	12.548	171	Solomon Islands	1.205
22	Taiwan	518.816	72	Ethiopia	63.022	122	Mongolia	12.409	172	Guinea-Bissau	1.035
23	Nigeria	492.986	73	Belarus	62.02	123	Nicaragua	12.321	173	Grenada	0.957
24	Sweden	483.724	74	Oman	60.179	124	Chad	11.688	174	St. Kitts and Nevis	0.889
25	Poland	481.235	75	Luxembourg	57.929	125	Brunei Darussalam	11.636	175	Samoa	0.867
26	Belgium	458.651	76	Uruguay	54.968	126	Albania	11.591	176	Vanuatu	0.771
27	Norway	397.59	77	Lebanon	54.395	127	Mauritius	11.567	177	St. Vincent - Grenadines	0.765
28	Iran	396.915	78	Costa Rica	51.618	128	Burkina Faso	11.323	178	The Gambia	0.761
29	Thailand	373.536	79	Croatia	48.932	129	Mali	10.954	179	Comoros	0.589
30	Austria	372.606	80	Panama	47.473	130	Armenia	10.607	180	Dominica	0.538
31	U. A. Emirates	339.085	81	Bulgaria	47.167	131	FYR Macedonia	10.088	181	Tonga	0.443
32	South Africa	317.285	82	Tanzania	46.192	132	Equatorial Guinea	10.025	182	São Tomé and Príncipe	0.326
33	Malaysia	313.479	83	Turkmenistan	44.362	133	Madagascar	9.514	183	Micronesia	0.307
34	Hong Kong	307.79	84	Tunisia	44.272	134	Malta	9.19	184	Palau	0.261
35	Philippines	299.314	85	Slovenia	42.736	135	The Bahamas	8.884	185	Marshall Islands	0.195
36	Israel	298.866	86	Lithuania	41.776	136	Republic of Congo	8.871	186	Kiribati	0.164
37	Singapore	293.959	87	D. R. of the Congo	39.059	137	Haiti	8.797	187	Tuvalu	0.034
38	Denmark	291.043	88	Jordan	38.21	138	Rwanda	8.468			
39	Colombia	274.189	89	Ghana	37.679	139	Tajikistan	8.045			
40	Pakistan	270.961	90	Serbia	36.555	140	Benin	7.701			
41	Chile	240.041	91	Yemen	34.929	141	Kyrgyz Republic	7.158			
42	Finland	230.685	92	Bolivia	33.537	142	Niger	7.119			
43	Ireland	227.498	93	Côte d'Ivoire	31.27	143	Guinea	6.733			
44	Bangladesh	202.333	94	Bahrain	30.914	144	Malawi	6.388			
45	Vietnam	198.805	95	Libya	29.721	145	Kosovo	6.309			
46	Portugal	197.51	96	Paraguay	29.065	146	Moldova	6.188			
47	Kazakhstan	195.005	97	Cameroon	28.524	147	Suriname	5.05			
48	Greece	192.98	98	Latvia	27.822	148	Mauritania	4.677			
49	Qatar	192.077	99	Trinidad and Tobago	27.668	149	Fiji	4.526			
50	Czech Republic	182.462	100	El Salvador	25.652	150	Barbados	4.451			

Table 1 - Nations of the world classify by GDP, current prices (U.S. billion dollars)[2]

A measurement of economic growth based on these indicators may be handy to politicians, but as for the management of the *Res publica* it carries immediately to the question: "If the GDP is Up, Why is America Down?".

How the scientific community has responded to the limits in the descriptive capability of the GDP and to the divergence between policy and reality generated by this indicator?

The scientific community seems split in two: there are those who, according to Landefeld (2000) and references therein, consider the GDP as "One of the Greatest Inventions of the 20th Century" praising Dr. Simon Kuznets for his work; on the other hand there are those like Simon Kuznets himself who, almost 30 years later wrote: "Distinctions must be kept in mind between quantity and quality of growth, between costs

and returns, and between the short and long run. Goals for more growth should specify more growth *of what* and *for what*" (emphasis added) (Kuznets, 1962).

Six years later, and only three months before his assassination in June 6, 1968, Robert F. Kennedy made his speech at the University of Kansas. In the 1970s the debate on the limits to growth started (Meadows *et al.*, 1972) and in 1989 Barber Conable, then the president of the World Bank said: "Current calculations ignore the degradation of the natural resource base and view the sales of non-renewable resources entirely as income - A better way must be found" (Cobb *et al.*, 1995). In 1991, the Conable "better way" was replacing GNP with GDP.

In 1997 Costanza *et al.* stated that, if the only way to take into account an activity within GDP is to have "dollars" as the measurement unit, then it could be useful to assign this kind of "value" also to ecosystem services (MEA, 2005). This effectively recognizes economy as the interface between science and politics. We will go into the specifics of this type of evaluation and its consequences following Martín-López (2009).

In 2007 McCulla and Smith claimed that GDP is "one of the most comprehensive and closely watched economic statistics: it is used by the White House and Congress to prepare the Federal budget, by the Federal Reserve to formulate monetary policy, by Wall Street as an indicator of economic activity, and by the business community to prepare forecasts of economic performance that provide the basis for production, investment, and employment planning". In the same year the Club of Rome, the European Commission, the European Parliament, the OECD (Organisation for Economic Co-operation and Development) and the WWF held the conference "Beyond GDP" with the objectives of clarifying "which indices are most appropriate to measure progress, and how these can best be integrated into the decision-making process and taken up by public debate" (EC, 2007).

In 2008 Nicholas Sarkozy, the French president, created the *Commission on the Measurement of Economic Performance and Social Progress* also known as the "Stiglitz-Sen-Fitoussi Commission" (the Nobel Prize Joseph Stiglitz chaired the commission) which generated a report with the aim of identify the limits of GDP and to suggest better indicators of social wellbeing (Stiglitz *et al.*, 2009). In the same year the European Commission, almost as an answer, published a report: *Beyond GDP. Measuring progress, true wealth and well-being*, which included 150 alternative indicators within the EU Sustainable Development Strategy (EC, 2009).

From almost the "year zero" (1934) until today, the debate on the economic growth and the GDP went hand in hand but the way to measure economic health and progress did not change.

1.2 Politics, Environment and Society: history of a drift.

Politicians themselves, over the course of human history, have reached a conception very far from the first attempts of defining what politics is.

Around 387 b. C. Plato founded his Academy (*Ἀκαδημία*) at Athens, centre and mother of the democracy where no free man was kept away from the state affairs. As a consequence, everyone felt obliged to participate in political life, to gave his contribution, the Academy above all, as demonstrated by Plato's books as *Republic* (the transcription of a dialogue with Socrates), *Statesman* (*Politikos*) and *Laws*. Even the young Aristotle took part in the Academy (367 b.C.) but over time he broke away from the Platonic thought, that he did not fully agree upon, writing eight books on the subject during his lifetime, which came up to us under the name of *Politics*. This collection has been considered for a long time a manual of political art. It became considerably widespread in the Middle Age and in Renaissance when people tried to find tips on events difficult to understand at the time. Its relevance today is demonstrated by the fact that intellectuals not so distant (in time) from us, such as Thomas Aquinas, Machiavelli and Guicciardini dedicated conferences, studies and comments to it (Laurenti, 2007).

By reading these books it is possible to extrapolate what Aristotle meant by politics: the administration of the *polis* for the benefit of everyone, the determination of a public space in which all citizens, defined as those who actively participate to the political life of their own state, belongs.

The definition of what politics is, has had a particular historical evolution due to the use that man has made of the political power acquired (democratically or not):

> "«Every state is founded on force», said Trotsky at Brest-Litovsk. That is indeed right [...] Of course, force is certainly not the normal or the only means of the state - nobody says that - but force is a means specific to the state. Today the relation between the state and violence is an especially intimate one. In the past, the most varied institutions [...] have known the

> use of physical force as quite normal. Today, however, we have to say that a state is a human community that (successfully) claims *the monopoly of the legitimate use of physical force* within a given territory. Note that 'territory' is one of the characteristics of the state. [...] The state is considered the sole source of the "right" to use violence. Hence, *"politics" for us means striving to share power or striving to influence the distribution of power, either among states or among groups within a state*." (Weber, 1946).

It is very interesting to make a further consideration on the manuscript of Weber. Continuing with the reading, it is possible to find what he defines "three 'pure' types" of obedience legitimation: *traditional*, *charismatic*, and *legal*. He admits to be interested in the second type above all but nowadays a charismatic leader is supported by another type of obedience legitimation as we could derive from the history of the GDP: the *scientific* one.

Returning to Aristotle, it is possible to break down the concept extrapolated from his books in three basic points useful to the purpose of this work:

> *the administration of the **polis** for the **benefit of everyone**, the determination of a public space in which all citizens actively **participate** to the political life of their own state, belongs.*

It is necessary to dedicate more than few words in a bulleted list to these three concepts, which are the pillars of a politician vocation. The politician, having clear in mind the impossibility to make the *benefit* universal, tries to achieve a balance through the management of human and natural resources, trying not to damage that part of stakeholders not directly involved in the decision-making process. In Economics, this means to reach the Pareto Optimal, *i.e.* a state of allocation of resources in which it is impossible to make any one individual better off without making at least one individual worse off (Kim, 2014). With his "Optimal", that does not necessarily mean being in a good condition, Pareto warns us that the allocation process gets to a point where going ahead can only cause damages.

To understand how to get to this "Optimal" it is necessary to have a good understanding of what is meant by "*polis*" and *benefit* and the potentialities of the role of *participation* in decision-making process.

1.2.1 The *polis* as a socio-ecological system

According to Bearzot (2009), during the Ancient Greece period the word *polis* had a specific meaning, which does not match with what we mean, in modern age, as the *city*. The *polis* was a form of settlement of a community in an area, who gathered around a political and religious centre. Structurally, it was possible to find four organizational distinct levels:

- The *Acropolis*: the higher part of the ancient Greece *polis* which was the most eminent and fortified. Protected by walls, it was the religious and administrative centre of the city.
- The *Asty*: the lower part of the ancient Greece *polis* where the inferior social classes (artisans and merchants) lived. It was the real core of the *polis*: in the middle there was the *agora* and the main square where the market took place.
- The *Chora*: On a terminological level, the *Chora* can be the territory as a whole, including the urban centre, or the countryside where a significant part of the population lived. The balance city-territory was one of the characteristic aspects of the polis, emphasizing the organic relationship between town and country.
- The *Eschatia*: It was the outer part of the territory, along the border, generally not fortified but marked by sacral indicators. It was deemed as a sort of no man's land undivided and not cultivated, used for public pasture and wood gathering. The idea of its inferior quality has its roots in the thought that the aristocratic political life took place in the city centre and the life outside it seemed not worth living.

On the basis of the site geomorphology it was possible to create a real continuum between the levels. But the real importance of the interconnection was understood during

the high Greek archaism: the *asty*, the *chora* and the *eschatia* are dependent on each other in a circular structure, as "circular" was the *polis* represented on the shield of Achilles described by Homer in his *Iliad* (Book 18, lines 478–608), where elements from all the *polis* organizational levels were represented by the god *Hephaestus* (Figures 4 and 5).

Figure 3 - Shield of Achilles illustration inspired by the Homer description within the Iliad (Book 18, lines 478–608) 1 - The plowing; 2 - The harvest; 3 - The grape harvest; 4 - The beef herds; 5 - The pastures; 6 - A dancing-floor where young men and women are dancing; 7 - The city in peace; 8 The city in war; 9 - The sky; 10 - The ocean (Quatremère De Quincy, 1814).

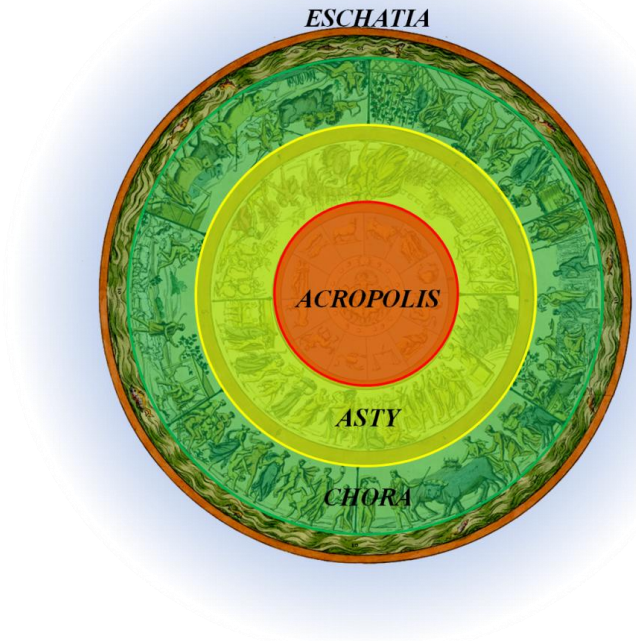

Figure 4 - Identification of the four organizational levels of the polis within the Shield of Achilles.

The description of the *polis* organization allows us to understand how the link between the human society and the surrounding environment was important during the high Greek archaism. Because of its socio-ecological structure (Redman *et al.*, 2004), if the socially inferior part of the *polis* (the *Eschatia*) were damaged also the higher parts of the *polis* (the *chora* and the *asty*) would be affected. In this way, the organizational structure of the *polis* itself was Pareto optimal: if the *Acropolis* or the *Asty* were to ask for a greater flow of resources from the *Chora* this would lead to increased exploitation of the *Eschatia* and then to consequences that would spread radially towards the centre.

1.2.2 From the *polis* management to the *sustainability* concept

In ancient Greece, the link between the human society and the environment was taken into account before the institution of a *polis* in order to find the right place for its foundation. On the contrary, in modern times the implication of the human development on nature have been neglected in a way almost inversely proportional to the advancement of scientific discoveries ("*Industrial Revolutions and Environmental Problems*" by Kasa 2007).

One of the first occasions of awareness was the publication of an environmental science book, *Silent Spring* (Carson R., 1962), which documented the detrimental effects on the environment, particularly on birds, of the indiscriminate use of *Dichloro Diphenyl Trichloroethane* (DDT). The publication of this book, according to Paull (2013), inspired an environmental movement that led to the creation of the U.S. Environmental Protection Agency (EPA) in December 1970. The EPA, on June 1972, cancelled all Federal registrations of DDT products, and from the December of the same year, the usage of DDT was banned in the United States.

Further steps were:

- "The Limits to Growth" report (Club of Rome and Meadows, 1972) which put an end to the illusion that the environment has an endless capacity of both providing resources and absorbing waste (Alfred Marshal, end of the 19th century), admitting that within a closed system no growth can continue indefinitely without leading to the collapse of the system.

- The "United Nations Framework Convention on Climate Change" (UNFCCC) with the objective to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system" (UN, 1992) and the following 21 Conferences of the Parties (COP) from Berlin 1995 to Paris 2015 which have kept turned on the spotlight on these topics (UNFCCC, 2015).

The need for a "sustainable" growth, parallel to the need for a GDP positive trend, has been part of the policies of the governments worldwide since the release of the famous *Brundtland Report* (Our Common Future - WCED, 1987) that put the bases of sustainable development defined as "a development that meets the needs of the present without compromising the ability of future generations to meet their own needs." The report is a kind of guideline of the sustainable economic and social behaviours needed to preserve the environment: "Economic growth and development obviously involve changes in the physical ecosystem. [...] In general, renewable resources like forests and fish stocks need not be depleted provided the rate of use is within the limits of regeneration and natural growth." These recommendation were also supported by Lanza (2006) who affirms that considering the reproduction capacity of one resource, its exploitation is "sustainable" as long as it occurs without exceeding certain limits defined as "critical natural capital" (2006).

The needs of economy and society must meet nature regeneration rate. The famous representation of the interaction between the three "dimensions" according to the concept of sustainability descends from this concept (see Figure 6).

According to Wallis (2011) "These models describe sustainability as three equal systems or parts, that are completely separate, as in the triple bottom line (Figure 6 - a) and pillars (Figure 6 - b) models, or with some interaction, as in the spheres model (Figure 6-c). The sustainability assessment methods developed using these models are often just sets of economic, social and environmental indicators assessed in isolation."

These models, as we will see in the next paragraph, do nothing more than confirm the Cobb theory according to which economists became "priests" whom, after the development of the GDP by Kuznets, "their opinions were sought and cited as canonical truth." This is confirmed by other representations (Figure 7).

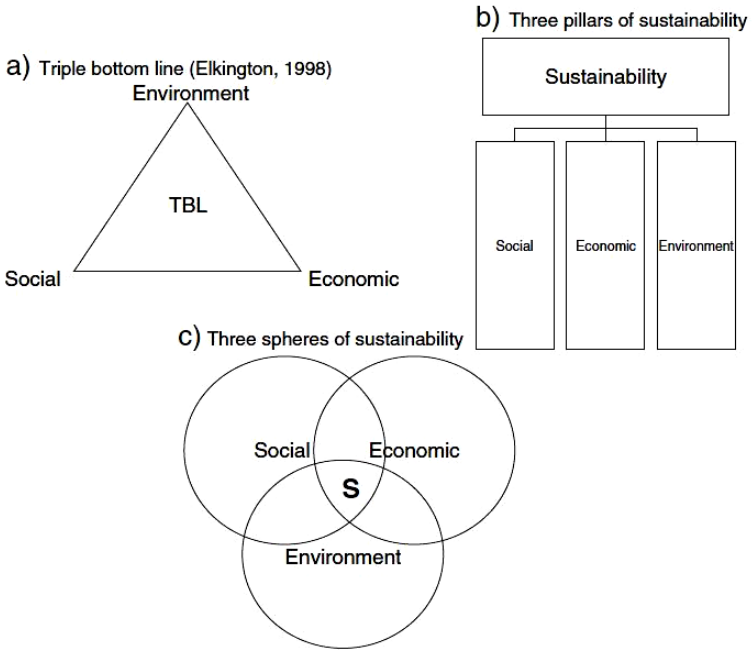

Figure 5 - The three dimensions of sustainability models: a) triple bottom line; b) three pillars of sustainability; and c) three interacting spheres of sustainability (Wallis *et al*., 2011)

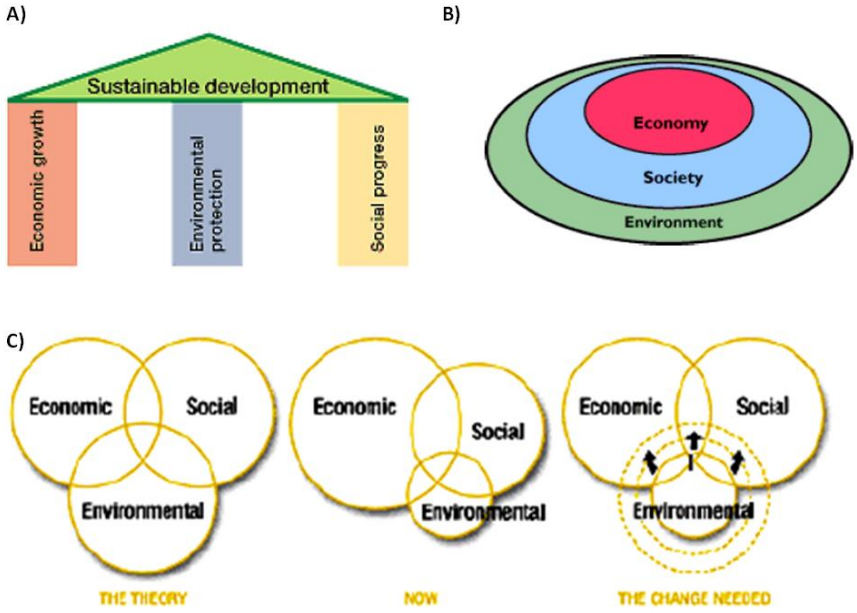

Figure 6 - Three visual representations of Sustainable Development: A) Pillars; B) Concentric circles; C) Overlapping Circles (Adams, 2006).

Where is the mistake?

All the topologies used to represent the three dimensions of sustainability recall in some ways the representation of the *polis* on the shield of Achilles (Figure 3). But there is a substantial difference: the shield represents a real situation of dependence among four organizational levels in direct contact with each other, a *continuum* without economic

indicators as interface between politics, society and nature. At the time, policy decisions were the result of collective participation of all citizens in political life. A good or a bad policy action, in the *polis* model, directly spreads its consequences to all the levels. This contrasts with what happened in the US during the Clinton administration: "The economy as economists define it was booming, but the individuals who compose it - or a great many of them, at least - were not. President Bill Clinton actually sent his economic advisers on the road to persuade Americans that their experience was wrong and the indicators were right." (Cobb *et al*, 1995)

According to Adam (2006), 19 years later than the Brundtland report, decisions by governments, businesses and other actors put the greatest emphasis on the economy above the other dimensions of sustainability. This is one of the main reasons why the environment continues to degrade and development does not achieve the desirable sustainable goals. And the GDP paradox, analysed in full in section 1.2.6, confirms this.

1.2.3 The consequences of sustainable thinking

A *polis* model is nowadays applicable only on a very local scale because of its direct interaction with the territory, but it could be helpful to develop sustainable thinking especially in the interface between science and policy.

The three dimensions of the sustainability models have been used to develop various sustainability assessment methods. Furthermore, the questions raised at the end of section 1.1 still has no answer: is the qualitative description of the social and environmental compartments satisfactory enough to convince a policy-maker to abandon economics as the only descriptor of his performance?

Looking at how the three pillars of sustainability are described in the previous figures, there is no doubt that the intention is to put the three compartments at the same level, giving them the same importance and to emphasize the fact that, in one way or another, these three compartments are in relation to each other. Despite a great effort, testified by the aforementioned 21 COP that have taken place with the intention to include these frameworks in the policy-making process, this did not happen (Adams, 2006; Wallis, 2011).

However, the real question is another: is this construction theoretically valid?

Focussing on what the economics sphere is meant to represent within the sustainability models it is possible to realize that the reality observed so far is far from being what it should be.

"Economics is the science of managing scarce resources. It examines the forms assumed by human behaviour in the management of these resources. It analyzes and explains the ways in which an individual or a society allocate limited resources to meeting the multiple and unlimited needs." (Barre, 1955). These words describe the economics like an impressionist painter would do, *i.e.* like an external science which examines the human behaviour in managing resources which, by definition, are considered scarce. If this definition were true, the world would not need a Brundtland Report and everything that came after. On the contrary, the current goal of policy is economic growth, and this is confirmed by the lack of intention by the world governments to abandon GDP as an indicator of their policy performance. A sentence can help us to understand:

> "***in the actions of all men****, and especially of princes, which it is not prudent to challenge****, one judges by the result****. For that reason, let a prince have the credit of conquering and holding his state,* ***the means will always be considered honest, and he will be praised by everybody***" (Machiavelli, 1513)

If the "goal" is the economic growth, the "mean" is the environment intended as an infinite stock of natural resource to be offered to the cause and with the capacity to absorb any amount of waste. According to Daly (1999) a kind of growth where the environmental and social costs increase more than benefits cannot be defined "economic" but "uneconomic".

How is it possible to give to the three compartments the same importance, if economics suggests to the society an exploitation rate of the natural resources without considering their degradation and the consequences on the society itself?

One solution is to abandon these ways of representing the three pillars of the sustainability because this leads to a scientific translation which describes them just as a "sets of economic, social and environmental indicators assessed in isolation" (Wallis, 2011). Policy-makers need a real and truthful analysis about what these three compartments represent and how they interact with each other, which translates, by an

operational point of view, in a tool useful to understand the consequences, both direct and indirect, of their decisions.

1.2.4 The environment: an epistemological complex system

The starting point for creating a new model able to represent the consequences of economic growth on the environment and the society, can only be the definition of the actors which, as we shall see, cannot be separated from each other.

This section will address the definition of "environment". It is useful to start with an explanation: this word does mean everything or it does not mean anything. It can be a political word-tool to gain more votes, a kind of word-flag for a new fundamentalism or a keyword to call the attention in a scientific paper. It can be a kind of art, a musical genre or a place where to work. If used to talk about the ecosystems (*i.e.* all which lies beneath the human being and not in direct contact with him, however far from him) it is put in a kind of "jail", made by "boundary" and "scale", a box where to include or not some given variables chosen on the basis of expert knowledge. It can be even more other things and every use is inappropriate and appropriate in the same time.

In this work, an attempt is made to give a definition (certainly influenced by the author's culture[3]) of the word "environment":

[1] *"The environment is a set of interacting elements, including their interactions and the motivations behind these interactions"*

As it is possible to note, in this definition there are no system scales or boundaries, nor it is possible to understand which kind of elements are interested by this definition. This choice is intentional: the environment cannot be reduced to a simple system. The environment is a complex system and treating it in this way, *i.e.* accepting the challenge of describing its complexity, is the only way to understand it.

---

[3] At the beginning of my doctoral research path, I felt myself like David against Goliath: how to achieve the knowledge necessary to support a policy making process in order to take a sustainable decision? I tried to find the answer in the immeasurable scientific literature but after a while (almost one year), I became aware that scientific literature alone could not satisfy this necessity of mine. Then I realized that the problem was not the literature, the problem was only mine and it started from the conception of what the word "environment" represent "for me" after a bachelor degree, a master degree and a Ph.D. course in environmental science (Author's note)

Becoming aware of the complexity of a system is the first step in a process that leads to a goal which can only be asymptotical[4]. This approach, however slow, is theoretically better than trying to describe a complex system, such as the environment, with frameworks based on reductionism or on "expert knowledge", as it will be shown later.

A complex system comprises many interactive agents (Juarrero, 1999). The system's components and their interaction are changing and can never be pinned down completely. *The system is irreducible*. Cause and effect cannot be separated because they are intimately intertwined.

Accepting the complexity of the system and its irreducibility has been the centre of discussions in different field of the human knowledge.

Edgar Morin, a French philosopher, affirms that scientific knowledge was conceived, and is still often conceived, as custodian of the mission to dissolve the complexity of phenomena, but sometimes a simplified knowledge mutilate reality (Morin and Corbani, 1993). He warns us that complexity cannot be summarized in a word, or reduced to a mathematical law, also because, according to Funtowicz and Ravetz (1990), the mathematical precision[5] is meaningless in the presence of high uncertainty. Morin wants to help us, when we must deal with complexity, to dissipate two illusions that distract the mind from complex thought:

- *complexity does not lead to the elimination of simplicity*: while simplified thinking disintegrates the complexity of the real, the complexity assimilates all possible simplified ways of describing the real (defined by Munda (2004) as the *epistemological complexity*);
- *complexity does not mean completeness*: although the study of complexity needs multidisciplinary knowledge, we must be aware from the beginning of the impossibility of a complete knowledge.

---

[4] The elements that make up a complex system are $n+1$, for $n \rightarrow \infty$; the interaction among the elements are $a+1$, for $a \rightarrow \infty$. (Author's note).

[5] In this note I would like to provide a interesting anecdote from Funtowicz and Ravetz (1990) called by them "The fossil joke": "A joke about fossils will illustrate many of the points we are making. It relates to a museum attendant, who was heard telling schoolchildren that a particular dinosaur bone was fifty million and twelve years old. Asked how he knew it so precisely, he answered that it was quite easy: when he came to work there, the fossil was labelled as 50,000,000 years old, and that was twelve years ago. Clearly, the attendant was somewhat simple-minded; but what was wrong with his reasoning? He did the sum 50,000,000 + 12; and as he has learned at school following the arithmetical rules of adding place by place, he obtained the precise result 50,000,012. Should he better use non-standard algebra?"

Morin defines his "*simplification paradigm*" as the domain of the principles of disjunction, reduction and abstraction, a paradigm which has led to enormous advances in scientific knowledge and philosophical reflection, but has radically isolated from each other the three major fields of scientific knowledge: physics, biology and human science. This led to the development of the *blind intelligence* and the consequences are the description of the three dimensions of sustainability as sets of economic, social and environmental indicators assessed in isolation (Morin and Corbani, 1993).

In this work the word "environment" will be used to describe a socio-ecological system which is defined, according to Berkes et al. (2003), as a bio-geo-physical unit, including its associated social actors and institution.

Having described:

- the political role of economy towards a sustainable development,
- the definition [1] of "*environment*",
- the definition of the socio-ecological system,

it seems now appropriate to provide the model which will be used as a reference for the development of these concepts in the next sections.

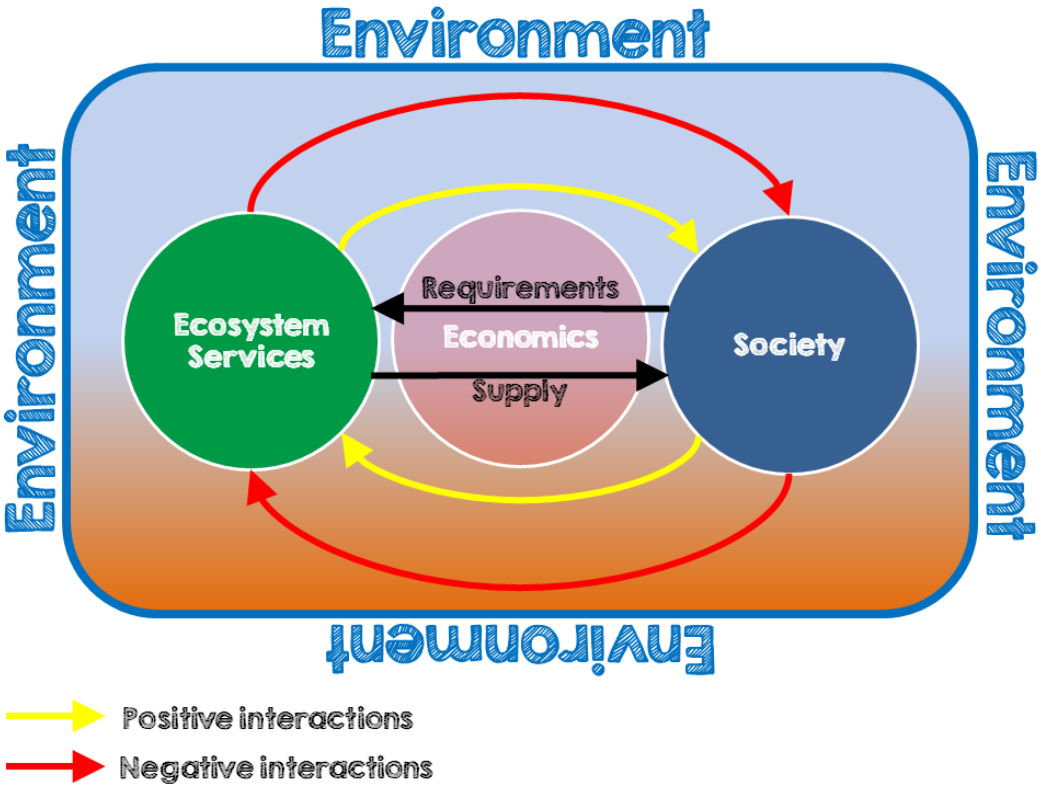

Figure 7 - The three dimensions of sustainability as conceived in this work.

The model of Figure 7 is the representation of the definition of *environment*: *a set of interacting elements, including their interactions and the motivations behind these interactions.* Let's take this step-by-step:

- *"a set of interacting elements"* - Economy is not a set of political intention which aims at the improvement of some parameters in a compensatory index and the environment is not the mean to achieve this goal. The environment is the place where the society relates to its needs, it must be interpreted by the economy taking into account the scarcity of resources to manage. This information is translated into the exploitation of these resources in a sustainable way;
- *"including their interactions and the motivations behind these interactions"* - The interchange between ecosystem services (MEA, 2005) and the society is not just economic. The reasons that bind a given society to its cultural and natural habitat or those that drive a society to exploit the habitat of others are arcs that may connect far apart nodes in a complex system This is the reason why a complex system cannot be confined.

Science and numerical models alone cannot provide all information needed for a complete description of the system, useful to policy-makers for being aware of the possible consequences of their decisions.

Science needs help by humanities, as suggested by another philosopher, Michel Serres. In his book "*Le passage du nord-ouest*" he dubs the division between science and the humanities as the Northwest Passage, referring to the twisting and convoluted coastlines that separate the Atlantic Ocean (representing Science) and the Pacific Ocean (representing Humanities). Serres's point is that such a passage is there to be traversed but this requires undertaking the most testing of journeys, one that will involve much doubling back and complex navigation (Brown, 2002).

> *"Je cherche le passage entre les sciences exactes et les sciences humaines. Ou, à la langue près, ou, au contrôle près, entre nous et le monde. [...] Le chemin n'est pas aussi simple que le laisse prévoir la classification du savoir. Je le crois aussi malaisé que le fameux passage du Nord-Ouest"* (Serres, 1980, p. 15)

1.2.5 The society dimension: a void to be avoided?

The definition of environment discussed above involves a necessary extension of the knowledge and culture of environmental scientists and, in general, of those who are interested in environmental management or politics. Otherwise, some environmental protection proceedings may appear as an "extremely" repressive action against the economic development of society. The "environment-ologist" role is quite different from the "environment-alist" one: in addition to the geological, physical, chemical and ecological variables, he must also take into account individuals and collective needs and intentions of a given society[6]. This is extremely important, if the aim is to provide a tool for the *polis* management, treating it as a complex system.

How to achieve this knowledge? Actually, to find a common answer it is very hard.

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[6] An environmental scientist does not embrace the trees, but rather suggests what and how many trees must be cut. (Author's note)

Kenneth Joseph Arrow in his book *Social choice and individual values*[7] (2012) published in 1951 addressed the problem of how to consider the individual values in policy choices. He observes that in a capitalist democracy there are essentially two methods by which social choices can be made: voting, typically used to make "political" decisions, and the market mechanism, typically used to make "economic" decisions. Focusing on the first method he tries to identify which voting method could satisfy his *Social Welfare Function* (SWF) defined as any rule for determining society preferences over alternatives sets, on the basis of the preferences of the individual members. More precisely, because individuals' preferences might not be known in advance, the SWF is a function: it must determine social preferences for every different set of preferences that individuals could have.

His publication had a great impact thanks to the statement of the *Impossibility Theorem* that constitutes its central finding. Arrow discovered that there is no SWF that satisfies even a few natural and seemingly undemanding conditions. These conditions are:

- *Unrestricted Domain* (U): the SWF must determine social preferences for all logically possible set; in other words, there are no limitations on the preferences that individuals might have.
- *Pareto Property* (P): if all individuals prefer alternative *a* to *b*, then *a* must be socially preferred to *b*.
- *Independence of Irrelevant Alternatives* (IIA): if there are two profiles and each individual ranks alternatives *a* and *b* the same way in both of them, then the social preference between *a* and *b* must also be the same for both. In other words, the social preferences between *a* and *b* depend only on individuals preferences between these two alternatives - and not on preferences involving some third alternative.
- *Nondictatorship* (ND): no member of the society always gets his way, in the sense that for any profile the social preferences coincide with his preferences.
- *Transitivity* (T): for any profile, if *a* is socially preferred to *b* and *b* is socially preferred to *c*, then *a* must be socially preferred to *c*.

[7] Third edition

The *Impossibility Theorem* establishes that if there are at least three alternatives in a set of social alternatives then there is no SWF that satisfies all of U, P, IIA, ND, and T. In other words it is not possible determine a voting system that maintains the social choices:

> *"If we exclude the possibility of inter-personal comparisons of utility, then the only methods of passing from individual tastes to social preferences which will be satisfactory and which will be defined for a wide range of sets of individual orderings are either imposed or dictatorial."* (Arrow, 1950)

How can a policy-maker, although supported by science or humanities, take into account preferences, interests and needs of all its citizens in order to make a decision which contravenes the *Impossibility Theorem*?

Suppose we could stop time. Now (at 16 and 38 minutes of the day 05 of February of the year 2016), 7,399,803,925 living human beings are present in the world (Worldometers.info, 2016). If there were a methodology, a supercomputer or anything able to identify everyone's preference, interest or need, there would be 7,399,803,925 preferences, interests or needs. We know that this is pure science fiction, such a thing would be unrealizable, but the most interesting thing is that if this were feasible it would be totally useless. This is because at exactly 16:39 (one minute later) while maintaining a fixed number of individuals present in the world, many of them would have changed their preference, interest and need.

It is impossible to determine what is preferable and what is not for an individual. Thomas Aquinas, citing Aristotle, says that one cannot expect to find the absolute stability in mutable creatures. The full and absolute immutability is reserved only to God while "*Natura enim hominis est mutabilis*" (human nature is mutable) (Pizzorni, 1999).

Choice, for each of us, can be a process outside of all what is commonly considered "logical". It is not only the individual's perception of what is right/wrong or good/bad to push him toward a choice rather than another. The obvious example is that people, while recognizing (and having under his eyes every day events that reinforce it) that smoking is harmful to human health (Yanbaeva et al., 2007), against any "logic" continue to smoke and against all probability theory believe that misfortunes like cancer will never happen to "them".

A more complicate example is the case of the ILVA Company in Taranto, Italy. ILVA is a joint-stock company, which is mainly engaged in production and processing of steel. The most important Italian plant, located in Taranto, is the largest industrial complex for steel processing in Europe and it represents a substantial part of the Italian steel compartment (see Table 2).

ILVA in brief	
Direct employees	16,200 31/10/2013
Average employee age	39 years
Steel produced	5,7 million of ton in 2013

Table 2 - Statistics from the official ILVA website (http://www.gruppoilva.com/)

The importance of the company for the whole Italian economy and for the local people employed as workforce is large. But other statistics are noteworthy.

In a 13-year observation period (1998-2010), the following consequences can be ascribed to ILVA emissions (Sanna *et al*., 2012):

- among adults
  - 386 deaths;
  - 237 cases of malignant tumours with hospitalization;
  - 247 coronary events with hospitalization;
  - 299 cases of hospitalization for respiratory diseases;
- among children
  - 17 cases of malignant tumours with hospitalization;
  - 638 cases of hospitalization for respiratory diseases.

On April 14, 2013 a (consultative) referendum was held in Taranto, organized by the "Future of Taranto" Committee. The population of the municipality was asked to vote on two questions:

1. *Do you want, as citizen of Taranto and in order to protect your health and the health of workers against pollution, the closure of ILVA?;*

2. *Do you want, as citizes of Taranto, in order to protect your health and that of workers, close ILVA "hot area", the major source of pollution, resulting in the dismantling of minerals parks*[8]*?*

In spite of the expectations, the referendum turned out unsuccessfully: out of 173,000 eligible voters, only 20% took part in the vote, so the result was not considered relevant (Bonelli, 2015).

« To be, or not to be, that is the question:
Whether 'tis nobler in the mind to suffer
The slings and arrows of outrageous fortune,
Or to take arms against a sea of troubles,
And by opposing end them? [...]»

(Words Spoken by Hamlet; drawn from "Hamlet, Prince of Denmark" - Act 3, Scene 1 - by William Shakespeare) (Edwards, 1985)

That day, the Taranto citizens opted for the first part of the Hamlet question. In view of the economic importance of the ILVA plant for Taranto people, they choose to "*suffer the slings and arrows of outrageous fortune"*, rather then being confronted with an uncertain future. The fault stands on the excess of reductionism and simplification in the questions.

In trying to assess the interests of the people and to provide a support to the decision-making process, both reductionism and simplification should be avoided.

Examining this example, the question of how to describe the interests of the people in order to provide support for decision-making processes, not only remains unanswered, but rather it acquires complications: how can a policy-maker, although supported by science and humanities, take into account conflicting preferences, interests and needs from all its citizens in order to make the fairest possible decision?

An approach to the solution of this question will be proposed in this work in the following chapters.

---

[8] open air deposits of minerals used by the plant which produce dust pollution

1.2.6 The GDP paradox and the scientific community *Ouroboros*

After this historical *excursus* we can word the third observation left open at the end of section 1.1: with all these criticisms which not only come from some scientists but also from governments and international institutions, what happens to the GDP?

According to Van den Bergh, J. C. (2009 and references therein) "despite all theoretically and empirically motivated criticism of GDP as a social welfare and progress indicator, its role in economics, public policy, politics and society continues to be influential". Actually, in 2014 the debate is still stalled on the need to leave GDP behind (Costanza *et al.*, 2014).

We have three actors in this play: Politicians who decide to use GDP as the indicator of their performance; part of the scientific community favourable to GDP, in particular the Economists which like the priests of the Greek temples have the duty to interpret the judgment of the God to which they are devoted (the GDP) and to communicate his approval or his anger towards the work of the devotees (Politicians); the other part of the scientific community which formulate the criticism.

However, if organizations like the European Union and a Country like France want to find other ways to measure national accountings, who is to blame for this stalemate?

The paradox can be solved by assuming that the scientific community is not split in two, but all are part of the same body: it is possible to represent this situation using the ancient symbol of the snake eating its own tail: the *Ouroboros* (also written *Uroboros*) (Figure 8) (Soto-Andrade, 2011)

Figure 8 - Drawing of the Ouroboros (Pelecanos T., 1478).

Let's attribute each part of the snake to the actors involved: the head of the snake is the part of the scientific community who see the limit of the GDP, which excludes the social and the environment compartments; for this reason the head eat its own tail which represent the part of the scientific community that gives credit to GDP and accept the above exclusion.

But is the "head of the *Ouroboros*" able to provide a globally recognized answer when describing *qualitatively* the social and environmental compartments, before even moving to the determination of the amount (*quantity*) in the elements that make them up? Is a qualitative description satisfactory enough to convince a government to abandon an indicator which, although criticized, is globally recognized and used as the GDP?

The answer is no, and Plato comes to our aid, with his dialogue *Timaeus of Locri*, who describes the *Ouroboros*:

> "[...] This he finished off, making the surface smooth all round for many reason; in the first place, because the living being had no need of eyes when there was nothing to be seen; nor of ears when there was nothing to be heard; and there was no surrounding atmosphere to be breathed; nor would there have been any use of organs by the help of which he might receive his food or get rid of what he had already digested, since there was nothing which went from him or came into him: for there was nothing beside him. Of design he was created thus, *his own waste providing his*

own food, and all that he did or suffered taking place in and by himself. [...]"(emphasis added) (Plato and Jowett B., 2003)

How to exit the infinite loop stalemate? The solution is to be found by making a distinction between *quantity* and *quality* and by including the variables which describe the social and environmental compartments into a unitary vision.

1.3 The "Normal Science" solution

The "normal science", is defined by Kuhn (1962) as the regular work of scientists theorizing, observing, and experimenting within a settled paradigm or explanatory framework. Instead of the term "theory", according to Rosenberg (2011), Kuhn "coined the term “paradigm”, a word which has gone into common usage. Paradigms are more than just equations, laws, statements encapsulated in the chapters of a textbook. The paradigm of Newtonian mechanics was not just Newton’s laws of motion, it was also the model or picture of the universe as a deterministic clockwork in which the fundamental properties of things were their position and momentum from which all the rest of their behaviour could eventually be derived when Newtonian science was completed. The Newtonian paradigm also included the standard set of apparatus or lab equipment whose behaviour was explained, predicted and certified by Newton’s laws, and with it a certain strategy of problem solving. The Newtonian paradigm includes a methodology, a philosophy of science, indeed an entire metaphysics."

In the presence of irreducible uncertainties, of a plurality of different legitimate values (Funtowicz and Ravetz 1993) and of relevant narratives to describe the observed system (Kovacic and Giampietro, 2015), technical knowledge cannot supply an objective, or optimal, solution to the problem, as in the "puzzle-solving exercise" defined by Kuhn (1962).

Dealing with the environment means taking into account the *epistemological complexity*: complex systems *i.e.* all real-world systems, present multiple possible descriptions, all of them correct. The same system can be modelled into different representations that are non-equivalent and non-reducible to each other (Munda, 2004). "Ecologists observe the evolution of ecosystems over hundreds of years, economists

observe the performance of the economy over one year, physicists may observe the behaviour of atoms over a nanosecond" (Figure 9) (Kovacic and Giampietro, 2015).

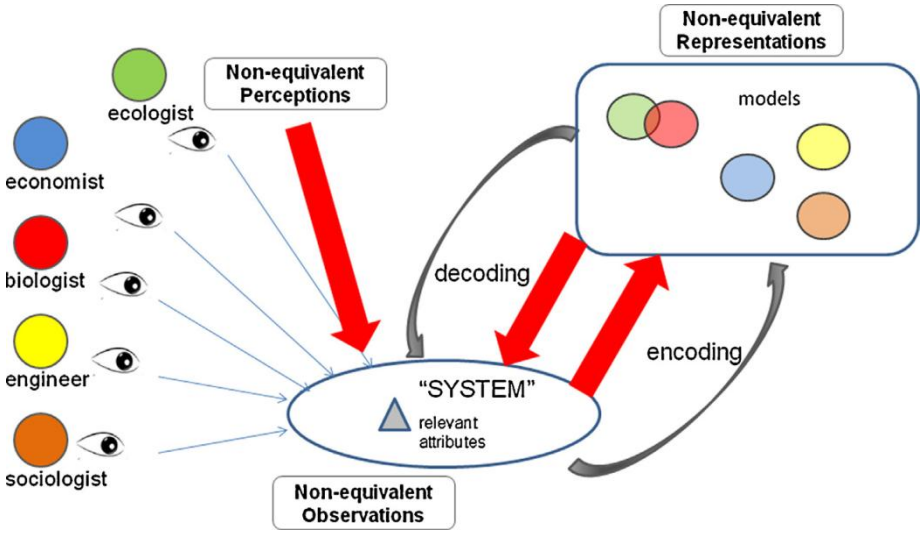


Figure 9 - The plurality of non-equivalent perceptions and non-equivalent representations of the same observed system. Drawn from Kovacic and Giampietro (2015).

Nevertheless a series of tools which, by their nature, are fully included within the definition of normal science (Munda, 2004), are still used for their supposed ability to support complex decision-making and problem solving (Shim et al, 2002). Such tools are the components of *Decision Support Systems* (DSSs).

What is of interest are not the DSSs themselves but their use and the trust that is placed in them when the support they provide is considered valid just because the supplied result are mathematically sound (Saltelli *et al.*, 2013).

1.3.1 DSS: "*Decision*" or "*Delusion*" support system?

DSSs find a large use in many fields (Jao, 2010). Originally developed to support business managers, DSSs have been widely applied in environment management, such as water quality management, and forest risk assessment (Guodong *et al.*, 2011). Figure 10 illustrates the steps of a generic DSS process.

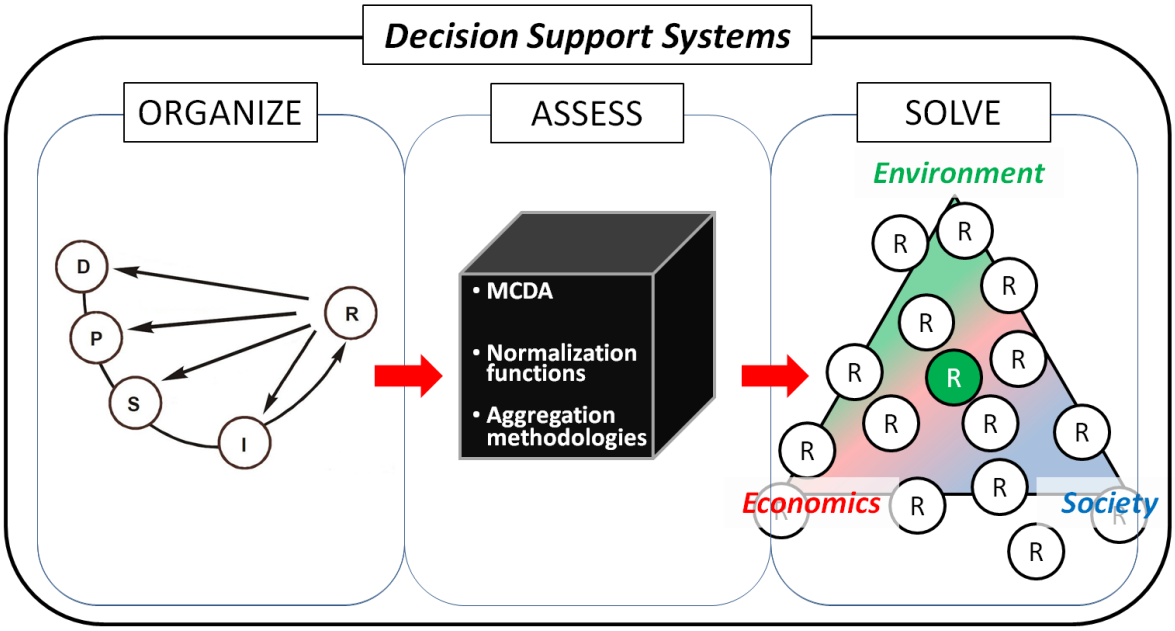


Figure 10 - Schematic overview of a DSS generic application.

A DSS provides the user with a way to *organize* the huge amount of information needed in an environment impact assessment, such as:

- the involved stakeholders;
- the impacted compartments;
- the indicators or indexes chosen in order to describe the possible impacts on environment, economics and society;
- the alternatives for future planning.

The organization of what we can define as the *epistemological complexity*, is generally entrusted to the ***D**rivers–**P**ressures–**S**tate–**I**mpacts–**R**esponses* framework which, within a short time, has "become popular among researchers and policy makers alike as a conceptual framework for structuring and communicating policy *relevant* research about the environment" (emphasis added) (Svarstad, 2008). This causal framework is so described (EEA, 2000): the ***Driving forces*** are the needs of individuals, organisations and nations, satisfaction of which may exert ***Pressures*** such as discharges and changes in land and water use, which change the ***State*** of the environment – the quality of the environmental compartments (air, water, soil) – changes which may have ***Impacts*** on ecosystems, human welfare and heritage, which - when they are undesirable - require

Responses by the society (which may be directed towards any part of the above elements) to reduce/ eliminate the impacts.

Once the *epistemological complexity* has been organized and "laid down" within this framework, a DSS *assesses* the different alternatives to plan interventions. On the basis of the importance credited to the various selected indicators or indices (generally defined as criteria), a numerical weight is attributed to each of them by applying *Multiple-Criteria Decision Analysis* (MCDA) methodologies (Mysiak *et al*., 2002) such as the *Analytic Hierarchy Process* (AHP) (Saaty, 1980). The assignment of weights is a very important step because it is at this stage that the concept of sustainability has a chance to enter by linking environmental, economic and social variables. In this phase, the weight to the criteria should be assigned in order to reach a balance among the needs expressed by the three compartments.

The normalization of the criteria follows, to convert them into dimensionless values in a common range (e.g., form 0 to 1). In this way, the values can be multiplied by the weights assigned to them, and then aggregated by means of different functions such as, for example, the *Simple Additive Weights* (SAW), or others (Mysiak *et al*., 2002). The aggregation stage allows to give, as a result, a *score* to each project alternative which provide a kind of ranking on the basis of their sustainability fixed by the allocation of weights to each of the selected criteria.

In Figure 10 it is possible to notice that the stage defined as "ASSESS" is a *black box*. This is because the software graphical interface normally accompanies the user during the various stages without major requests or difficulties. This in most cases leads to a total confidence in the DSS and to a total ignorance of the mathematical procedures which are behind the process.

Relying completely on a DSS may involve a series of "*side effects*" that could bring the final solution far away from the sustainability goal.

1.3.2 "Side effects" of expert knowledge-based tools and methodologies

This section describes a critical aspect experienced both through the use of various types of DSS (Tomasello *et al.*) and by analysing some accounting methodologies which,

very valid from a conceptual and mathematical point of view, may be affected by the same *side effects*.

1. Reflexivity

The reflexivity of expert knowledge is an aspect of the decision-making processes subject of a great interest (Kovacic and Giampietro, 2015 and references therein). As Rittel and Webber (1973) point out, the information used to represent a problem "depends on one's idea for solving it". According to Kovacic and Giampietro, (2015) the decision of "what to observe" is necessarily based on the observer's goals and beliefs, and acts as a filter (Figure 11 - b) between the observer and the external world (*i.e.* the expert in the case of the Figure 11 - b): "The sun did not revolve around the earth before Copernicus' findings; the new observation is due entirely to the adoption of a different narrative. In this example, the observed system does not change, what changes is the way the observation is interpreted".

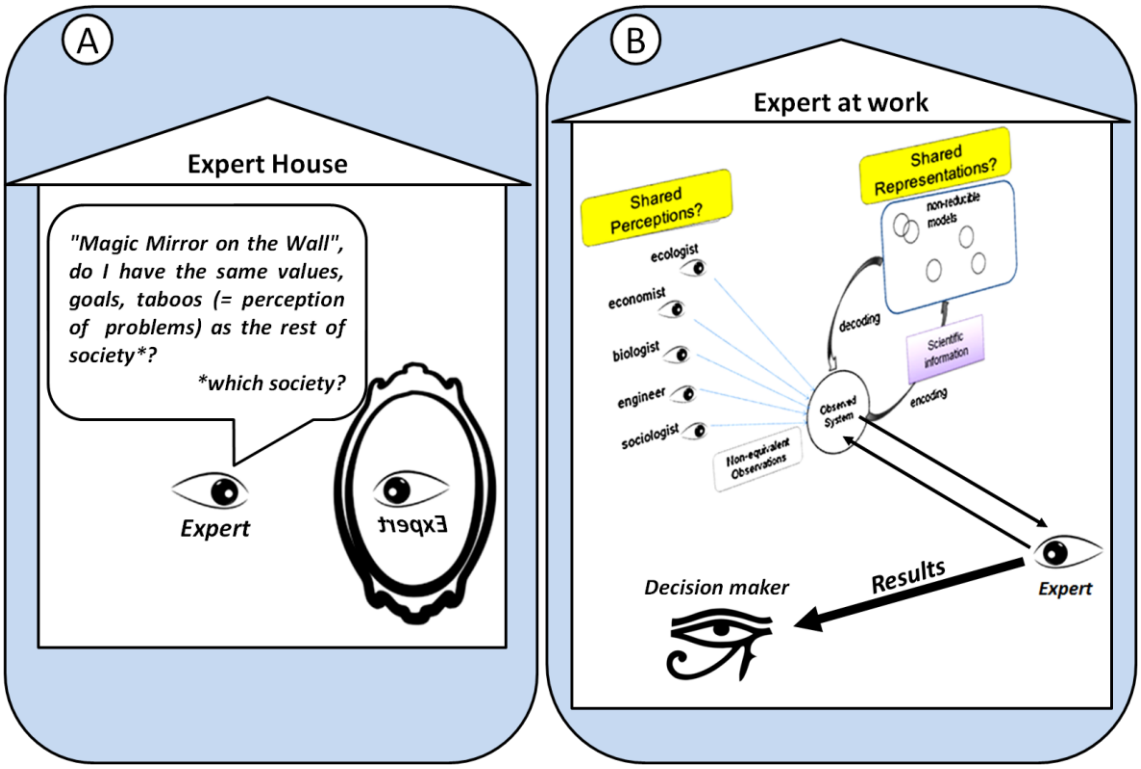


Figure 11 - Reflexivity requires awareness of the process of production and use of scientific knowledge (elaboration from Kovacic and Giampietro, 2015).

As shown in Figure 9, the *epistemological complexity* is the plurality of non-equivalent perceptions and non-equivalent representations of the same observed system.

Figure 11 shows the next problem which affects a decision-making process. The question is: *which set of perception and representation is relevant for the expert?* The answer, according to the reflexivity concept depends on the *expert* and on his knowledge, his perception of the problem and his ideas for solving it. In this sense, the expert reflects, by the mirror (Figure 11 - A), his own values, goals and taboos to the problem he is examining.

2. Reproducibility

"Reproducibility of results is a cornerstone of the scientific method. Therefore, the scientific community has been encouraging researchers to publish their contributions in a verifiable and understandable way" (Santana-Perez *et al.*, 2016).

The *reproducibility* of tools or methodologies based on the expert knowledge is difficult due to the reflexivity problem. Changing the expert means changing the mirror though which the values, goals and taboos are projected into the problem under examination. Even in the case of accounting methodologies such as the *Emergy accounting* (Odum, 1996) and the *Multi-scale integrated analysis of societal and ecosystem metabolism* (*MuSIASEM*) (Giampietro *et al*., 2009) with internationally recognized bases, the limited knowledge of the expert compromises the reproducibility of the results.

It is necessary to intervene in the pre-analytical phase, *i.e.* in the qualitative description of the system, and make it robust by accepting the challenge of describing system complexity.

3. Analyticity

Reflexivity and Reproducibility should find their mathematical soundness in the Analyticity properties of the DSSs.

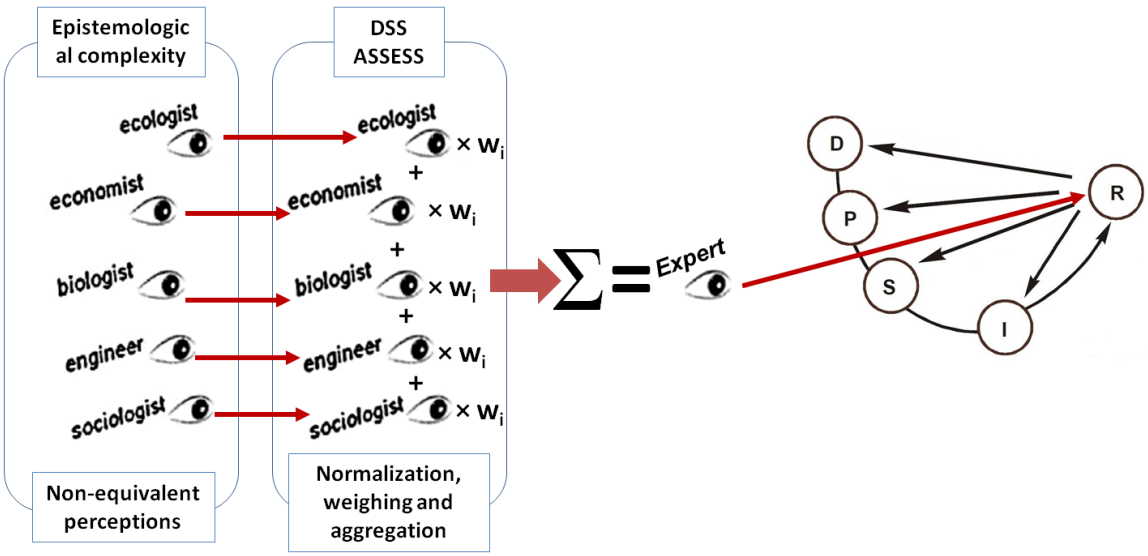


Figure 12 - Illustration of how a DSS allows to analytically reduce and simplify the *epistemological complexity*.

The problem here appears to be another: are quantitative computations always valuable? During the DSS processes (see Figure 12) non-equivalent perceptions undergo a normalization process. The resulting values are then multiplied by a corresponding weight set, which is the outcome of the expert perception of the problem. This produces a loss of information which can be detrimental to the usefulness of the result. An example is provided by the *Index of Sustainable Economic Welfare* (ISEW – Cobb and Daly, 1989). According to Munda (2013), this index is so aggregated that it does not provide any clear information on the cause of its bad performance.

Another example comes from a research work, part of the author's Master Degree Thesis, on spatial analysis of biodiversity on the Ural river Delta (Tomasello, 2013). On the basis of field observations, biodiversity (in particular birdlife) is spatially analysed in order to provide maps of the *Conservation Values*, which give an immediate information about areas where threatened species can be found (red areas) and others where not threatened species live (blue areas). The resulting maps are shown in Figure 13. There are three maps corresponding to the three different methodologies used to aggregate the data:

- *Technique for Order Preference by Similarity to Ideal Solution* (TOPSIS) - Figure 13, map A;
- *Simple Additive Weighting* (SAW) - Figure 13, map B;
- *Ordered Weighted Averaging* (OWA) - Figure 13, map C.

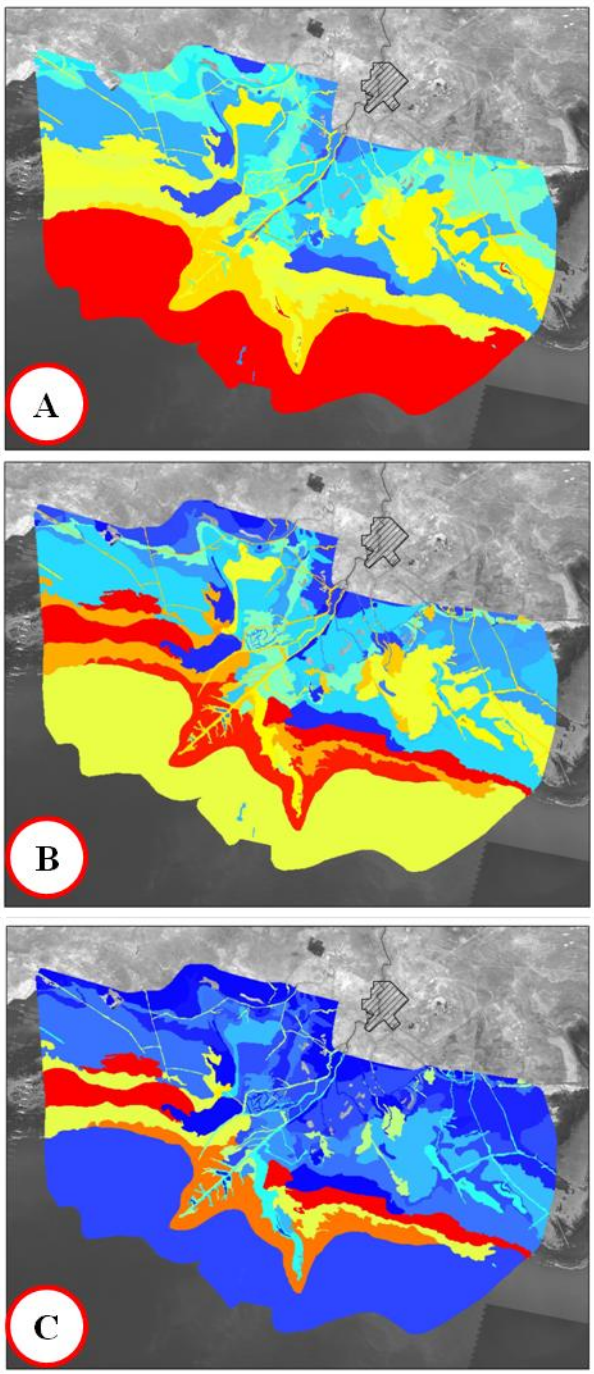


Figure 13 - Ural river Delta, representation of the Conservation Value distribution calculated through the application of three different aggregation methodologies: A - Technique for Order Preference by Similarity to Ideal Solution (TOPSIS); B - Simple Additive Weighting (SAW); C - Ordered Weighted Averaging (OWA).

Even if each aggregation method is mathematically sound and applied to the best of the author's knowledge, the results are substantially different. How to interpret these substantial differences and how to prevent difference in results? Using a DSS without opening the *black box* in Figure 10, could lead to "accredited" but wrong environmental management actions that would result in a possible loss of biodiversity. Opening that box

and understanding what is meant by the use of one or the other aggregation functions could help in making the expert aware of the reflexivity and analyticity problems.

4. Perspectivity

The term "support" cannot be attributed to methodologies affected by the above faults because a conscious and well controlled use of specific methods can lead to a misuse of scientific findings. The concept of perspectivity is developed in this work as the ability to make prevalent and accepted an extraneous and non-sustainable solution, because it is apparently supported by scientific arguments.

Let's assume, for the sake of the argument, that:

- there is an important external decision maker influencing the expert in charge to evaluate project alternatives using an expert knowledge-based DSS;
- "THE" Decision-maker (represented in Figure 14 by the *"*Eye of *Horus*", also known as *"*The Eye of *Ra"*) has already decided which of the alternatives is the one that has to be successful even if it is totally unsustainable.

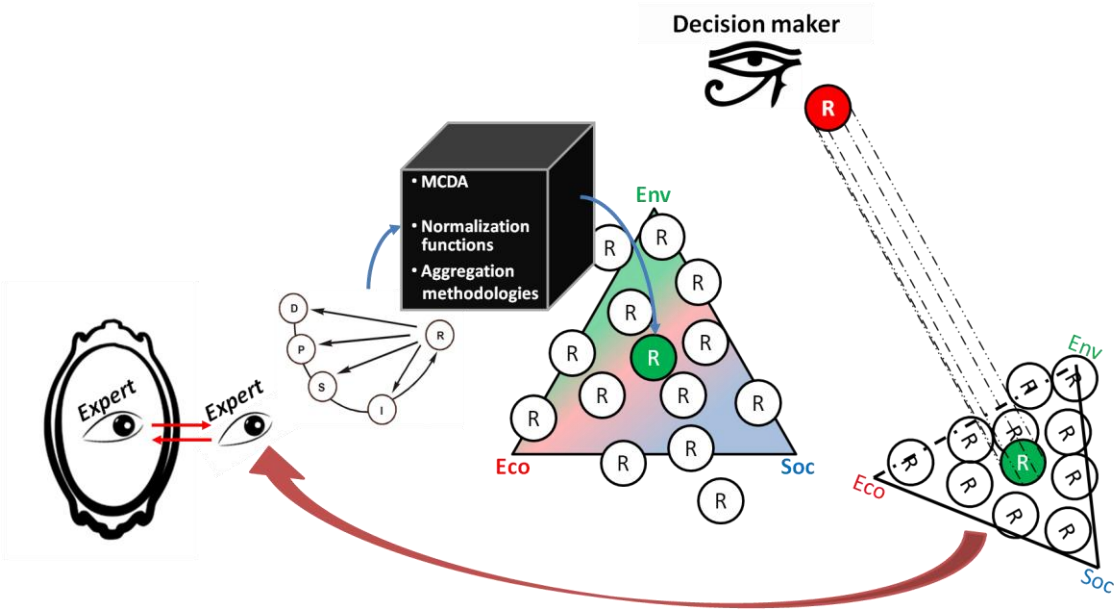


Figure 14 - Scheme of a generic decision-making process influenced by an external decision-maker. The red Response is the one preferred by decision maker, and it is outside the sustainability triangle.

The influenced expert (Figure 11), conscious of the components that characterize the support system (software or methodology to apply), after careful analysis of the relationships between environmental, social and economic variables that characterize the alternatives can be able to:

- choose the relevant *perception and representation* among the *epistemological complexity* both not including those which could hamper the desired alternative and/or giving them the "appropriate" weight in order to pilot the interesting variables to the desired result;
- choose the appropriate aggregation function in order to attribute to the desired project alternative the highest score.

This kind of misuse of DSSs is possible, and so far as the above listed *"side effects"* are not limited, it is not possible to use the term "support" talking about the DSS. This because a DSS so conceived cannot "support" decisions but instead can "confirm" or "analytically credit", a decision already taken.

1.4 The "Post-Normal Science" solution

> In response to the challenges of policy issues of risk and the environment,
> a new type of science -'post-normal'- is emerging.
> (Funtowicz and Ravetz, 1993)

The *"side effects"* described above are the weapons that "normal science" uses to challenge complexity. But using the "normal" science and its *"side effects"*, is comparable to a puzzle-solving exercise, where the final puzzle is composed by 200 pieces, but the player wants to solve it with only 150 pieces.

The challenge requires a different thinking: an increase of the analyst's culture in order to enhance its perception of the system, an extension of the system descriptive boundaries, now bland, the involvement of stakes which were not considered before and the acceptance of an increased and irreducible uncertainty.

How the "normal science" behaves against both the system uncertainty and the increasing in decision stakes has been the subject of an interesting publication: *Science for*

the post-normal age (Funtowicz and Ravetz, 1993). Their work is a genuine and involving critique, challenge, provocation on the solutions proposed by normal science:

> *"[...]The reductionist, analytical worldview which divides systems into ever smaller elements, studied by ever more esoteric specialism, is being replaced by a systemic, synthetic and humanistic approach. The old dichotomies of facts and values, and of knowledge and ignorance, are being transcended. Natural systems are recognized as dynamic and complex; those involving interactions with humanity are 'emergent', including properties of reflection and contradiction. The science appropriate to this new condition will be based on the assumptions of unpredictability, incomplete control, and a plurality of legitimate perspectives. [...]"*

Contrary to what may seem, Funtowicz and Ravetz do not consider traditional science irrelevant; the task, for them, is to choose the appropriate problem-solving strategy for each particular case.

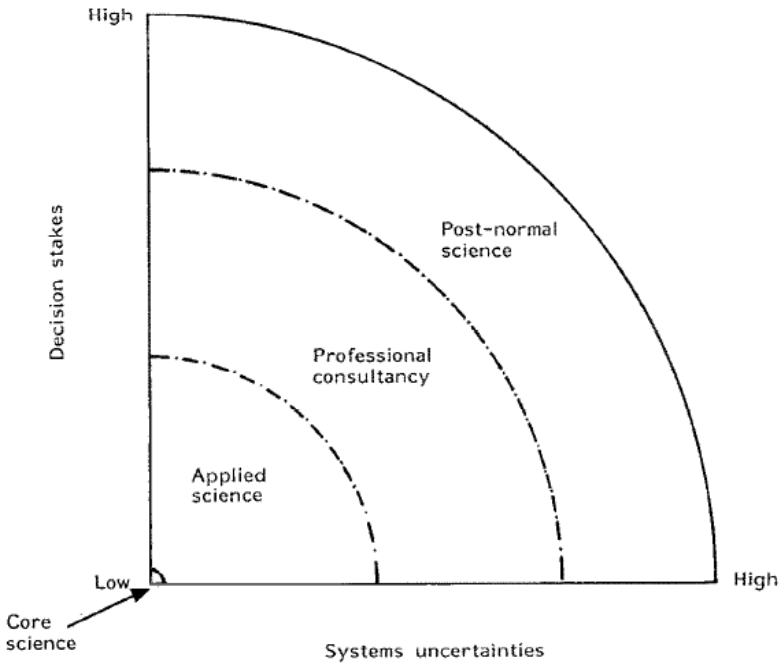


Figure 15 - Problem-solving strategies. (Funtowicz and Ravetz, 1993)

As shown in Figure 15, four typologies of problem-solving strategies have been identified on the basis of different levels of system uncertainties and decision stakes, defined as:

(1) *system uncertainties*: the comprehension or management of an inherently complex reality.
(2) *decision stakes*: all the various costs, benefits, and value commitments that are involved in the issue through the various stakeholders.

The different problem-solving strategies are organized in the following way:

- *Core science* - is the "pure" science and generally there are no external interests at stake in curiosity-motivated research, so decision stakes are low.
- *Applied science* - is involved when both systems uncertainties and decisions stakes are low. The systems uncertainties are at the technical level, and can be managed by standard routines and procedures (like an architect designing an arcade, a carpenter building a table, etc.).
- *Professional consultancy* - when the level of uncertainties and stakes is medium, then the application of routine techniques is not enough; skill, judgement, sometimes even courage are required. As uncertainty increases, professional consultancy is seen as a more appropriate practice. In the case of surgery, for example, patients are most likely to ask for a second medical opinion before submitting themselves to a risky treatment, because the complexity of the problem may imply the existence of different solutions depending on the specific point of view adopted when framing the issue.

According to Munda (2004), methodologies such as the MCDA belong to these three problem-solving strategies.

1.4.1.1 The Post-normal science strategy: the "extended peer review"

When uncertainty is irreducible and risks cannot be quantified, then we are out of the range of competence of traditional sorts of expertise and traditional problem-solving methodologies.

The resolution of policy issues in post-normal science wants the inclusion of a growing set of legitimate participants in the process of quality assurance of the scientific inputs. In post-normal science, uncertainty is not banished but is managed, and values are not presupposed but are made explicit. The model for scientific argument is not a formalized deduction but an interactive dialogue.

As we could observe, in *applied science* and *professional consultancy* the peer communities are already extended beyond those for *core science*, but the multiple uncertainties require that the relative importance of persons is taken into account.

These new problems are in many ways different from those of research science, professional practice, or industrial development, with established means for quality assurance of the results (peer review, professional associations, or the market). For these new problems, keeping quality depends on open dialogue between all those affected. (Funtowicz and Ravetz, 2003). Therefore, the matter is not a broader democratic participation, but of an e*xtended peer community*, not merely consisting of persons with some form of institutional accreditation, but rather of all those with a desire to participate in the resolution of the issue.

1.5 Objectives

The post-normal science solution strategy provided by Funtowicz and Ravetz, allows to close a circle, which started from the definition of *politics* provided by Aristotle:

> *the administration of the polis for the benefit of everyone, the determination of a public space in which all citizens, defined such as those who actively participate to the political life of his own state, belong.*

The solution to the policy-making problems, has always resided in cultural matters (philosophy, history) that, apparently, do not belong to the science realm where everything can be described by numbers.

That citizen participation has undergone a drift from policy-making processes, is a fact and it is very likely due:

- by the side of citizens

    - to the loss of trust in institutions;
    - to the idea of not being taken into account;
    - to a lack of interest;
    - ...
- by the side of politics
    - to a complete trust in science;
    - to the idea of the impossibility (or non-necessity) of taking into account a high number of stakes;
    - to the need to take urgent decisions in contrast to, e.g., the *Environmental Impact Assessment* (EIA) procedures that require a fair and extensive public participation (Directive 2011/92/EU)
    - to the transparency and communication of the informations;
    - ...

The work behind this thesis agrees with the post-normal solution firmly believing in the power of participation in the policy-making process as a way to find the more sustainable solutions and to make citizens (and the politicians, which are a part of them) more aware of issues which affect them directly or indirectly both in the present and in the future.

Aware that:

- the tools and methodologies analysed in the previous sections are still widely used, beyond the levels of uncertainty and decision stakes typical of the complex systems;
- it is necessary to account for the stakeholders involved directly or indirectly in the policy choices but also for those normally hidden because of their non-material nature (i.e., virtual);
- the assessment of the interaction between society, environment and economy may lead to the identification of interests which could be interpreted as useless, outside the scope of the analysis or extravagant;

the thesis work aims to develop a causal *framework* to be used in the pre-analytic stage in order to create a map of the possible stakeholders, of their interests and of the natural and economic compartments involved.

While the consequent quantitative stage, that does not concern this thesis, can be carried out by any of the valid and recognized methodologies found in the scientific literature, this work concerns the quality of the expert perception related to his geographic knowledge of the problem in order to support him in a descriptive path from the global (general information) to the local (specific information). It does not matter if the intention is to sculpt a statue using a chisel, a rasp or a nail clipper (quantitative accounting methodologies), it is important to know that the amount of marble needed at the beginning cannot be less than that of the final creation (reductionist perception of a complex system). The *framework*, indeed, aims to provide a shareable description of the individual, collectives and ecological interests and, furthermore, to find all the possible relation between each others.

Using an *Adjacency Matrix* derived from graph theory and a *Narrative Structure* (Mark Lombardi in Bigge, 2005) , the user will be able to exclude the elements not present in his case study justifying the exclusion. The resulting set of interacting elements provides a map of all stakeholders, including virtual ones (*i.e.* not identified by a physical participation in decision making process), with the intent to minimize the "side effects" (*Reflexivity*, *Reproducibility*, *Analyticity*, and *Perspectivity).*

«'This is Prostetnic Vogon Jeltz of the Galactic Hyperspace Planning Council, as you will no doubt be aware, the plans for development of the outlying regions of the Galaxy require the building of a hyperspatial express route through your star system, and regrettably your planet is one of those scheduled for demolition. The process will take slightly less than two of your Earth minutes. Thank you.'

[...]

'There's no point in acting all surprised about it. All the planning charts and demolition orders have been on display in your local planning department in Alpha Centauri for fifty of your Earth years, so you've had plenty of time to lodge any formal complaint and it's far too late to start making a fuss about it now.'

[...]

'What do you mean you've never been to Alpha Centauri? For Heavens' sake, mankind, it's only four light-years away, you know. I'm sorry, but if you can't be bothered to take an interest in local affairs that's your own lookout. Energize the demolition beams.'

[...]

'I don't know,' said the voice on the PA, 'apathetic bloody planet, I've no sympathy at all.'

There was a terrible ghastly silence.

There was a terrible ghastly noise.

There was a terrible ghastly silence.»

(The hitch hiker's guide to the galaxy - Adams 1995)

2. Materials and Methods

"I like to imagine that the world is one big machine.
You know, machines never have any extra parts.
They have the exact number and type of parts they need.
So I figure if the entire world is a big machine,
I have to be here for some reason.
And that means you have to be here for some reason, too."

The Invention of Hugo Cabret *(Selznick, 2015)*

2.1 The virtual stakeholders

According to the Post-normal Science principles (section 1.4), the *extended peer review* is the strategy to be undertaken in problems characterized by high system uncertainty and high decision stakes. This is true for all cases involving decision-making processes, even when the procedures are quite standard (as in the case of EIA). The problem is that such a review requires both considerable time and economic investment in order to collect the necessary information.

A judgement based on expert knowledge, as we have seen, is still the preferred solution. Nevertheless, *Professional consultancy* (see Figure 15) can satisfy uncertainty and decision stakes levels far lower than those that concern the post-normal science and this forcibly leads to reductionist and a simplistic view of the complex systems and, consequently, to inadequate solutions. However, this is the reality, so the task of a post-normal scientist is to accept it and try to limit the damages.

In this work, the concept of *Virtual Stakeholder* is introduced and developed taking into account the definitions of politics (section 1.2) and environment (section 1.2.4) described in the Introduction.

A *Virtual Stakeholder* is the representative of the existence, intentions, motivations and interests (where present) that make up the complex environmental system. The *Virtual Stakeholders* are the components of the three compartments chosen to build the methodology which will be described in detail in the next sections. Because of the different

nature of these compartments, a *Virtual Stakeholder* can represent something material or non-material, concrete or abstract.

Each *Virtual Stakeholder* wants to realize his target, and its achieving depends on the interaction with the other *Virtual Stakeholders* which, in their turn, want to realize their targets.

These interactions can be described by the general equation:

$$I_{\mathrm{VS_i}} = f\left(I_{\mathrm{VS_1}} + I_{\mathrm{VS_2}} + ... + I_{\mathrm{VS_{i-1}}} + ... + I_{\mathrm{VS_{i+1}}} + ... + I_{\mathrm{VS_n}}\right)$$

where the achieving of the interests (*I*) by the *i-th Virtual Stakeholder* is a function of the interests of the other *n-1 Virtual Stakeholders*, for $n \rightarrow \infty + 1$ (see the definition of a complex system, section 1.2.4 and footnote 4). Each *Virtual Stakeholder* is intimately intertwined with the others (Juarrero, 1999) and if the interests of one of them change, the consequences may spread with varying intensity to the other connected *Virtual Stakeholders* within the system.

As specified in section 1.5, the goal of the framework developed in this research work is not the quantification of the impacts transmitted because of the interactions among the *Virtual Stakeholders*, but the interactions themselves. The framework, as we will see, aims to identify the possible relations among the *Virtual Stakeholders* both directly and indirectly involved in a process that can be defined as *forced global participation policy*.

The framework, in this way, appears to be the place where the *Virtual Stakeholders* participate in order to express their concept of benefit (when it exists), thus giving the opportunity to highlight the possible interactions that may take place with the other participants of the political process.

2.2 The Policy Choices Analysis/Synthesis System 42 (*PoChASSy42*)

- "Forty-two," [...]"The Answer to the Great Question, of Life, the Universe and Everything. I checked it very thoroughly," [...] "and that quite definitely is the answer. I think the problem, to be quite honest with you, is that you've never actually known what the question is."

- "But it was the Great Question! The Ultimate Question of Life, the Universe and Everything," [...].

- "Yes," [...] "but what actually is it?"

A slow stupefied silence crept over the men as they stared at the computer and then at each other.

- "Well, you know, it's just Everything … Everything ..." [...].

- "Exactly"[...] "So once you know what the question actually is, you'll know what the answer means."

(The hitchhiker's guide to the galaxy - Adams 1995)

In Figure 7 the representation of the *environment* is shown as a socio-ecological system. This vision is the foundation of the " *Policy Choices Analysis/Synthesis System 42* (*PoChASSy42*)" methodology.

PoChASSy42 is a pre-analytic tool useful to identify the *Virtual Stakeholders* involved in a choice when a change in one of them is foreseen. It will help the user of any accounting methodology to identify the elements on which to focus the quantitative analysis (whenever possible) in order to organize the information provided by the epistemological complexity in the quantitative stage.

The first part of the methodology name, on the base of the definition of Politics, suggests that the participation is the principle on which it is based: *PoChASSy42* indeed is the virtual place where the *Virtual Stakeholders* can manifest their interests. However, the term "*Policy Choices*" does not reduce the scope of the system assessment to the mere choices made by political representatives, which are anyway included, but it indicates a map of possible *Virtual Stakeholders* involved, starting from each single *Virtual Stakeholder*, target of the change, regardless of the decision makers.

In the methodology name other two terms are useful to understand how the tool works before entering into the details: *Analysis* and *Synthesis*.

According to Dettmer (2006), the word “analysis” has been overused, to the point of becoming a *cliché* deeply embedded in our lives (e.g. environmental analysis, business analysis, financial analysis, cost-benefit analysis, metallurgical analysis, spectrographic analysis, systems analysis): "Since the Renaissance, analysis has been the foundation of problem solving. But as we move from the 20th into the 21st century, it's becoming clearer that analysis alone is an incomplete, suboptimal way of understanding the functioning of our world. Worse, without the next step (*synthesis*) practicing analysis alone is a dangerous way of operating."

Analysis is a process of reducing a complex whole, or system, into its components and of dealing with those parts in isolation (see the *simplification paradigm* - section 1.2.4) while *Synthesis* amounts to putting things together. According to the *Meditations on First Philosophy* by Descarte, the *analysis* consists in dividing the *cognitive process* in its simpler components, with a warning not to proceed too far with the breakdown to avoid losing the overall sense of the problem; *synthesis* consists in putting together the parts, thus

identifying the right structure and composition of the problem to be solved (Descartes, cited by Cottingham, 2013).

In order to develop *PoChASSy42*, the *Virtual Stakeholders* have been *analyzed* deconstructing the environment in three dimensions:

- ***Individuals Interests*** - identified through the study of the *Normative Values* that have led to *Universal Declaration of the Human Rights* (UDHR) (UN, 1948);
- ***Collective Interests*** - identified through the study of the *Nomenclature statistique des activités économiques dans la Communauté européenne*[9] (NACE) (Eurostat, 2008);
- ***Ecosystem Services*** - identified through the study of the *Millennium Ecosystem Assessment* (MA, 2005) and the *Water Cycle* (Evans and Perlman, 2005).

The choice of these descriptive tools is due to the *synthesis* suggested by the model in Figure 7. In the model:

- the "society" is the compartment which, in connection with the ecological compartment, allows individuals to achieve their interests, both through a *Demand/Supply* link, passing through the economic activities which transform materially this link, and through the satisfaction of religious, cultural and emotional needs;
- the "economic activities" depend on the requirement of products and services from the society and the capacity of the ecosystem to provide the materials needed to the products fabrication in order to ensure individuals and society well-being. Moreover, in the case of artisans, maintaining this balance is the only way to pass on their manufacturing art to future generations, thus ensuring a job to his own children or other's;
- the "ecosystem" is the compartment which, besides being connected with the above described compartments according to their needs, provides a number of material and immaterial services through preservation and conservation

[9] Statistical Classification of Economic Activities in the European Union

policies. The *Virtual Stakeholders* which represent this compartment have, as a goal, to maintain their existence and efficiency, so as to retain essentially the same function, structure, identity, and feedbacks (Walker, 2004). The ecosystem capacity to absorb disturbance and reorganize while undergoing change (resilience) is essentially determined by the biodiversity which characterise the ecosystem itself: the greater is its complexity, the more it proves able to rebalance, following the occurrence of more or less serious failures (Ciancio, 2005).

The aim of the *synthesis* which is the basis of *PoChASSy42* is to highlight these relations. Before dealing with this procedure, it is necessary to enter into the description of the *Virtual Stakeholders* in order to fully understand the interests which they represent.

2.3 The Individual Interests

The reasons that lead the social *Virtual Stakeholders*, representative of individual interests, to activate the *Requirements/Supply* machine and, in the general, to establishing an interaction with the ecosystem, can be the most varied. According to Abraham Harold Maslow (1970a, 1970b), the American psychologist who is best known for the Maslow's hierarchy (or pyramid) of needs, they can be classified as:

1. ***Biological and Physiological needs*** – air, food, drink, shelter, warmth, sex, sleep, etc.
2. ***Safety needs*** – protection from elements, security, order, law, stability, etc.
3. ***Social Needs*** – belongingness and love, – group work, family, affections, relationships, etc.
4. ***Esteem needs*** – self-esteem from achievements, mastery, independence, status, dominance, prestige, managerial responsibility, etc.
5. ***Cognitive needs*** – knowledge, meaning, etc.
6. ***Aesthetic needs*** – appreciation and search for beauty, balance, form, etc.
7. ***Self-Actualization needs*** – realizing personal potentials, self-fulfilment, personal growth and peak experiences.
8. ***Transcendence needs*** – helping others to achieve self actualization.

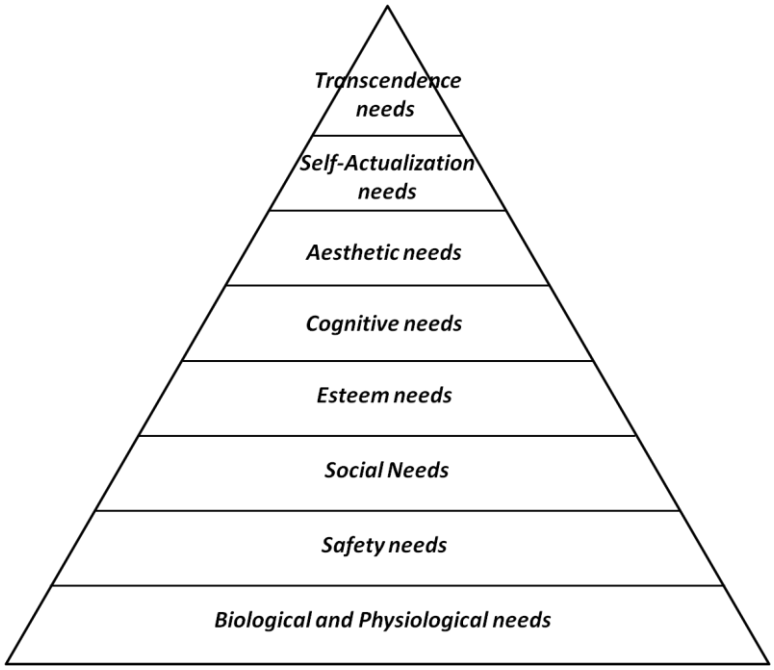


Figure 16 - Maslow Pyramid of needs

From a political point of view it is hard to decipher and to concretize such a wide range of needs, and include them in a policy-making process (see also section 1.2.5). This is because these needs vary from person to person and the aim of policy is not the satisfaction of one human being at a time, but all together, always keeping in consideration the limitations identified by Arrow's *Impossibility Theorem* (section 1.2.5).

Although the discomfort of scientists due to the considerable difficulties in describing the society is more than understandable, reducing this variety in a single number provided by an index cannot certainly be helpful in order to include it within a policy-making process. An help in describing human behaviour can only come from the study of human history (i.e., by making the journey through *Le passage du nord-ouest*, following the allegory of section 1.2.4).

2.3.1 A brief history of the human rights

Aristotle, in his first book on *Politics*, discusses the *polis* or "political community" as opposed to other types of communities and partnerships such as the household and the village. Aristotle focused on the *polis* because he believed that the public life was far more virtuous than the private one, and because men are "political animals" (Laurenti, 2007).

But how these "political animals" behave when they are deprived of the freedom to choose their present and their future? Human history gives us, and is unfortunately still providing, many examples. Some have led to the subjugation of entire populations. In others, the popular revolt or the intervention of enlightened sovereigns, ended with the drafting of agreements where the parties guaranteed the non-repeatability of the actions that led to the dark period during then lives.

In 539 B.C., the armies of Cyrus the Great, the first king of the ancient Persia, conquered the city of Babylon thus deposing the king Nabonidus, accused of desecration of the temples of the gods and the imposition of forced labour upon the populace. According to the legend, as a result of these offenses, the god Marduk (the highest Babylonian god) abandoned Babylon and sought a more righteous king. Marduk called forth Cyrus to enter Babylon and become its new ruler (Finkel, 2010). But it was Cyrus next actions that marked a major advance. He freed the slaves, declared that all people had the right to choose their own religion, and established racial equality. These and other decrees were recorded on a baked-clay cylinder in the Akkadian language with cuneiform script. Known today as the Cyrus Cylinder, this ancient record has now been recognized as the world's first charter of human rights (United for Human Rights, 2016).

When Richard the Lionheart died (April 6, 1199), he was succeeded by his younger brother John of England. John, to defend and then win back the possessions of the Plantagenêt in France, had to engage in a war against the kingdom of France, financed through a strong taxation of his barons, who publicly denounced its arbitrary nature. Because of the failure of the French expedition (which culminated in the Battle of Bouvines in 1214), the rebel barons refused loyalty to the king. This revolt led to the First Barons' War. King John of England, meeting the rebels in Runnymede (near Windsor, June 15, 1215), in return for a renewed obedience, was forced to a number of concessions which constitute the main content of the *Magna Carta* (Powicke, 1999), also known as the Great Charter, which enumerates what later came to be thought of as human rights.

Some of the contents of the Charter were: the right of the church to be free from governmental interference; the rights of all free citizens to own and inherit property and to be protected from excessive taxes; the right of widows who owned property to choose not to remarry. With the Great Charter, the principle of due process and equality before the law was established. It also contained provisions forbidding bribery and official misconduct. Nowadays, the *Magna Carta* is widely viewed as one of the most important legal

documents in the development of modern democracy and as a crucial turning point in the struggle to establish freedom.

But History has accustomed us to its *recurring cycle* (Vico, 1948). In 1628, the refusal by English Parliament to finance the king's unpopular foreign policy had caused his government to exact forced loans and to quarter troops in subjects' houses as an economy measure. Arbitrary arrest and imprisonment for opposing these policies produced a violent hostility to Charles and to George Villiers, the Duke of Buckingham. As a consequence, the Parliament sent to Charles I the *Petition of Right* as a statement of civil liberties. The *Petition of Right* contents concerned the prohibition of imposing: taxes without the approval of Parliament; forced loans; arbitrary arrest; imprisonments contrary to *Magna Charta*; interference with private properties; obligation to provide accommodations to the soldiers; imposition of martial law; exemption of officers from prosecution.

England and taxation were also the generating causes of another famous popular rebellion: the American War of Independence (1775-1783). The war had its origins in the resistance of many Americans to taxes imposed by the British parliament, which they claimed as unconstitutional. Patriot protests escalated into boycotts and, on December 16, 1773, in the destruction of a shipment of tea at the Boston Tea Party. That was the spark which led to almost 9 years of war and to the death of 25,000–70,000 American Patriots (Peckham, 1974) and at least 51,000 dead British soldiers (Almon, 1781). The consequent foundation of the United States of America had been strongly wanted since the United States Declaration of Independence drafting by Thomas Jefferson and approved by the United State Congress on July 4, 1776. Philosophically, the Declaration stressed two themes such as the individual rights and the right to revolution. In the wake of the Declaration, there was the subsequent drafting the Constitution of the United States of America (1787) and the famous Bill of Rights (1791) which protects freedom of speech, freedom of religion, the right to keep and bear arms, the freedom of assembly and the freedom to petition. It also prohibits unreasonable search and seizure, cruel and unusual punishment and compelled self-incrimination, prohibits to Congress to draft laws on religion and prohibits the federal government from depriving any person of life, liberty or property without due process of law.

The ideas which that made up the Declaration of Independence, became widely held by Americans and spread internationally as well, influencing in particular the French Revolution. The causes of the French Revolution are complex and are still debated among historians: the unpopular raising of the taxation to consolidate the debts due to the France

participation in the Seven Years' War and the American Revolutionary War and years of bad harvests inflamed popular resentment due to the privileges enjoyed by the clergy and the aristocracy. That atmosphere sprang a relentless series of events leading up to 10 years of civil war and bloodshed: the convocation of the Estates-General, the assault on the Bastille, the women's march on Versailles, the abolition of feudalism, the institution of the Republic and the execution of Louis XVI in January 1793 (Brinton, 1963). Just six weeks after the storming of the Bastille, and barely three weeks after the abolition of feudalism, *La Déclaration des Droits de l'Homme et du Citoyen* (the Declaration of the Rights of Man and of the Citizen) was adopted by the National Constituent Assembly as the first step toward writing a constitution for the Republic of France. The Declaration, influenced by the Enlightenment thought as well as by the Jefferson's American Declaration, proclaims that all citizens are to be guaranteed the rights of "liberty, property, security, and resistance to oppression" to the sound of the inviolable principles of *Liberté, Égalité, Fraternité* (liberty, equality, fraternity).

Of great importance for the purpose of this work, as we will see, is Article VI of the *Déclaration* (Rials, 1988):

> *"The law is the expression of the general will. All the citizens have the right of contributing personally or through their representatives to its formation.[...]"*

2.3.2 Final considerations about the "brief history of the human rights"

This historical introduction about the human rights allows us to understand some aspects of human behaviour. By focusing on the key points of each event from Cyrus the Great until the French Revolution, it is possible to identify some common moments which are repeated cyclically (Figure 17): an extra-popular *Repression*, the popular *Rebellion* and the popular *Redemption* through an agreement of non-repeatability of the *Repression* event signed between rebels and repressor (in case the repressor was still alive) or by the new policy makers. New age, old story.

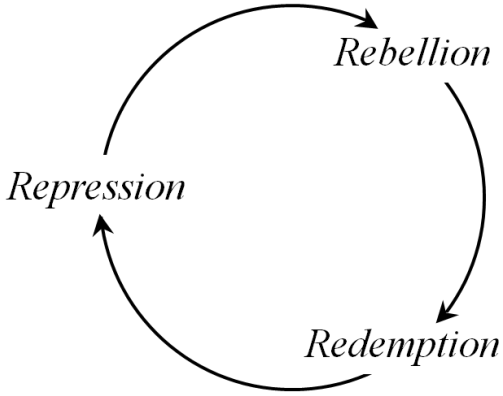


Figure 17 - The "three *R*s cycle": a summary diagram of the human rights history

From Figure 17, it seems that history really repeat cyclically and the facts seems to confirm this. However, what we see like a "three *R*s cycle" is actually a "three *R*s helical succession" as illustrated in Figure 18.

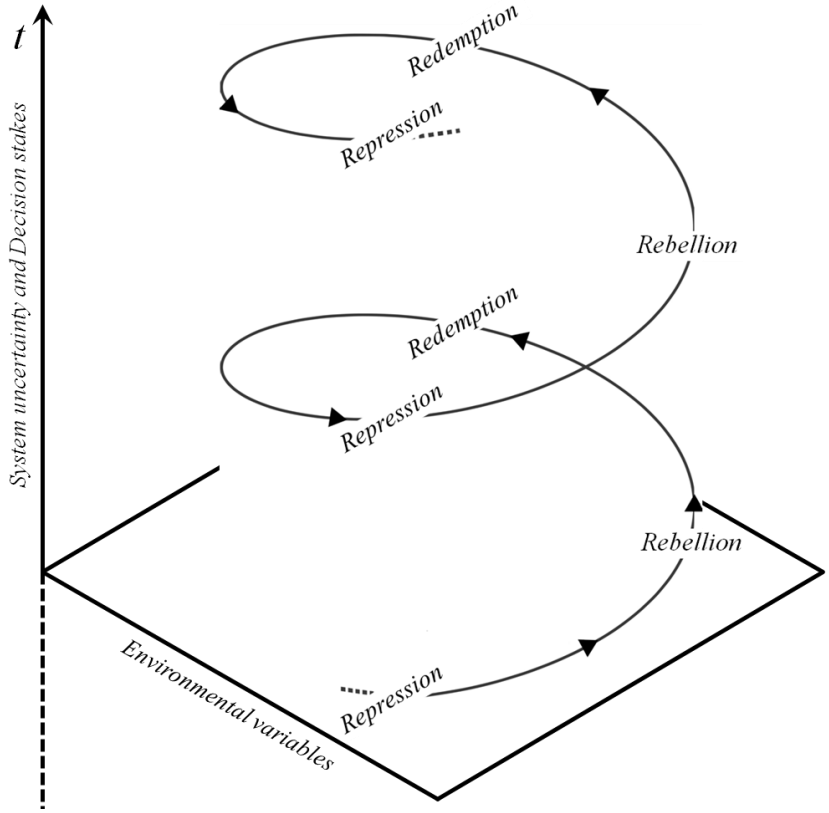


Figure 18 - The "three *R*s helical succession"

This model shows that the cyclical succession of the three *R*s is due to an increase in the Decision stakes and of the complex system uncertainty along the vertical (time) axis. If Man had not culturally evolved from the times of Cyrus the Great to the present, we would not need anything more than his forward-looking cylinder. But human beings have changed and, most importantly, also the environment and the geographical compartment that houses them have changed. Even if cycles follow a similar model, the causes generating them and the results are characterised by an increasing level of complexity.

For this reason *PoChASSy42* considers the *Normative Values*, that led to the drafting of the different human right declarations, as the representatives (*Virtual Stakeholders*) of individual interests of people, living in a given geographical area. The protection of these interests, more than of the needs identified by Maslow (Figure 16), is the main job of any government that recognizes them as fundamental for the management of the *Res publica*.

2.3.3 The "Universal" Declaration of the Human Rights (UDHR - 1948)

It is not easy to summarize the complex world scenario that developed after the end of World War I: such a scenario, which was further aggravated by the economic crisis of 1929, led to a widespread discontent among people thus creating optimal conditions for the establishment of totalitarian regimes such as Fascism in Italy and Spain (this one just emerged from a bloody civil war), and Nazism in Germany (Taylor, 2001), a strange *Rebellion* analysing it with the benefit of hindsight. Furthermore, the League of Nations inability to deal with major international issues favoured the expansionist ambitions of Japan in China, and of Italy in Abyssinia (Walters, 1965). There was also Hitler's decision to ignore the Treaty of Versailles and remilitarise the Rhineland, the annexation of Austria, and of Sudetenland, Bohemia and Moravia. But, overall, it was the breaking of the Treaty of Non-Aggression between Germany and the Union of Soviet Socialist Republics (the Molotov-Ribbentrop Pact) and the invasion of Poland, which generated a hard and hostile reaction from Europe against Germany thus giving a start to the largest armed conflict in history, which cost humanity six years of suffering, destruction and massacres with a total of 55 to 60 million deaths (Gilbert, 2004).

World War II lasted from 1939 to 1945, six years characterized by a continuous loop between *Repression* and *Rebellion*, six years which left cities throughout Europe and

Asia lay in ruins. The common intention of not relive that horror in the future led, at the end of the war in 1945, the delegates from fifty countries to meet them in San Francisco: "The goal of the United Nations Conference on International Organization was to fashion an international body to promote peace and prevent future wars. The ideals of the organization were stated in the preamble to its proposed charter: «We the peoples of the United Nations are determined to save succeeding generations from the scourge of war, which twice in our lifetime has brought untold sorrow to mankind.»" The new United Nations Organization was born in October 24, 1945.

Here comes the *Redemption*. The step that led to the signing of the *Universal Declaration of Human Rights* (UDHR) by the members of the United Nations was brief but not easy. The Universal Declaration was adopted by the General Assembly by a vote of 48 in favour, none against, and eight abstentions: the Soviet Union, Ukrainian SSR (Soviet Socialist Republic), Byelorussian SSR, Federal Republic of Yugoslavia, Republic of Poland, Union of South Africa, Czechoslovakia, and the Kingdom of Saudi Arabia. Violating practically all articles in the Declaration with its system of apartheid, South Africa couldn't be in favour of the Declaration as it was the case of the Saudi Arabia, opposed to the right to change religion and equal rights in the marriage. The Soviet Union asserted that the Declaration did not go far enough in condemning Fascism and Nazism (Johnson and Symonides, 1998) but, according to Glennon (2004), Eleanor Roosevelt attributed the abstention of the Soviet Union to the inclusion of the right of citizens to leave their countries.

The UDHR approved by the General Assembly came praised from all over the world: Charles Malik (Lebanese philosopher and diplomat) called it "an international document of the first order of importance". In a speech on October 5, 1995, Pope John Paul II called the UDHR "one of the highest expressions of the human conscience of our time." (Herath, 2012). US President Ronald Reagan stated: "For people of good will around the world, that document is more than just words: it's a global testament of humanity, a standard by which any humble person on Earth can stand in judgment of any government on Earth.". Eleanor Roosevelt (President Franklin Roosevelt's widow and first chairwoman of the Commission that drafted the Declaration) stated that it "*may* well become the international *Magna Carta* of all men everywhere." (Fine, 2007).

2.3.4 The non-universality of the UDHR: the Shari'a and the Fiqh

In the title of the previous paragraph the word *Universal* was placed between quotation marks. It is precisely in the "*may*" of Eleanor Roosevelt sentence that the non-universality of the UDHR resides, and for some countries the Declaration is seen as *Repression*. As shown in Figure 18, the evolution path of history does not depend only on the increasing uncertainty and decision stakes: it depends also on the geography, on the environmental variables, on the birth place.

Extending "universal" law to all geographic contexts not always leads to spontaneous acceptance because it might be in contrast with historical culture. This is what happened with the UDHR, widely inspired by the Jefferson's Declaration of Independence and by the *Déclaration des Droits de l'Homme et du Citoyen* (Bonanate *et al.*, 2011).

The abstention of the Islamic countries during the General Assembly is the expression of these contrasts, is the *Rebellion* to what they saw as an imposition by the Western countries.

The Islamic law, according to Emon *et al*. (2012), is a modern term that is used as an English translation for *Shari'a* and *Fiqh*:

- *Shari'a*, in its strictest definition, is a divine law. There are two sources of *Shari'a*: the *Quran* and the *Sunnah*. The *Quran* is viewed as the unalterable word of God. The *Sunnah* is the life and example of the Islamic prophet Muhammad. Being an interpretation of these two sources, the establishment of *Shari'a* religious and legal construct has always been problematic. The solution is in the divine origin of the law, which excludes the role of human reason.
- *Fiqh* is usually considered the substantive law of Islam. It is the human understanding of the *Shari'a* (Vogel, 2000) and it is defined as the science of studying it. Internal tensions between different schools of thought in the *Fiqh* interpretation makes the *Fiqh* more dedicated to rituals then to other matters (Emon, 2012).

Shari'a, through the *Fiqh*, is the cultural base which led the Islamic countries to international demonstrations (the *Redemption*) against the UDHR. This happened first with the *Universal Islamic Declaration of Human Rights* (UIDHR), the result of the Islamic

Council (a non-governmental Muslim organization) held in London in the 1981, and then with the *Cairo Declaration on Human Rights in Islam* (CDHRI), a result of the Organisation of the Islamic Conference held in Cairo, Egypt, in 1990. The CDHRI provides an overview on the Islamic perspective on human rights, and affirms Islamic *Shari'a* as its sole source.

The two documents are widely similar with the UDHR, although almost every article is carefully written in order to avoid clashes with the Shari'a. In particular:

- The UIDHR expresses reservations on the UDHR articles pertaining to freedom of expression, security, torture, marriage;
- The CDHRI express reservations against the freedom of expression, assembly, public office, movement, asylum (Emon, 2012).

Universality is a *Reflexivity* problem (see section 1.3.2) and the solution reside in accepting the cultural differences even if they are not sharable in our opinion and according to our values. Things can only change slowly and with the dialogue (participation), by respecting the differences and by not imposing a different perception of the reality, which could be felt as *Repression*.

2.3.5 The *Normative Values* identification.

Through a deep study of the UDHR (UN, 1948) and in light of the relevant comments of Prof. Papisca (2009), 42 *Normative Values* has been identified (Table 3) which will became the *Virtual Stakeholders* of *PoChASSy42* representing the *individual interests* of the citizens.

The table structure is inspired by René Cassin (Nobel Peace Prize in 1968 for his work in drafting the Universal Declaration of Human Rights) who compared the Declaration to the *portico* of a Greek temple:

- Articles 1 and 2 are the foundation blocks, with the principles of dignity, liberty, equality, and brotherhood;
- The first column (articles 3 - 11) expresses the rights of the individual;

- The second column (articles 12 - 17) expresses the rights of the individual in civil and political society;
- The third column (articles 18 - 21) is concerned with spiritual, public, and political freedoms;
- The fourth column (articles 22 - 27) sets out social, economic, and cultural rights.

In Cassin's model, the last three articles of the Declaration provide the pediment which binds the structure together (Leach et al, 2012).

These are the *values* for which people all over the world have rebelled, until their death, against their repression during the World War II. The UN General Assembly's ability to collect and interpret these feelings made sure that they would become the *Normative Values* which characterize the UDHR. These Normative Values are the *Virtual Stakeholders* who represent the *individual interests* of the society dimension in *PoChASSy42*.

Six articles have not been considered:

- Art. 5 - Freedom from Torture and Degrading Treatment;
- Art. 6 - Right to Recognition as a Person before the Law;
- Art. 8 - Right to Remedy by Competent Tribunal;
- Art. 9 - Freedom from Arbitrary Arrest and Exile;
- Art. 10 - Right to Fair Public Hearing;
- Art. 11 - Right to be Considered Innocent until Proven Guilty;

for operational reasons because of their low probability to have interactions during the *synthesis* stage with the environment *Virtual Stakeholders*.

In *PoChASSy42* further developments these articles may be included.

UDHR Arts. 1 and 2	Cassin coloumns	UDHR Arts.	NORMATIVE VALUES		CODES
EQUALITY: Birth, Colour, Language, National or social origin, Political, Property, Race, Sex, Other status	Rights of the individuals	3	Right to life		NV3.1
			Right to liberty		NV3.2
			Right to personal security		NV3.3
		4	Prohibited slevery		NV4
		7	Right to equality before the law		NV7
	Civil rights	12	Right to privacy		NV12
		13	Right to movement and residence*		NV13.1
			Right to leave and return*		NV13.2
		14	Right to seek and enjoy asylum		NV14
		15	Right to nationality		NV15
		16	Right to marry and found a family		NV16
		17	Right to private property		NV17
	Political Rights	18	Right to freedom of thought		NV18.1
			Right to freedom of coscience		NV18.2
			Right to freedom of religion		NV18.3
		19	Right to freedom of opinion and expression		NV19
		20	Right to freedom of peaceful assembly and association		NV20
		21	Right to take part in the government of his country		NV21
	Social, economic and cultural rights	22	Right to a social security		NV22
		23	Right to work		NV23.1
			Right to free choice of employment		NV23.2
			Right to just and favourable work condition		NV23.3
			Right to equal pay for equal work*		NV23.4
			Right to form and join trade unions		NV23.5
		24	Right to rest and leisure		NV24.1
			Right to limitation of working hours		NV24.2
			Right to periodic payed holidays		NV24.3
		25	Right to a standard of living adequate for the health and well-being of himself and of his family	Food	NV25.1
				Clothing	NV25.2
				Housing	NV25.3
				Medical care	NV25.4
			Right to security in the event of:	Unemployment	NV25.5
				Sickness	NV25.6
				Disability	NV25.7
				Widowhood	NV25.8
				Old age	NV25.9
				Other lack of livehood	NV25.10
			Right to a special care for motherhood and childhood		NV25.11
		26	Right to free education		NV26
		27	Right freely to participate in the cultural life of the community		NV27.1
			Right to enjoy the arts		NV27.2
			Right to share in scientific advancement and its benefits		NV27.3

Table 3 - The selected UDHR *Normative Values*

2.4 The Collective Interests

> Labour is, in the first place, a process in which both man and Nature participate,
> and in which man of his own accord starts, regulates, and controls
> the material re-actions between himself and Nature.
> Capital (Marx, 1867)

The relationship between the realization of individual interests and the goods and the services coming from ecosystems lies in the man ability to exploit and elaborate resources. Human evolution has led from the simple collection of food for the satisfaction of what Maslow defines as "Biological and Physiological needs", to a complex world which added more levels to the Maslow pyramid (Figure 16). Scientific revolutions provided the technology that characterizes the modern era passing through two industrial revolutions. The same evolution has led to an increasing pressure on the environment, generating increasingly complex environmental impacts such as those described in section 1.2.2.

The same variables which guided the discussion on Human Rights are present here. The increase in System uncertainty and of the Decision stakes has led to the UDHR, but also to the development of new scientific discoveries and, as a consequence, to new jobs useful to guarantee the realization of individual interests (the UDHR *Normative Values*). It's a kind of circle, and trying to establish which of these three has stimulated the evolutionary leap of the other two, is like to solve the chicken-and-egg question.

At present, the individual interests are achievable thanks to the current level of diversity in human activities. As for biodiversity, the richness of human activities not only allows more people to work in various fields (which corresponds to the achieving of two *Normative Values*: the right to work and to free choice of employment), but it provides support to the entire system with regard to the other *Normative Values*.

Inspiration comes from the so called "Ghost Towns". According to Baker (2003), a ghost town is an abandoned village, town, or city, which contains substantial visible remains. The causes of the abandon could be the failure of the *Economic Activities* which supported the town, or to a natural or human-caused disasters such as flood, government action, war, or nuclear disaster. Many examples of Ghost Towns can be found in Texas. It seems that the shared cause of their fate is the depletion of oil wells whose exploitation has

generated the original wealth which led to their development. Some examples can be found in Italy[10]:

- Liguria - Calice Ligure, abandoned at the beginning of the sixties following the closure of a major mine;
- Sardinia - Naracauli (near Piscinas), Montevecchio[11] (in the municipalities of Guspini and Arbus) and Ingurtosu (Arbus). In the fifties they were thriving villages that housed the miners of the nearby mines of lead, zinc and silver; once the economy based on mining collapsed, the countries have been abandoned;
- Sardinia - Santa Chiara del Tirso, at Ula Tirso (OR); a village that housed employees of the Electricity Company Sarda, about 450 people employed in the nearby dam of Santa Chiara. In the late 1980s, with the sale of the hydroelectric power station of the old dam, the small town was abandoned.
- Tuscany - The town of Rocca San Silvestro, in the Campiglia Marittima municipality is a medieval ghost town founded in the tenth or eleventh century by the Gherardesca family and abandoned along with copper and silver-bearing lead mines that surrounded it, the exploitation of which began in the Etruscan period.

The abandon of these towns is the consequence of the high vulnerability of societies which have chosen to develop themselves on the exploitation of one non-renewable resources and, as a consequence, convey the majority of the work force towards this goal.

The human species is part of the ecosystem and it behaves following the same rules: in section 2.2 the concept of *resilience* has been introduced, as the capacity of a system to absorb disturbance and reorganize while undergoing change, so as to retain essentially the same function, structure, identity, and feedbacks. This capacity is proportional to the biodiversity which characterise the ecosystem itself: the greater is its complexity, the more it proves able to rebalance following the occurrence of more or less serious failures. If we imagine the society as a socio-ecological system, the "diversity" among the human species is determined by their different abilities, by the role which every

[10] https://it.wikipedia.org/wiki/Citt%C3%A0_fantasma_in_Italia
[11] https://it.wikipedia.org/wiki/Montevecchio

man plays in the society. In other terms, what makes the difference among men is the work they perform.

In the study of ecological communities, in particular of the α-diversity (*i.e.* diversity of the specific composition of a community), two components are relevant: the species richness (number of species) and the evenness (uniformity of the distribution of individuals among species). The most used function for measuring the α-diversity is the index of Shannon (Ferrari, 2001):

$$H = -\sum p_i \ln p_i$$

where

$$p_i = \frac{N_i}{N}$$

and N_i is the number of organisms in the sample belonging to the species *i*. This index assumes its maximum value in the event that all species have the same frequency.

The same information can be applied to understand the causes which led to the Ghost Towns: at a given level of complexity which has generated the *Normative Values* and *Economic Activities* able to feed them, a scarce evenness of the workers among the different jobs makes the society vulnerable in the event of failure of that particular labour sector. The model on the left of Figure 19 represents a potential ghost town: the main *Economic Activity* (EA) gives job to a high percentage of the citizens, which support other *Economic Activities* useful to satisfy the other *Normative Values*. In this way the small *Economic Activities* became "satellites" of the dominant one, which failure would lead to a collapse of the local economy due to the breakdown of the demand for the other *Economic Activities*.

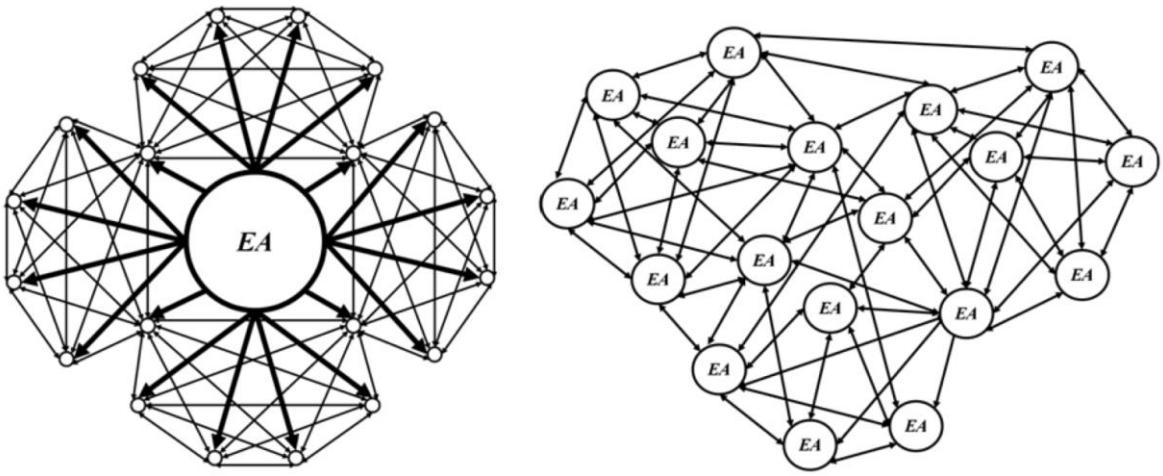


Figure 19 - Two models of workers distribution among *Economic Activities* (EA). The size of the circles is proportional to the number of workers in each activity and the arrows represent the interaction with other activities. Left: a dominant *Economic Activity*. Right: equal share between the *Economic Activities*.

The scheme on the right of Figure 19 shows a fair distribution of the workers among the EAs. The failure of one of them would lead to a loss in demand of goods but not to the collapse of the local economy because the loss will be compensated by the other activities. If the collapse happens, the individuals will be unable to meet all their interests (and therefore there *Normative Values*) and are forced to move to a more suitable environment.

But human beings are not a migratory species (or at least not instinctively): in some cases, they show a strong sense of belonging to the land where their were born and raised, and the abandonment of certain places may not be the best solution or may even jeopardise the realization of the first *Normative Value*: the right to life. This could be the motivations behind the abstention in the *referendum* proposed to the Taranto citizens illustrated in section 1.2.5.

2.4.1 The "*Nomenclature statistique des activités économiques dans la Communauté européenne*" (NACE) within *PoChASSy42*

The motivations which have led to the inclusion of a classification of the *Economic Activities* within the *PoChASSy42* framework, and why they are considered as the *collective interests* which characterize the profile of the economic compartment *virtual stakeholders* are the following:

1. It is in the interest of all the citizens, and therefore *collective*, to maintain as many *Economic Activities* as possible (depending on the environmental conditions and the availability of resources), in order to reduce the vulnerability during the crisis periods and to satisfy all of the *Normative Values*.
2. Labour is the material part of the link which connect mankind to nature: it is "a process in which both man and Nature participate" (Marx, 1867).
3. A classification provides a constantly updated list of jobs which are able to satisfy and connect to the current *Normative Values* complexity level.

The operative choice, has been to classify the *Economic Activities* by the *Nomenclature statistique des activités économiques dans la Communauté européenne* (NACE - Eurostat, 2008).

Historical background and legal context	
From 1961 to 1963	Nomenclature des industries établies dans les Communautés européennes (NICE) (Classification of Industries Established in the European Communities)
1965	Commerce dans la CEE (NCE) (Classification of Trade and Commerce in the European Communities)
1967	Classification for services, followed by one for agriculture, both in broad divisions.
1970	Nomenclature générale des activités économiques dans les Communautés Européennes (NACE - General Industrial Classification of Economic Activities within the European Communities)
1990	NACE Rev. 1. Starting from the structure of ISIC Rev. 3, details were added to reflect European activities that were inadequately represented in ISIC.
2002	Minor update of NACE Rev. 1, called NACE Rev. 1.1
2006	NACE Rev. 2. It is to be used,in general, for statistics referring to economic activities performed from 1 January 2008 onwards (Article 8 of the NACE Regulation provides details on implementation)

Table 4 - Historical background and legal context of the NACE classification (Eurostat, 2008)

NACE, by Eurostat (see Table 4), is part of an integrated system of statistical classifications, developed mainly under the auspices of the United Nations Statistical Division in order to provide a framework for collecting and presenting a large range of

statistical data, according to *Economic Activity*, that are comparable at European and, in general, at World level.

NACE consists of a hierarchical structure, described in the NACE Regulation as follows:

- *Sections* - (the first level) consisting of headings identified by an alphabetical code;
- *Divisions* - (the second level) consisting of headings identified by a two-digit numerical code;
- *Groups* - (the third level) consisting of headings identified by a three-digit numerical code;
- *Classes* - (the fourth level) consisting of headings identified by a four-digit numerical code.
- *Categories* - (the fifth level) consisting of headings identified by a five-digit numerical code.
- *Subcategories* - (the sixth level) consisting of headings identified by a six-digit numerical code.

Code digit number	***Definition***	***Number of codes***
1	*Sections*	21
2	*Divisions*	88
3	*Groups*	272
4	*Classes*	615
5	*Categories*	918
6	*Subcategories*	1,224

Table 5 - Number of codes identified for the hierarchical levels which composes the NACE classification.

On the base of this classification, the Eurostat has identified, to date, up to 1,224 *Economic Activities* (see Table 5) which are the *Subcategories* of the 21 main *Sections* shown in Table 6.

The best choice for the development of the *PoChASSy42* framework, it would have been to use all of the 1,224 *Economic Activities*, but this would have resulted in the investigation of a large number of interactions with the other compartments, which would led to an unnecessary detailed information.

For these reasons, the NACE hierarchical organization level used in the following for the development of *PoChASSy42* is the *Division*, shown in the Table 7 and Table 8.

Code	***Section name***
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage; waste managment and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transporting and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other services activities
T	Activities of households as employers; undifferentiated goods - and services - producing activities of households for own use
U	Activities of extraterritorial organizations and bodies

Table 6 - The 21 Sections of the NACE classification.

Sec.	Div.	Division name
A	01	Crop and animal production, hunting and related service activities
A	02	Forestry and logging
A	03	Fishing and aquaculture
B	05	Mining of coal and lignite
B	06	Extraction of crude petroleum and natural gas
B	07	Mining of metal ores
B	08	Other mining and quarrying
B	09	Mining support service activities
C	10	Manufacture of food products
C	11	Manufacture of beverages
C	12	Manufacture of tobacco products
C	13	Manufacture of textiles
C	14	Manufacture of wearing apparel
C	15	Manufacture of leather and related products
C	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
C	17	Manufacture of paper and paper products
C	18	Printing and reproduction of recorded media
C	19	Manufacture of coke and refined petroleum products
C	20	Manufacture of chemicals and chemical products
C	21	Manufacture of basic pharmaceutical products and pharmaceutical preparations
C	22	Manufacture of rubber and plastic products
C	23	Manufacture of other non-metallic mineral products
C	24	Manufacture of basic metals
C	25	Manufacture of fabricated metal products, except machinery and equipment
C	26	Manufacture of computer, electronic and optical products
C	27	Manufacture of electrical equipment
C	28	Manufacture of machinery and equipment n.e.c.
C	29	Manufacture of motor vehicles, trailers and semi-trailers
C	30	Manufacture of other transport equipment
C	31	Manufacture of furniture
C	32	Other manufacturing
C	33	Repair and installation of machinery and equipment
D	35	Electricity, gas, steam and air conditioning supply
E	36	Water collection, treatment and supply
E	37	Sewerage
E	38	Waste collection, treatment and disposal activities; materials recovery
E	39	Remediation activities and other waste management services
F	41	Construction of buildings
F	42	Civil engineering
F	43	Specialised construction activities
G	45	Wholesale and retail trade and repair of motor vehicles and motorcycles
G	46	Wholesale trade, except of motor vehicles and motorcycles
G	47	Retail trade, except of motor vehicles and motorcycles
H	49	Land transport and transport via pipelines

Table 7 - First part - list Divisions of the NACE classification

Sec.	Div.	Division name	Sec.	Div.	Division name
H	50	Water transport	M	75	Veterinary activities
H	51	Air transport	N	77	Rental and leasing activities
H	52	Warehousing and support activities for transportation	N	78	Employment activities
H	53	Postal and courier activities	N	79	Travel agency, tour operator and other reservation service and related activities
I	55	Accommodation	N	80	Security and investigation activities
I	56	Food and beverage service activities	N	81	Services to buildings and landscape activities
J	58	Publishing activities	N	82	Office administrative, office support and other business support activities
J	59	Motion picture, video and television programme production, sound recording and music publishing activities	O	84	Public administration and defence; compulsory social security
J	60	Programming and broadcasting activities	P	85	Education
J	61	Telecommunications	Q	86	Human health activities
J	62	Computer programming, consultancy and related activities	Q	87	Residential care activities
J	63	Information service activities	Q	88	Social work activities without accommodation
K	64	Financial service activities, except insurance and pension funding	R	90	Creative, arts and entertainment activities
K	65	Insurance, reinsurance and pension funding, except compulsory social security	R	91	Libraries, archives, museums and other cultural activities
K	66	Activities auxiliary to financial services and insurance activities	R	92	Gambling and betting activities
L	68	Real estate activities	R	93	Sports activities and amusement and recreation activities
M	69	Legal and accounting activities	S	94	Activities of membership organisations
M	70	Activities of head offices; management consultancy activities	S	95	Repair of computers and personal and household goods
M	71	Architectural and engineering activities; technical testing and analysis	S	96	Other personal service activities
M	72	Scientific research and development	T	97	Activities of households as employers of domestic personnel
M	73	Advertising and market research	T	98	Undifferentiated goods- and services-producing activities of private households for own use
M	74	Other professional, scientific and technical activities	U	99	Activities of extraterritorial organisations and bodies

Table 8 - Second part - list of Divisions of the NACE classification

2.5 The *Ecosystem Services*

"[...] Clyde Martin: «Just one more question. You've just told me your entire history:
childhood, family, career, every person you've ever had sex with.
But there hasn't been a single mention of love.»
Alfred Kinsey: «That's because it's impossible to measure love.
And, as you know, without measurements there can be no science.
But I have been thinking a lot about the problem lately.»
Clyde Martin:«Mmh, "problem"?»
Alfred Kinsey: «When it comes to love, we're all in the dark.»"
Dialogue taken from "Kinsey" (Motion Picture by Condon and Mutrux, 2004)

According to Plato (*Laws* 744B - in Kinzl, 2010), "an ideal *οἶκος* (*oikos* - household) owned sufficient land to feed itself and produce a *surplus* in order to avoid stasis". In this simple concept resides the fundamental idea at the base of the Brundtland report: the sustainable development. In other terms, reporting the Plato observation to modern times, the ideal administration of the *oikos* depends by the *economics* ability to manage the *ecological* capital in order to meet "the needs and aspirations of the present without compromising the ability of future generations to meet their own needs" (Our Common Future - WCED, 1987). The word *oikos* is the Greek root shared by both prefixes. In their suffixes resides the different perception in observing the same thing: the link between human and nature. In the case of *ecology*, it is *λογία* - *logy* - "study of" while for *economy* it is *νόμος* - *nomos* - "custom" or "law".

Ernst Heackel, who, in his book *Generelle Morphologie der Organismen* (1866), coined the term *ecology* (coming from *Oecologie*), explained it as the science of the economy of the habitat, of the external relation of the organisms to each other and to the environment (partly organic and partly inorganic), including all the "condition of existence" (Stauffer, 1957): *"[...]physiology has largely neglected the relations of the organism to the environment, the place each organism takes in the household of nature, in the economy of all nature, and has abandoned the gathering of the relevant facts to an uncritical "natural history," without making an attempt to explain them mechanistically. [...]"* (Heackel, 1866)

According to Heackel, this gap was filled by Darwin with his theories on the selection and on the evolution which show us *"[...]how all the infinitely complicated relations in which each organism occurs in relation to the environment, how the steady reciprocal action between it and all the organic and inorganic conditions of existence are*

not the premeditated arrangements of a Creator fashioning nature according to a plan but are the necessary effects of existing matter with its inalienable properties and their continual motion in time and space.[...]" (Heackel, 1866).

In the modern era, this humanist vision, *i.e.* humans as external observers of nature almost aliens to the facts, has been replaced by an anthropocentric view, due to the inevitable environmental reactions generated by the impacts of the anthropogenic development (physiological vision). This vision could be considered a materialistic and utilitarian one, but this is the way humans put themselves in relation with ecosystems.

As a consequence, within *PoChASSy42* the natural part of the environment is represented by the *Ecosystem Services* which are "the benefits people obtain from ecosystems". This definition has been introduced by the *Millennium Ecosystem Assessment* (MA, 2005). Indeed, the MA project has been carried out, with the support of the UN, between 2001 and 2005 in order to assess the consequences of ecosystem change to human well-being and to respond to government requests for information, through four international conventions: *Convention on Biological Diversity; United Nations Convention to Combat Desertification; Ramsar Convention on Wetlands; Convention on Migratory Species.* The results of the assessment have allowed to reach a global overview of ecosystems, which is literally stunning. Over the past 50 years, humans have changed the ecosystems more rapidly and extensively than in any comparable period of time in human history:

- 60% of the planet's *Ecosystem Services* have been degraded;
- About a quarter of the planet's land surface is cultivated and more land was converted to cropland in the 30 years after 1950 than in the 150 years between 1700 and 1850;
- Water withdrawals from rivers and lakes doubled since 1960; most water use (70% worldwide) is for agriculture;
- Natural resources overexploitation, especially overfishing: the biomass of fish targeted in fisheries has been reduced by 90% relative to levels prior to the onset of industrial fishing;
- Approximately 20% of the world’s coral reefs were lost and an additional 20% degraded in the last several decades of the twentieth century, and approximately 35% of mangrove area was lost during this time;

- Since 1960, flows of reactive (biologically available) nitrogen in terrestrial ecosystems have doubled, and flows of phosphorus have tripled;
- The rate of extinction of species is 100 to 1000 times higher than the natural rate;
- Since 1750, the atmospheric concentration of carbon dioxide has increased by about 32%, primarily due to the combustion of fossil fuels and land use changes;
- The harmful effects of the degradation of *Ecosystem Services* are being borne disproportionately by the poor, are contributing to growing inequities and disparities across groups of people, and are sometimes the principal factor causing poverty and social conflict.

Another important result from the assessment is the identification and classification of the *Ecosystem Services*. These services were classified into four different categories, on the basis of the benefits they provide to the human well-being (Figure 20).

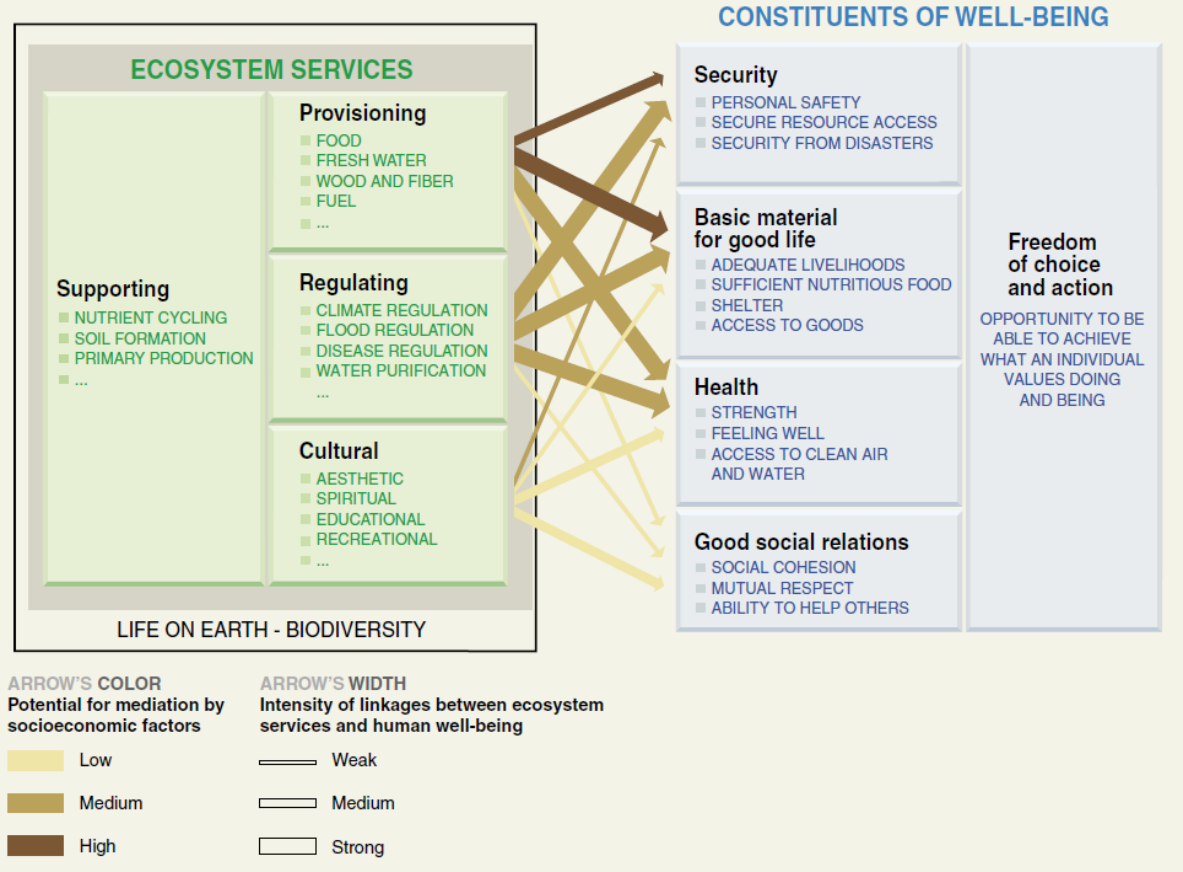


Figure 20 - Linkages between *Ecosystem Services* and Human Well-being (source MA, 2005)

Ecosystem Services are organized in the following categories:

- *Provisioning services* - which provide products from ecosystems.
- *Regulating services* - which bring benefits from the regulation of ecosystem processes.
- *Cultural services* - nonmaterial benefits obtained by people from ecosystems: spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences.
- *Supporting services* - "are those that are necessary for the production of all other *Ecosystem Services*. They differ from provisioning, regulating, and cultural services in that their impacts on people are often indirect or occur over a very long time, whereas changes in the other categories have relatively direct and short-term impacts on people" (MA, 2005).

There are several motivations which have led to the choice of this particular description of the natural components to be to be included within the *PoChASSy42* framework. The main is functional: thanks to their ability to synthesize the different connection typologies which may occur with human individual interests (*Normative Values*) *Ecosystem Services* are easily integrated within *PoChASSy42*, as illustrated in Figure 20. Such connections can be either *material*, passing through *Economic Activities* (*collective interests*), or *non-material* mainly involving the *Normative Values* related to the human health or to the development of human personality.

Of particular importance is the inclusion of *non-material* services or goods such as *cultural services*: *"Human cultures are strongly influenced by ecosystems, and ecosystem change can have a significant impact on cultural identity and social stability"* (MA, 2005). This concept is confirmed by section 2.3.1 and by Figure 18 where it is shown that different sets of environmental situations may produce similar but culturally different reactions. The introduction of these non-quantifiable elements within a globally recognized the scientific report, has allowed these services to emerge from "darkness" so that they can no longer be ignored: "When it comes to love, we're all in the dark" said Alfred Kinsey, but *love* exists, even if it is not measurable, and it has a great significant for people worldwide.

Furthermore, these services represent the only way to rise the priority of the ecosystems in policy actions: the Earthquake website (http://www.emsc-csem.org/ Earth

quake/ – Bossu, 2016) collects real time parametric data (source and phase pickings) from 65 seismological networks in the Euro-Mediterranean region. By opening another section of the same website (http://www.emsc-csem.org/Earthquake/significant_earthquakes.php), it is possible to see a selection of the most significant earthquakes in the World during the last year. All over the world, many earthquakes happen with different magnitude. However, none of the online newspaper of the areas affected by these earthquakes talks about a seismic event if it has not caused damage to buildings or people. The *Ecosystem Services*, even if not sufficiently specific, enclose all the necessary information for policy makers to manage at least the aspects that could cause harm to the collective and individual interests of their citizens.

Being generated by biodiversity, as specified both in Figure 20 and in the MA report, *Ecosystem Services* are the *Virtual Stakeholders* of the entire ecosystem. They are intimately intertwined, so that damaging one of them may compromise the efficiency or even the survival of the others, with obvious consequences to the anthropic sphere. Including them in the *PoChASSy42* framework aims at giving them the possibility to be represented and to defend themselves during the virtual participatory process characteristic of the methodology developed in this work.

2.5.1 The *Ecosystem Services* and the Water Cycle processes

The list of *Ecosystem Services* is shown in Table 9. In this list, the Water Cycle and Fresh Water have been highlighted because of a methodological choice. The Water Cycle describes exchanges of water between the oceans, atmosphere, land surface, biosphere, soils, groundwater systems, and the solid Earth (see Figure 21). Water is the matrix in which everything is submerged and its cycle shares many of its processes with the other cycles such as those of the C, N, P, S, and O (Mackenzie, 1999).

Being the aim of the *PoChASSy42* framework to find all the possible interactions among the *Virtual Stakeholders* in order to identify those which are involved in a process which could change the environmental system, it has been a choice to extrapolate the Water cycle (the Fresh Water being part of it) from the Ecosystem services and to deal with it in more detail in order to connect its processes to the other different *Virtual Stakeholders*.

Service category	*Ecosystem service*	*Code*	
Supporting	Nutrient cycling	Su	01
	Photosynthesis	Su	02
	Primary production	Su	03
	Soil Formation	Su	04
	Water cycling	Su	05
Provisioning	Biochemicals, natural medicines, and pharmaceuticals	Pr	06
	Fiber	Pr	07
	Food	Pr	08
	Fresh water	Pr	09
	Fuel	Pr	10
	Genetic resources (Biodiversity)	Pr	11
	Ornamental resources	Pr	12
Regulating	Air quality regulation	Re	13
	Climate regulation	Re	14
	Disease regulation	Re	15
	Erosion regulation	Re	16
	Natural hazard regulation	Re	17
	Pest regulation	Re	18
	Pollination	Re	19
	Water purification and waste treatment	Re	20
	Water regulation	Re	21
Cultural	Aesthetic values	Cu	22
	Cultural diversity	Cu	23
	Cultural heritage values	Cu	24
	Educational values	Cu	25
	Inspiration	Cu	26
	Knowledge systems	Cu	27
	Recreation and ecotourism	Cu	28
	Sense of place	Cu	29
	Social relations	Cu	30
	Spiritual and religious values	Cu	31

Table 9 - List of the *Ecosystem Services*.

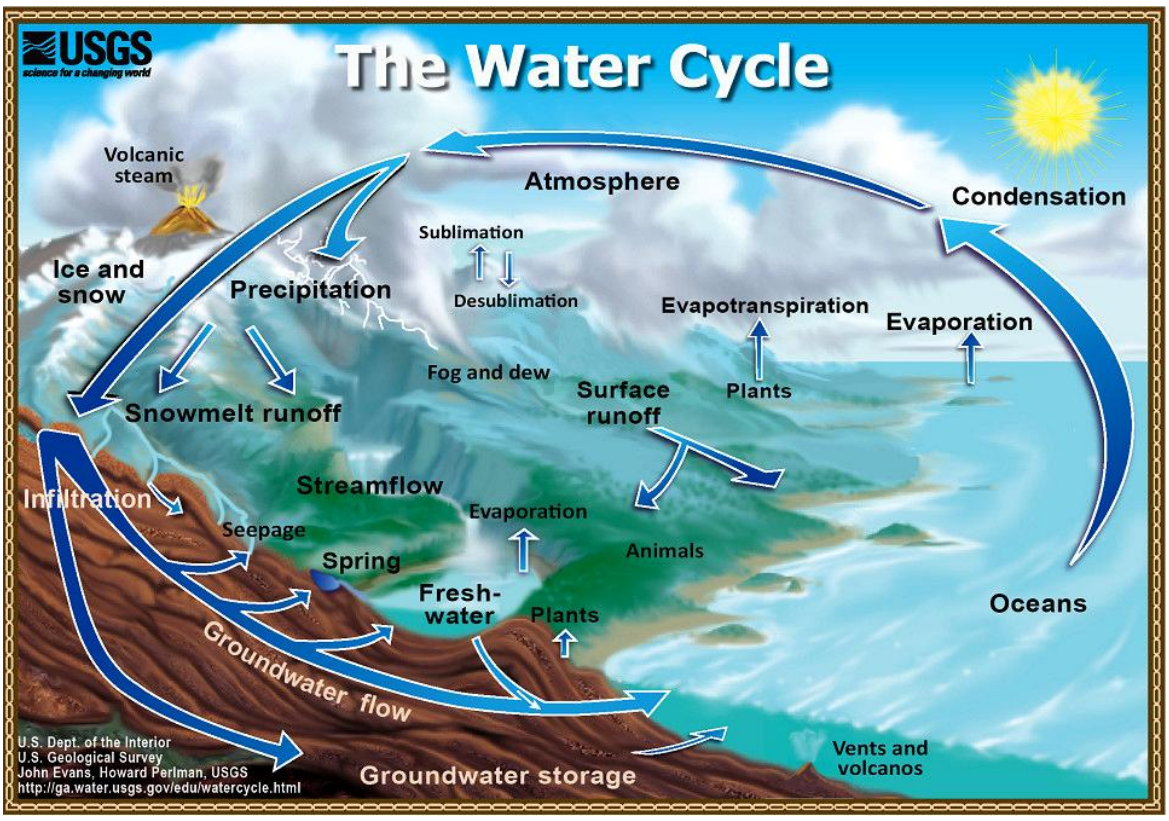


Figure 21 - The Water cycle (source Evans and Perlman, 2005).

Compartment	*Processes*	*Code*	
ATMOSPHERE	Condensation	At	01
	Desublimination	At	02
	Evaporation	At	03
	Fog & Dew	At	04
	Precipitation	At	05
	Snow	At	06
	Sublimination	At	07
BIOGEOSPHERE	Evapo-traspiration	Bg	08
	Fresh water	Bg	09
	Groundwater storage	Bg	10
	Ice	Bg	11
	Infiltration	Bg	12
	Meltwater	Bg	13
	Salt water	Bg	14
	Seepage	Bg	15
	Spring	Bg	16
	Stream flow	Bg	17
	Surface runoff	Bg	18
	Wetlands	Bg	19

Table 10 - List of the Water Cycle processes.

2.6 The *PoChASSy42* synthesis: the *Adjacency Matrix*.

The *analysis* carried out so far of the compartments which define the environment that the *PoChASSy42* framework wants to describe, has led to the identification of the profiles of the *virtual stakeholders* involved in the virtual participatory process.

As it has been said in section 2.2, practicing *analysis* alone without a *synthesis* is a dangerous way of operating. In the following sections two ways will be proposed, through which the *synthesis* is applied to the information collected so far. These are the *Adjacency Matrix* and the *Narrative Structure*, two tools related to each other, derived from the *graph theory*. Such tools have been chosen in order to provide to *PoChASSy42* users both an interactive procedure to evaluate the possible interactions between *Virtual Stakeholders* and a way to communicate information through a graphical representation understandable even by non-experts.

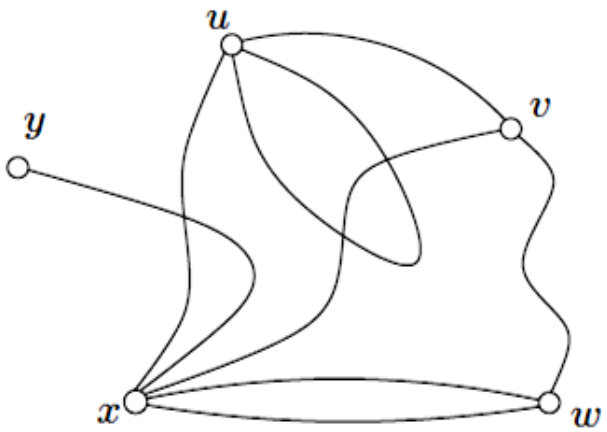
The word "interaction" means *any kind of relation between two or more elements*. These relations can be:

- *material*
    - e.g., the *Requirements/Supply* link between *Economic Activities* and ecosystem resources to provide products either to be elaborated by other *Economic Activities* or to be purchased by individuals;
    - or the atmospheric emissions or the sewage discharging within the hydrologic compartment, two processes carried out by *Economic Activities* which put them in interaction with the ecosystem;
- *non material*
    - such as the ecosystems aesthetic or even the spiritual and religious values which establish an interaction between individual's development and nature;
    - or the ecosystem educational value which makes ecosystems interact with scientific research.

All the identified interactions among the *Virtual Stakeholders* are described within the *PoChASSy42* methodology through the development of the *Adjacency Matrix*.

The *Adjacency Matrix*, derived from *Graph Theory*, can be seen as a logical matrix with entries from the Boolean domain B = {0, 1}. In *Graph Theory*, the *Adjacency Matrix*

of G (Figure 22) is the $n \times n$ matrix $A_G := (a_{uv})$, where a_{uv} is the number of edges joining vertices *u* and *v*, each loop counting as two edges (Bondy and Murty, 2008). In other terms, it is a numerical way to describe when an interaction occurs, signalled by the presence of an *arc*, between two *nodes* of the graph.



G

	u	v	w	x	y
u	2	1	0	1	0
v	1	0	1	1	0
w	0	1	0	2	0
x	1	1	2	0	1
y	0	0	0	1	0

A

Figure 22 - Adjacency matrices (A) of the graph (G) (Bondy and Murty, 2008).

Except for the double-counting of arcs, this description has been chosen to develop the *PoChASSy42* general matrix which is characterized by 29,920 possible interactions among *Virtual Stakeholders*.

2.7 The *PoChASSy42* matrix structure and rules

Because of its size, the full *Adjacency Matrix* cannot be shown in a detailed way within the normal size of an A4 sheet. For this reason, and to give the possibility to understand the interactions between *Virtual Stakeholders*, the full Excel file, containing the entire and modifiable matrix, can be downloaded from the web site: http://www.emrg.it/ PoChASSy42 /PoChASSy42_v1.1.xlsm[12]

[12] please contact the author for user name and password

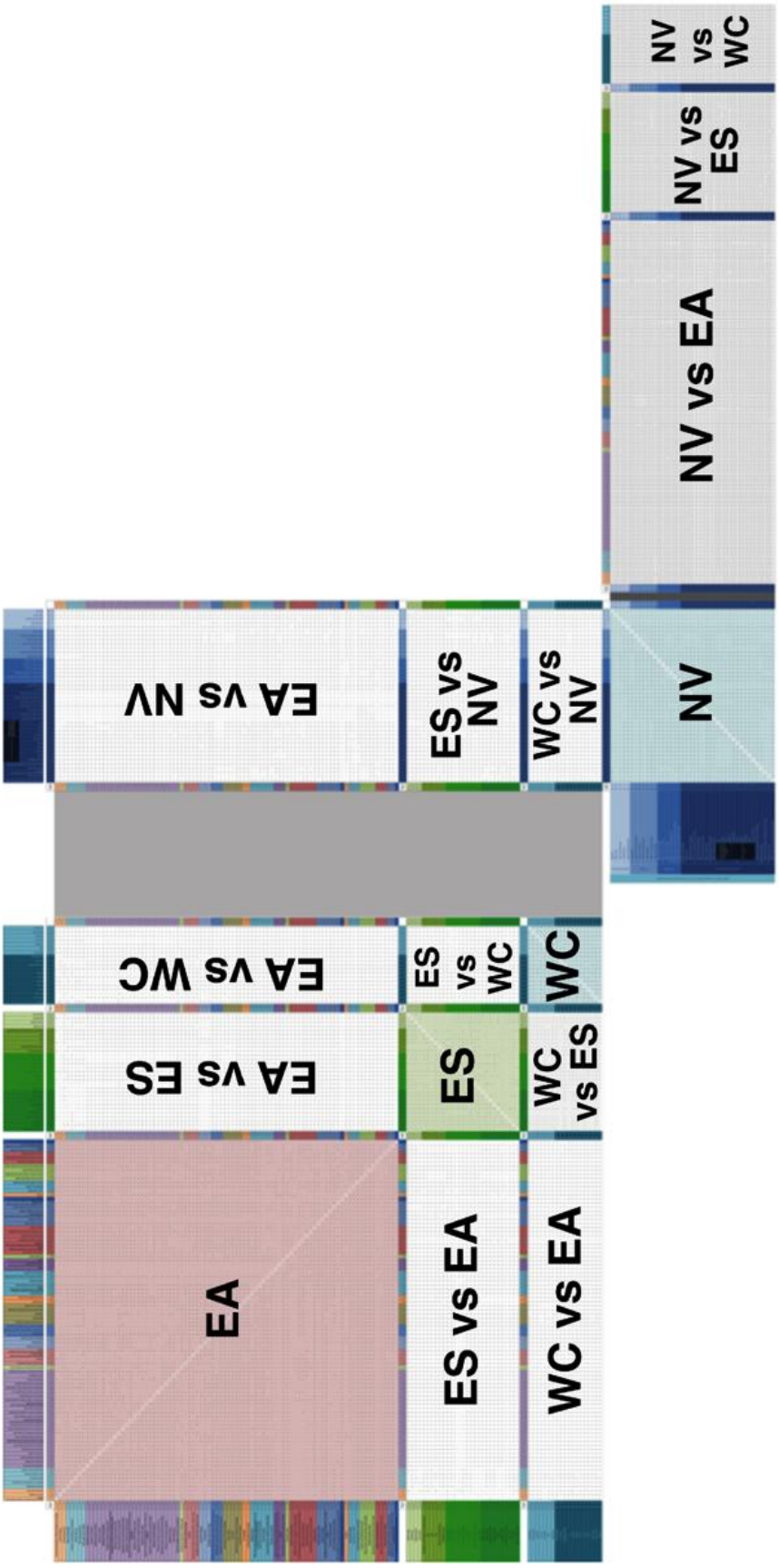


Figure 23 - The *PoChASSy42 Adjacency Matrix*.

Figure 23 shows the full matrix made up by 16 sub-matrices. Each matrix is identified by an acronym and a name, as shown in

Table 11. The colours at the edges recall those used in the tables contained in the previous sections describing the different *Virtual Stakeholders*.

Acronym	***Name***	***Reading direction***
EA	Economic Activities	Row to Column and Column to Row
EAvsES	Economic Activities *versus* Ecosystem Services	Row to Column
ES	Ecosystem Services	Column to Row
ESvsEA	Ecosystem Services *versus* Economic Activities	Row to Column
EAvsWC	Economic Activities *versus* Water Cycle	Row to Column
WC	Water Cycle	Column to Row
WCvsEA	Water Cycle *versus* Economic Activities	Row to Column
WCvsES	Water Cycle *versus* Ecosystem Services	Row to Column
ESvsWC	*versus* Water Cycle	Row to Column
EAvsNV	Economic Activities *versus* Normative Values	Row to Column
ESvsNV	Ecosystem Services *versus* Normative Values	Row to Column
WCvsNV	Water Cycle *versus* Normative Values	Row to Column
NV	Normative Values	Column to Row
NVvsEA	Normative Values *versus* Economic Activities	Row to Column
NVvsES	Normative Values *versus* Ecosystem Services	Row to Column
NVvsWC	Normative Values *versus* Water Cycle	Row to Column

Table 11 - *PoChASSy42* sub-matrices.

The matrices can be used in different ways, in a "standalone" mode or connected to each other, producing an "information flow". Each matrix is briefly explained in the following. Applications will be shown in chapter 3.

2.7.1 EA matrix

EA is a 88 × 88 matrix (Figure 27) which describes the interactions among the Collective Interests extrapolated from the NACE classification and it may represent a starting point for *PoChASSy42*. The interactions among the *Virtual Stakeholders* (*i.e.*, among the different NACE codes) describe the economic supply chain, which starts from raw material extraction to the creation, processing, distribution, marketing and supply of the final product. These interactions are defined in the "NACE Rev. 2 - Statistical classification of *Economic Activities* in the European Community" (Eurostat, 2008), where descriptions are

given of the materials to be extracted/processed for each *Economic Activity* and of the final product to be distributed by each *Economic Activity* to the others (if not sold directly to the final consumer). The reading direction of this matrix can be both "*Row to Column*" and "*Column to Row*".

When read "*Column to Row*", the *Economic Activities* in the interacting rows are those which provide the products needed by the *Economic Activity* in the Column.

When read "*Row to Column*", the *Economic Activity* in the Row interacts with other activities due to the flow of products from the selected *Economic Activity* to the other ones.

In both cases, the result is a scenario of the *Virtual Stakeholders* related to the Collective Interests directly involved in the main *Economic Activities* concerned by a policy choice.

		Row VS Column		A 1	A 2	A 3	B 5	B 6	B 7	B 8	B 9	C 10	C 11	C 12	C 13	C 14	C 15	C 16	C 17	C 18	C 19	C 20	C 21	C 22
				Crop and animal production, hunting and related service activities	Forestry and logging	Fishing and aquaculture	Mining of coal and lignite	Extraction of crude petroleum and natural gas	Mining of metal ores	Other mining and quarrying	Mining support service activities	Manufacture of food products	Manufacture of beverages	Manufacture of tobacco products	Manufacture of textiles	Manufacture of wearing apparel	Manufacture of leather and related products	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Manufacture of paper and paper products	Printing and reproduction of recorded media	Manufacture of coke and refined petroleum products	Manufacture of chemicals and chemical products	Manufacture of basic pharmaceutical products and pharmaceutical preparations	Manufacture of rubber and plastic products
Agriculture, forestry and fishing	Crop and animal production, hunting and related service activities	A	1	1	0	0	0	0	0	0	0	1	1	1	1	1	1	0	1	0	0	0	1	0
	Forestry and logging	A	2	0	1	0	0	0	0	0	0	1	1	1	1	1	0	1	1	0	0	1	1	1
	Fishing and aquaculture	A	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Mining and quarrying	Mining of coal and lignite	B	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Extraction of crude petroleum and natural gas	B	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
	Mining of metal ores	B	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
	Other mining and quarrying	B	8	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	0
	Mining support service activities	B	9	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Manufacture of food products	C	10	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
	Manufacture of beverages	C	11	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
	Manufacture of tobacco products	C	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Manufacture of textiles	C	13	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	1	1
	Manufacture of wearing apparel	C	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Manufacture of leather and related products	C	15	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

Figure 24 - Part of the EA sub-matrix.

2.7.2 ES matrix

ES is a 29 × 29 matrix (Figure 25) which describes the interactions among the *Ecosystem Services*. Elaborating from the *Millennium Ecosystem Assessment* report (MA,

2005) it is possible to derive that the *Supporting services* are the basis for the development of the other services (see Figure 20) which led, lastly, to the creation of *Cultural and Amenity Services*. This hierarchy among the *Ecosystem Services* is kept and considered within this matrix which is characterized by a reading direction either *Column to Row* or *Row to Column.*

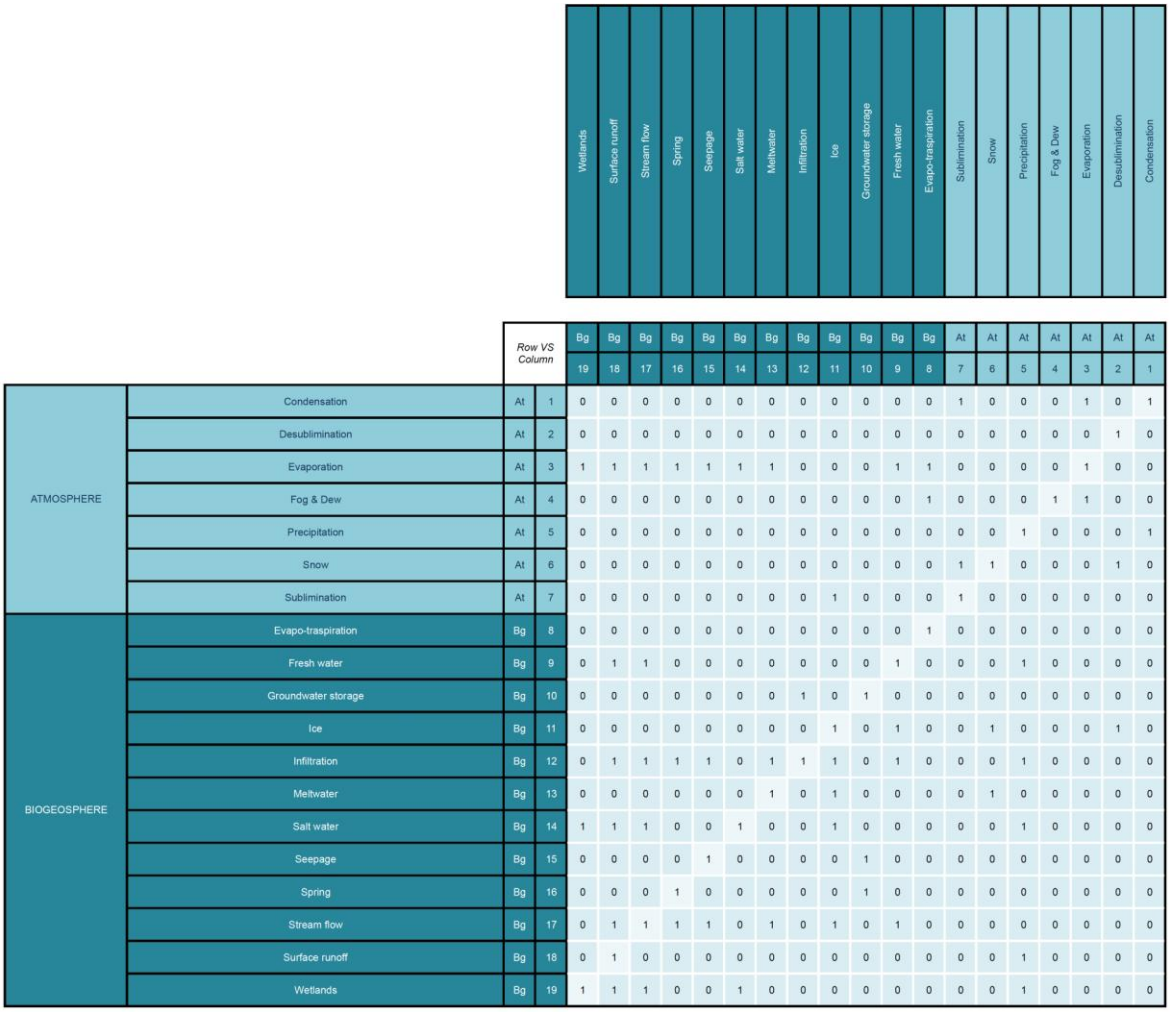
		Row VS Column		Spiritual and religious values	Social relations	Sense of place	Recreation and ecotourism	Knowledge systems	Inspiration	Educational values	Cultural heritage values	Cultural diversity	Aesthetic values	Water regulation	Water purification and waste treatment	Pollination	Pest regulation	Natural hazard regulation	Erosion regulation	Disease regulation	Climate regulation	Air quality regulation	Ornamental resources	Genetic resources (Biodiversity)	Fuel	Food	Fiber	Biochemicals, natural medicines, and pharmaceuticals	Soil Formation	Primary production	Photosynthesis	Nutrient cycling
				Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Cu	Re	Re	Re	Re	Re	Re	Re	Re	Pr	Pr	Pr	Pr	Pr	Pr	Su	Su	Su	Su
				31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	8	7	6	4	3	2	1
Supporting	Nutrient cycling	Su	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1
	Photosynthesis	Su	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	1	0	0	1	1
	Primary production	Su	3	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	1	0	1	1	0
	Soil Formation	Su	4	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	1	0	1	0	1	1	0	1	1	0	1
Provisioning	Biochemicals, natural medicines, and pharmaceuticals	Pr	6	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	1	1	0	1
	Fiber	Pr	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	1	0	1
	Food	Pr	8	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	0	1	1	0	1	0	1	0	0	1	1	1	1
	Fuel	Pr	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	1	0	1
	Genetic resources (Biodiversity)	Pr	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	1	0	0	0	0
	Ornamental resources	Pr	12	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	1	1	1	1	1	0	1
Regulating	Air quality regulation	Re	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	1	1	1	1
	Climate regulation	Re	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	0	1	0	1	0	1	1	1	1
	Disease regulation	Re	15	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1	1	1	1	0	0	0	1	0	0	0	0
	Erosion regulation	Re	16	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	1	0	1	0	1	0	1	1	0	0	0	0
	Natural hazard regulation	Re	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	0	0	1	0	1	0	0	0
	Pest regulation	Re	18	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0
	Pollination	Re	19	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0
	Water purification and waste treatment	Re	20	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
	Water regulation	Re	21	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	0	0	1	0	1	0	1	0	1	0	1	0	0	0
Cultural	Aesthetic values	Cu	22	0	0	0	0	1	0	0	0	0	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1	1	0	0	0
	Cultural diversity	Cu	23	0	0	0	0	0	0	0	1	1	1	1	0	1	1	0	1	0	1	0	1	1	1	1	1	1	1	0	1	
	Cultural heritage values	Cu	24	0	0	0	0	0	0	0	1	0	1	1	0	1	0	1	1	0	1	0	1	1	1	1	1	1	1	0	0	0
	Educational values	Cu	25	0	0	0	0	1	0	1	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1	1	1	1	1	1	1
	Inspiration	Cu	26	1	0	1	0	0	1	0	1	1	1	1	1	1	0	1	1	0	1	0	1	1	1	1	1	1	1	0	0	0
	Knowledge systems	Cu	27	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Recreation and ecotourism	Cu	28	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
	Sense of place	Cu	29	0	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0
	Social relations	Cu	30	0	1	1	1	1	0	1	1	0	1	1	0	0	1	1	1	1	1	1	0	0	1	1	0	1	0	0	0	
	Spiritual and religious values	Cu	31	1	0	1	0	1	1	1	1	1	1	1	0	0	1	1	0	1	1	1	1	1	1	1	1	1	1	0	0	0

Figure 25 - The ES sub-matrix.

2.7.3 WC matrix

WC is a 19 × 19 matrix which describes the interactions among the *Water Cycle* processes. The interactions are due to the paths that the water (in all its different states) has to follow in order to pass from one process to another as indicated in Figure 21. This

means that a change or any kind of modification in the water cycle processes can spread to others processes. The reading direction of this matrix is either *Column to Row* or *Row to Column.*



				Wetlands	Surface runoff	Stream flow	Spring	Seepage	Salt water	Meltwater	Infiltration	Ice	Groundwater storage	Fresh water	Evapo-traspiration	Sublimination	Snow	Precipitation	Fog & Dew	Evaporation	Desublimination	Condensation
		Row VS Column		Bg	Bg	Bg	Bg	Bg	Bg	Bg	Bg	Bg	Bg	Bg	Bg	At	At	At	At	At	At	At
				19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
ATMOSPHERE	Condensation	At	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1
	Desublimination	At	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
	Evaporation	At	3	1	1	1	1	1	1	1	0	0	0	1	1	0	0	0	0	1	0	0
	Fog & Dew	At	4	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0
	Precipitation	At	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
	Snow	At	6	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1	0
	Sublimination	At	7	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
BIOGEOSPHERE	Evapo-traspiration	Bg	8	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
	Fresh water	Bg	9	0	1	1	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
	Groundwater storage	Bg	10	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
	Ice	Bg	11	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	0	0	1	0
	Infiltration	Bg	12	0	1	1	1	1	0	1	1	1	0	1	0	0	0	1	0	0	0	0
	Meltwater	Bg	13	0	0	0	0	0	0	1	0	1	0	0	0	0	1	0	0	0	0	0
	Salt water	Bg	14	1	1	1	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0
	Seepage	Bg	15	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Spring	Bg	16	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
	Stream flow	Bg	17	0	1	1	1	1	0	1	0	1	0	1	0	0	0	0	0	0	0	0
	Surface runoff	Bg	18	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	Wetlands	Bg	19	1	1	1	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0

Figure 26 - The WC sub-matrix.

2.7.4 EAvsES matrix

EAvsES is a 88 × 29 matrix which describes the interactions between *Economic Activities* and *Ecosystem Services*, caused by changes or emissions generated by human activity which can compromise the ecosystem efficiency. The reading direction of this matrix is *Row to Column*: a given *Economic Activity* may interfere with the functioning of one or more *Ecosystem Services*. The identification of the interactions results mainly from the *Millennium Ecosystem Assessment* (MA, 2005) (see Figure 20), which reports the causes of *Ecosystem Services* degradation due to anthropic activities, but also from books

like "The human impact on the natural environment: past, present, and future" (Goudie, 2013) and others. The same references has been used throughout the rest of the sub-matrix definition.

2.7.5 ESvsEA matrix

ESvsEA is a 29 × 88 matrix which describes the interactions between *Ecosystem Services* and *Economic Activities*. Its reading direction is *Row to Column*. The difference between this matrix and matrix *EAvsES* is that in this case the interactions identify the *Ecosystem Services* and the resource flows toward the related *Economic Activities*, which use them for their production purposes.

2.7.6 EAvsWC matrix

EAvsWC is a 88 × 29 matrix which describes the interaction between *Economic Activities* and the *Water Cycle* processes. The reading direction of this matrix is *Row to Column*. The interactions are the result of the same studies used to fill the "*EAvsES*" matrix (MA, 2005 - Goudie, 2013) with which it shares the same descriptive intent: to identify the connections between *Economic Activities* and the *Water Cycle* processes through emissions or changes generated by human activity which can compromise the cycle efficiency.

2.7.7 ESvsWC

ESvsWC is a 19 × 29 matrix which describes the interaction among the *Ecosystem Services* and the *Water Cycle*. The role of this matrix is to link modifications of the *Ecosystem Services* to possible modifications of the *Water Cycle* processes. The reading direction of this matrix is *Row to Column*.

2.7.8 WCvsEA

WCvsEA is a 19 × 88 matrix which describes the interactions between the *Water Cycle* processes and *Economic Activities*. The goal is to identify the *Water Cycle* processes

needed to the *Economic Activities*, which use them for their production purposes. The reading direction of this matrix is *Row to Column.*

2.7.9 WCvsES

WCvsES is a 19 × 29 matrix which describes the interactions between the *Water Cycle* processes and *Ecosystem Services*. It is symmetrical to the WCvsEA matrix. The reading direction of this matrix is *Row to Column.*

2.7.10 Sub-matrices involving Normative Values

The sub-matrices involving *Normative Values* have been developed in order to find the interactions between the *Virtual Stakeholders* representing *Economic Activities* (Collective Interests) and *Ecosystem Services* (Ecosystem Interests) and the *Normative Values* chosen to describe the Individual Interests in the society.

The nature of these interactions is a new argument developed within this work, therefore the matrix content is not the result of the study of available bibliography, but derived from the experience gained during the studies which have led to development of *PoChASSy42*. For this reason, such interactions "definitely" have to be the subject of discussion before a full use of the methodology.

2.7.11 EAvsNV

EAvsNV is a 88 × 42 matrix which describes the interactions between all the *Economic Activities* directly and indirectly involved in a policy choice and the *Normative Values* which describe the individual *Virtual Stakeholder* interests. The interactions, in this case, follow from the usefulness of services and products coming from selected *Economic Activities* in the individual interests realization. The matrix reading direction is *Row to Column*.

2.7.12 ESvsNV

ESvsNV is a 29 × 42 matrix which describes the interactions between all the *Ecosystem Services* directly and indirectly involved in a policy choice and the *Normative Values*. As for the EAvsNV matrix, the interactions follow from the usefulness of the services and goods coming from selected *Ecosystem Services* to the individual interests realization. Of particular interest are the interactions between the human personality development and the cultural and amenity services, which represent a conspicuous part of the interactions. The matrix reading direction is *Row to Column.*

2.7.13 WCvsNV

WCvsNV is a 19 × 42 matrix which describes the interactions between the *Water Cycle* processes directly and indirectly involved in the policy choice and the *Normative Values*. The interactions describe the link between services and goods coming from the selected *Water Cycle* processes which are useful to the individual interests realization (e.g., *fresh water* is useful to the *right to food and life*). The matrix reading direction is *Row to Column*.

2.7.14 NV

NV is a 42 × 42 matrix which describes the interactions among all the *Normative Values*. These interaction are the result of experience, of a deep study of the UDHR (UN, 1948) and of the relevant comments of the Prof. Papisca (2009).

2.7.15 The "NVvsEA", "NVvsES" and "NVvsWC" matrices

These matrices (respectively 42 × 88, 42 × 29 and 42 × 19) rise a provocative question: can the demand generate the supply? These matrices may be useful to explore, in the quantitative assessment stage, how the realization of the inalienable human right could lead to different consequences on the other compartments of a complex system such as the environment.

2.8 The *PoChASSy42* synthesis: the *Narrative Structure*.

2.8.1 The importance of a graph

"Creativity is intelligence having fun"
Albert Einstein

There are several motivations which led to the creation of a graph. One of these is that an *Adjacency Matrix* is a graph theory tool to describe numerically *nodes* and *arcs* of a graph. Another motivation is that a graph can be a powerful communication tool, if made with a functional style. The motivation behind this power resides in one advantage which graphs hold with respect to scientific communication made by numbers: creativity.

An example of the graph communication power is given by what has become known as the first modern organizational chart (Rosenthal, 2013): the New York and Erie Railroad diagram made by Daniel McCallum (1855), reported in Figure 27.

This diagram is the graphical representation of a report which contains the average number of employee's of each class engaged in the Operating Department of the railroad company. It shows also the powers and duties of each individual and to whom they were reporting, a hierarchy which is admirably represented by this graph. The interpretation of this graph allows to achieve a direct, easy and exhaustive range of information otherwise obtainable only through reading the written report (where the workers able to read) in a language perhaps not known by all workers.

Another example is provided by the American neo-conceptual artist Mark Lombardi. According to Zdebik (2011) "Mark Lombardi's artistic oeuvre consists of large-scale diagrams composed of curved and straight lines precisely drawn in pencil on paper in frenetic spirographic patterns [...]. These diagrams, partly shown in Figure 28, are intricate in their constellation-like configurations that reveal the interactions of governments, politicians, banks, and corporations; for example, the Vatican, Oliver North, Presidents George Bush Sr. and George W. Bush, and the Mafia figure prominently in his work. With their minimal diagrammatic aesthetic, Lombardi's artworks represent what he sees as nebulous, clandestine, and often invisible corruption". For these reasons Lombardi called his diagrams *Narrative Structures*.

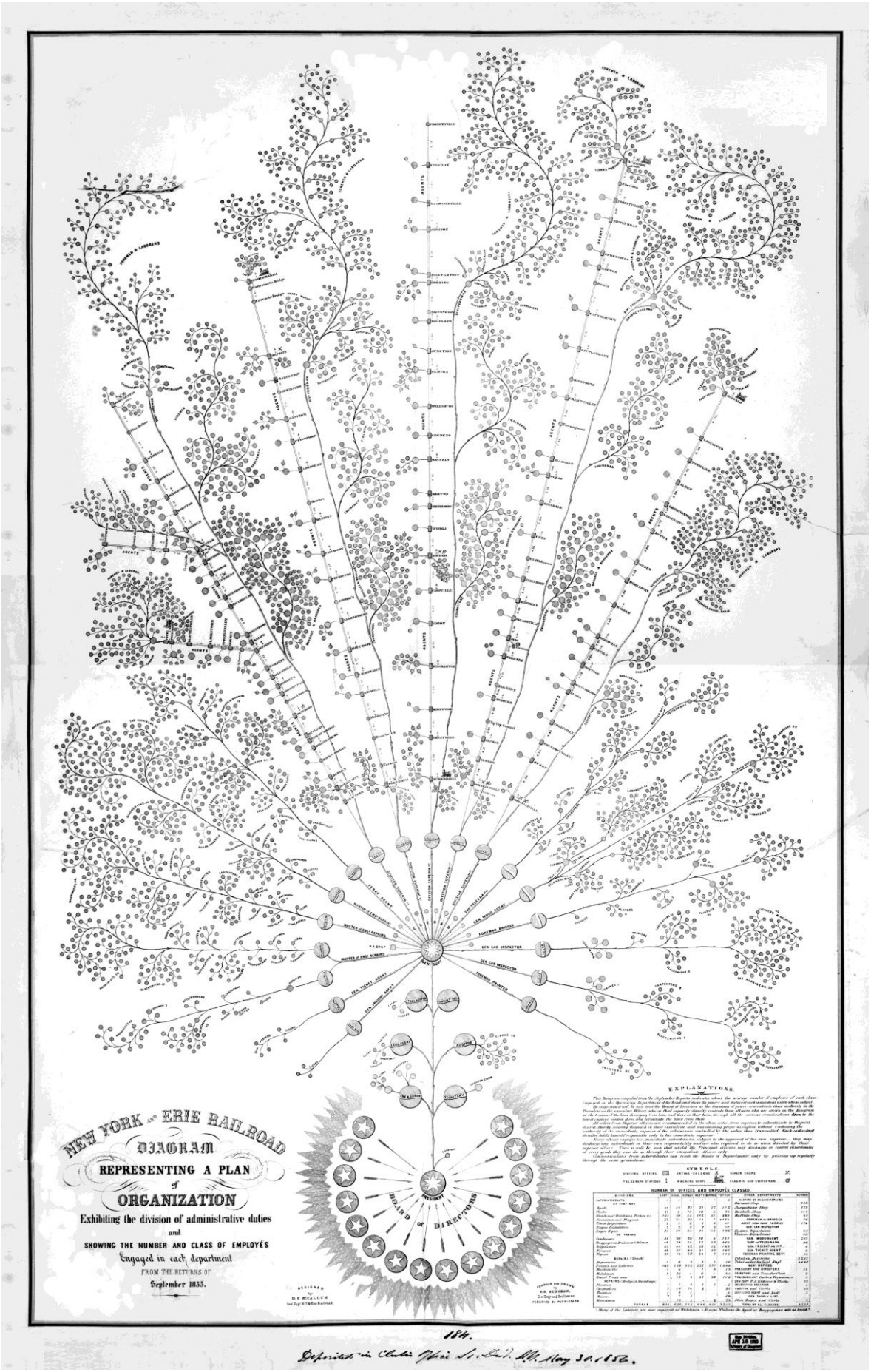


Figure 27 - The New York and Erie Railroad organization diagram made by Daniel McCallum (1855).

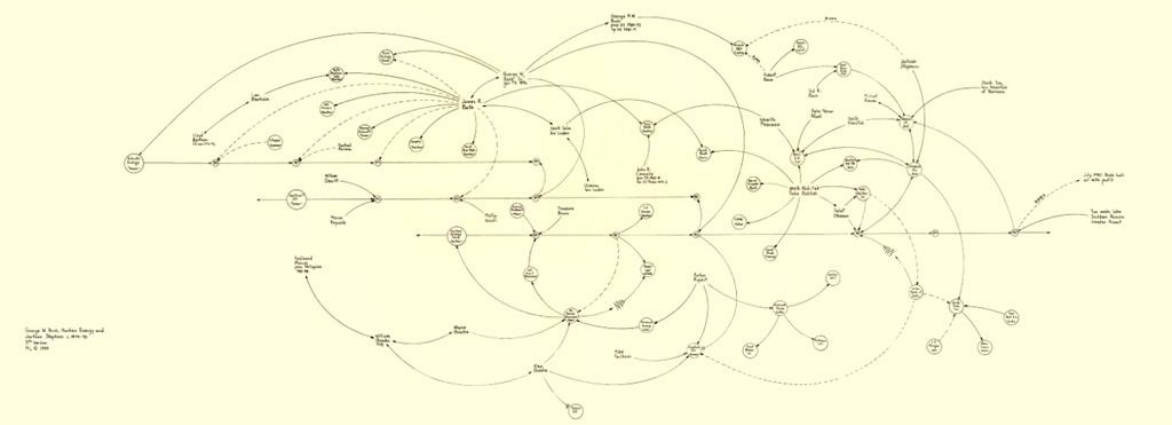


Figure 28 - "George W. Bush, Harken Energy and Jackson Stephens c.1979-90" (Lombardi, 1987).

The drawing, over one metre wide, traces the corrupt enterprises Bush carried out before his presidency: "The web-like diagram captures the complexities of an insider trading scandal that Lombardi believes George W. Bush perpetrated. Harken Energy's suspiciously aggressive expenditure despite its cash flow problems and its being selected to drill in the Middle East despite its small size and lack of international business experience triggered rumours of cronyism. Lombardi shows how Bush, with the help of George Bush Sr., Yale friends, his ties to the Harvard Business School, certain Saudi investors, and Bahrain officials, kept a network afloat just long enough to cash in at the expense of American taxpayers under the cover of the Gulf War" (Zdebik, 2011). A rather curious fact is that the diagram shows as well an alleged connection between James Bath, the Bush and bin Laden families. The same connection between Bush and bin Laden was also highlighted in a 2003 Boston Globe article that described the FBIs interest in Lombardi's works immediately following the September 11, 2001, attacks (Glenn, 2003).

The Lombardi relational charts work essentially as a display of information, showing it in an effective and economical way with relations not otherwise understood.

As a conclusion, sometimes an important or even essential information which results from an empirical knowledge (experience → knowledge), requires a universal language that goes beyond the limits of cultural diversity in order to be made accessible. The language is that of Arts: creativity.

2.8.2 The *PoChASSy42 Narrative Structure* diagram

In the case of *PoChASSy42*, the graph shows in a visual way the service and product flows from one virtual stakeholder to another, i.e., the interactions described by the matrices. Such a graph makes understandable the concept that lies behind the information flow that characterize each matrix.

Figure 29, which represent the *PoChASSy42 Narrative Structure* diagram (developed through the use of the open source software *Dia Diagram Editor*[13]), is only a "miniature" representation of the diagram which can be downloaded in high resolution from the site http://www.emrg.it/PoChASSy42/PoChASSy42_narrative.jpg. A thumbnail has been reported here, just in order to understand that creativity cannot be only part of the scientific knowledge-making processes (in this case of a policy-making process), but it could became a fundamental tool and, in this case, even complementary to the matrices described so far, in order to complete the information that *PoChASSy42* wants to provide.

By reading the diagram legend (Figure 30), which describe the items needed to build it, it is possible to image the dynamicity that this diagram wants to express: while reading the matrix, the presence of an interaction acquires flow properties by a Virtual Stakeholder to another on the basis of the reading direction. Following the arrows on the graph, which describe the input/output flows, this information is immediately provided. The "logical connection" line wants to represent the kind of connection which do not describe a flow, as in the case of the interactions between Normative Values.

[13] https://wiki.gnome.org/Apps/Dia/ - (C) 1998-2009

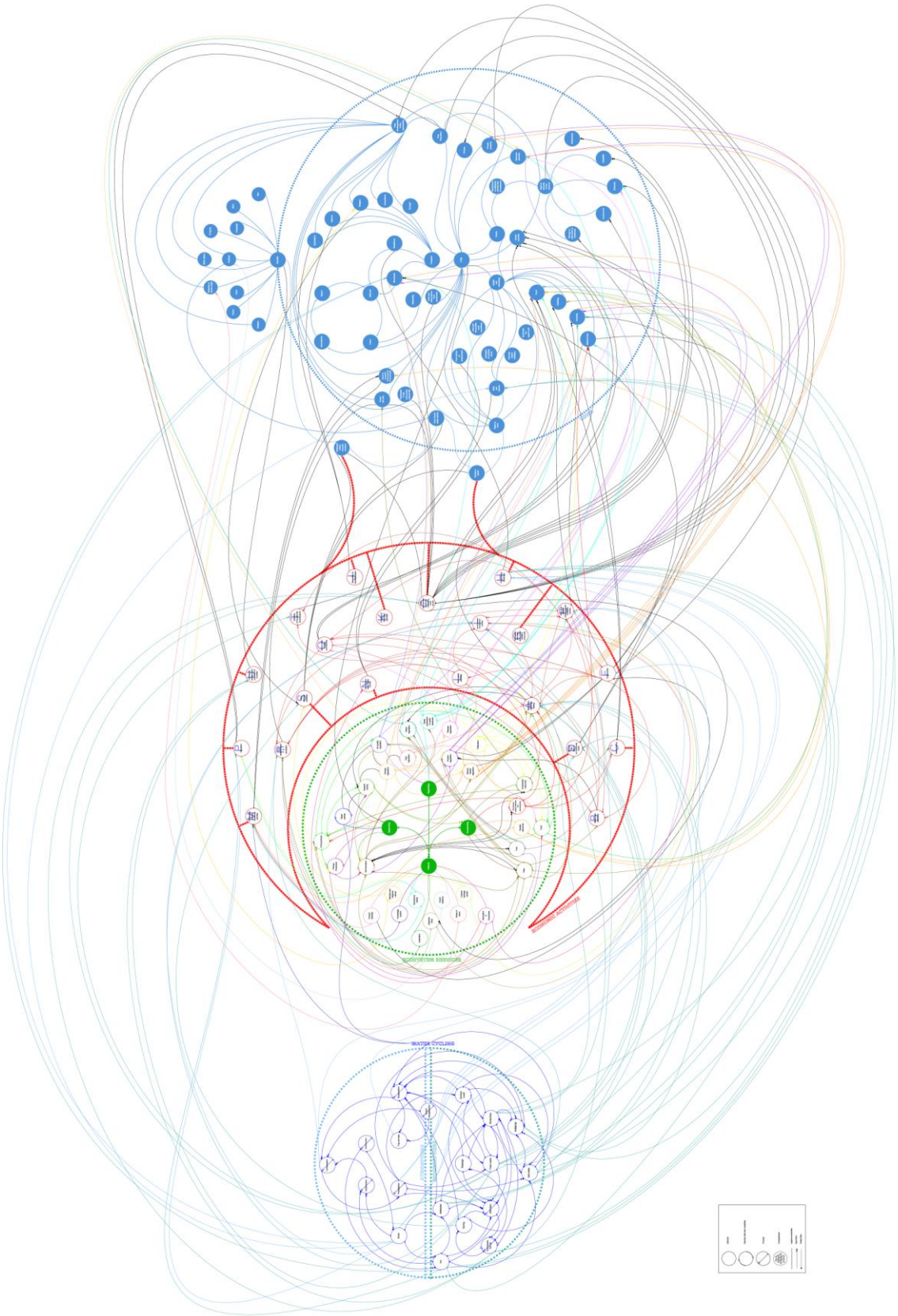


Figure 29 - The *PoChASSy42 Narrative Structure* diagram

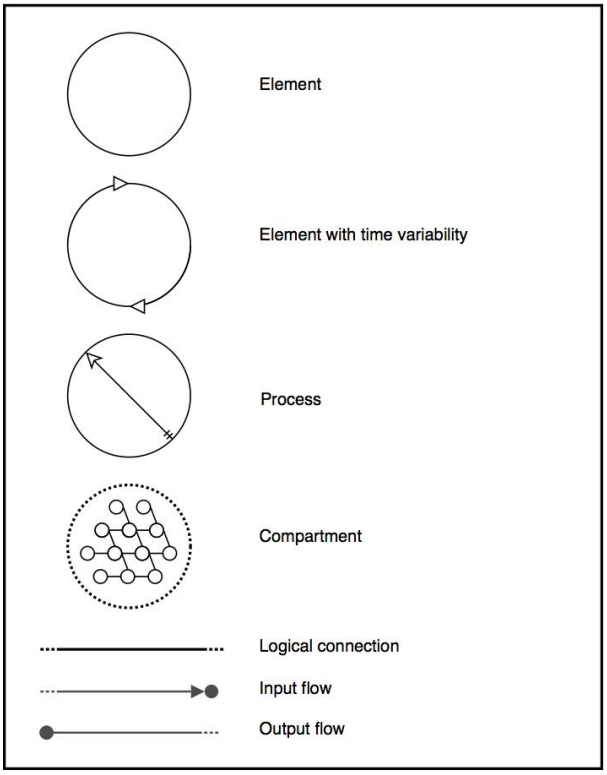


Figure 30 - The *PoChASSy42* diagram legend.

The circular elements describe the Virtual Stakeholders providing two more information:

- the "process" circle is assigned to *virtual stakeholders* which represent a production process;
- the "time variability" circle puts an emphasis on regeneration times of the specific item (for example regarding the providing of *Ecosystem Services*). This information may be useful in terms of the sustainability of policy choices: if "the needs of the present" cannot compromise "the ability of future generations to meet their own needs", than the exploitation rate of these resources must respect their regeneration rate, in order to give the opportunity to enjoy the same amount of resource in 30 years, the period that elapses from one generation to another (Adema *et al.* 2009 and OECD consulted website).

There are four "compartments", delimited by dashed lines which contour the *virtual stakeholders*. From left to right there are:

- the *Water Cycle* processes (blue circle divided into two halves),
- the *Ecosystem Services* (the green circle),
- the *Economic Activities* (Collective Interests – the red rising moon) and
- the *Normative Values* (Individual interests – the blue circle on the right).

An enlarged view of the compartments is given in Figure 31 to Figure 34, respectively.

Figure 31. The *Water Cycle* processes graph.

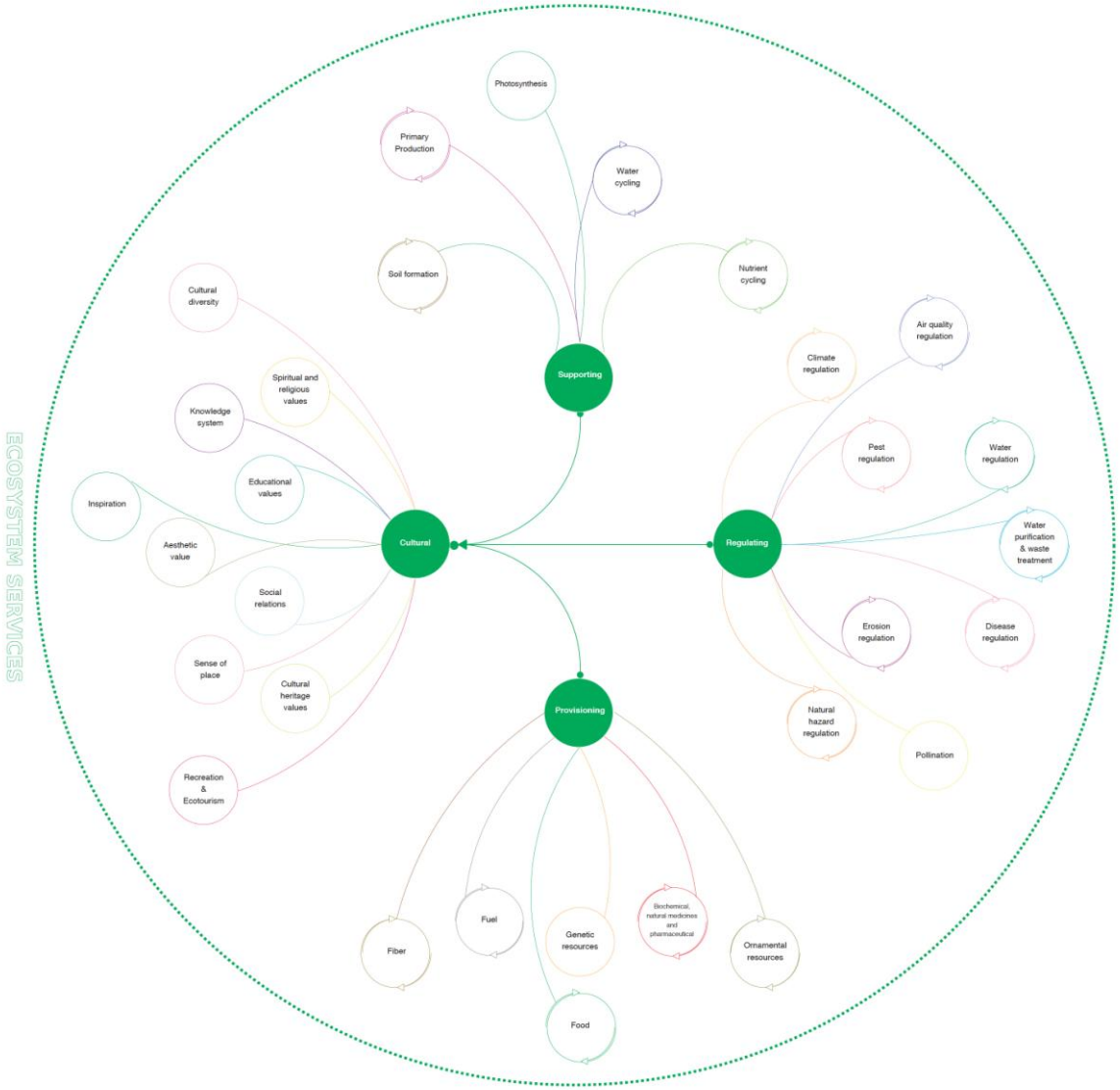


Figure 32. The *Ecosystem Services* graph.

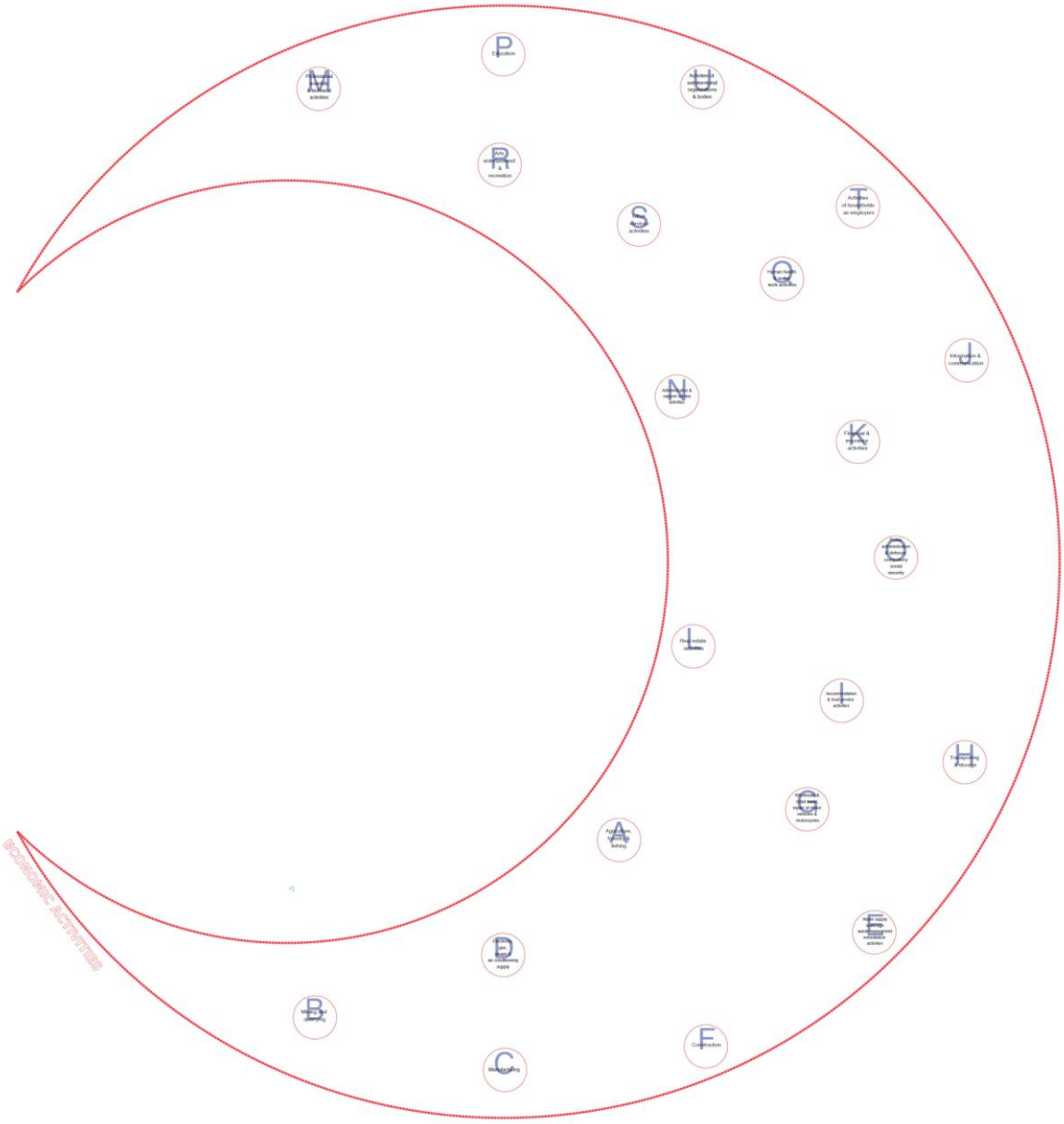


Figure 33. The *Economic Activities* graph. The capital letters in the circles refer to the NACE code *Divisions*.

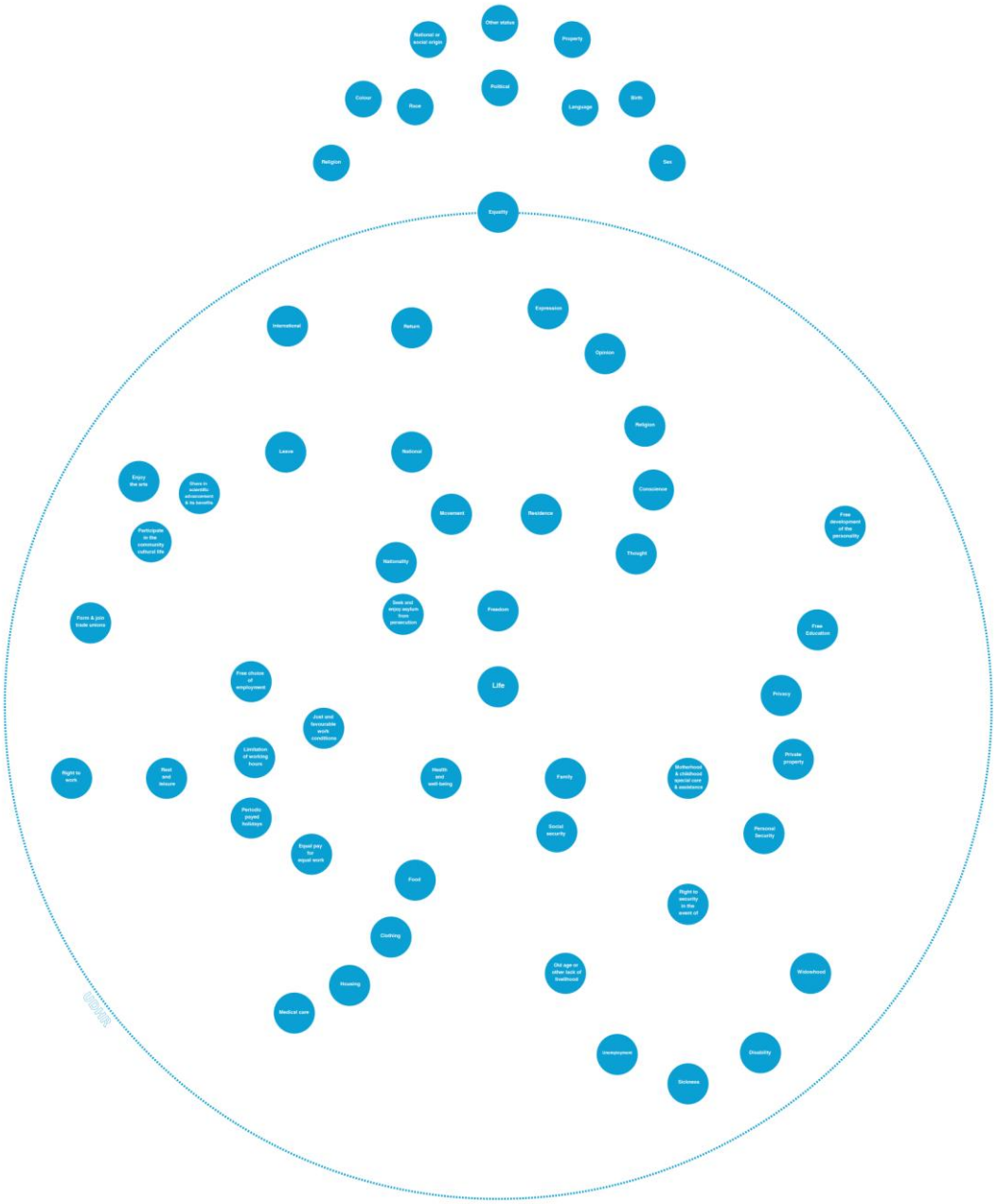


Figure 34. The *Normative Values* graph.

The distribution of the compartments (and the related internal elements) reflects the environment representation provided in the introduction (Figure 7). In this representation the *Economic Activities* are the interface between *Ecosystem Services* and societal (collective and individual) interests.

The rising moon form of the *Economic Activities* is not accidental. Sometimes, the desire to achieve at all costs one's own interests, regardless of others (such as future generations) could lead to the nature eclipsing. We hope that the future history of mankind will never see the effects of such eclipse.

3. Results

This chapter covers the results of the thesis work. However, it is important to note that the definition of the *Virtual Stakeholders*, described in chapter 2, represents part of the methods used to define the *PoChASSy42* framework, but it is also one of the results of the work.

Some possible uses of the *PoChASSy42 Adjacency Matrix* are described. As stated in many occasions, *PoChASSy42* is a tool which allows for improvements: what is reported here is a first step useful to chart a new path, a new paradigm on which to develop a dynamic framework constantly updated in an open source perspective.

3.1 Warnings and clarifications about the *PoChASSy42 Adjacency Matrix*

Before describing how the *PoChASSy42* Adjacency matrices can be used, it is important to recall three important points:

1) The interaction among *Virtual Stakeholders* are weightless, i.e. the cell values can be either 1, "an interaction occurs", or "0", "no interaction is present". As *PoChASSy42* is a pre-quantitative methodology, its aim is to highlight all possible stakeholders involved in a choice which could led to some changes in the environment. It will be the task of the accounting methodologies that will be used in the subsequent analytical phase, to establish the importance of the interactions highlighted by *PoChASSy42*.
2) The cells with a "1" have been selected in order to describe all the possible motivations, and therefore interactions, that could tie a *Virtual Stakeholder* to another. It will be the task of the local expert's judgment to eliminate the interactions that does not exist in the specific application, justifying the reasons for such exclusion.
3) The identification of the interconnections between the various *virtual stakeholders* has been the most delicate part of the work, not to be affected

by the *Reflexivity* problem. As already partly explained in section 2.7, the guidance for the filling up of the adjacent matrix cells has been derived by many publications, selected for: i) their credibility; ii) the capability of the publishing institution to keep them up-to-date; iii) their widespread availability.

3.2 How to use the *PoChASSy42 Adjacency Matrix*

As a matter of principle, the *PoChASSy42 Adjacency Matrix* contains all possible interactions between the virtual stakeholders identified in chapter 2. Starting from any stakeholder, all connections are defined by the matrix content.

For example, if a policy choice involves one *Economic Activity*, the related *Ecosystem Services*, *Water Cycle* processes and *Normative Values* can be identified as shown by the path 1→2 in Figure 35, representing the projection through the sub matrices EAvsES, EAvsWC and EAvsNV of the *Economic Activity*.

A further step could be to include in the analysis also the activities which provide products or services to the selected *Economic Activity* (see section 2.7.1). Path 1→2 in Figure 36 represents the projection of the selected activity on those which provide products and services to it. The resulting output, to be propagated through the EAvsES, EAvsWC and EAvsNV sub-matrices will contain all the *Economic Activities* directly involved in the policy choice.

The *Services*, *Water Cycle* processes and *Normative Values* impacted by the change in the *Economic Activities* involved in the policy choice may also impact other *Economic Activities*. As an example, if one activity excessively deplete a water reservoir, many other activities may suffer. This is the reason why 2nd order paths, like the one shown in Figure 37 must be also included in the analysis. Paths 4→5 and 4'→5' represent the identification of the *Economic Activities* indirectly involved in the choice by the modifications induced on *Ecosystem Services* and on *Water Cycle* processes, respectively. For this purpose, the ESvsEA and WCvsEA sub-matrices are used.

Additional, 3rd order paths can be foreseen, if needed in specific case studies.

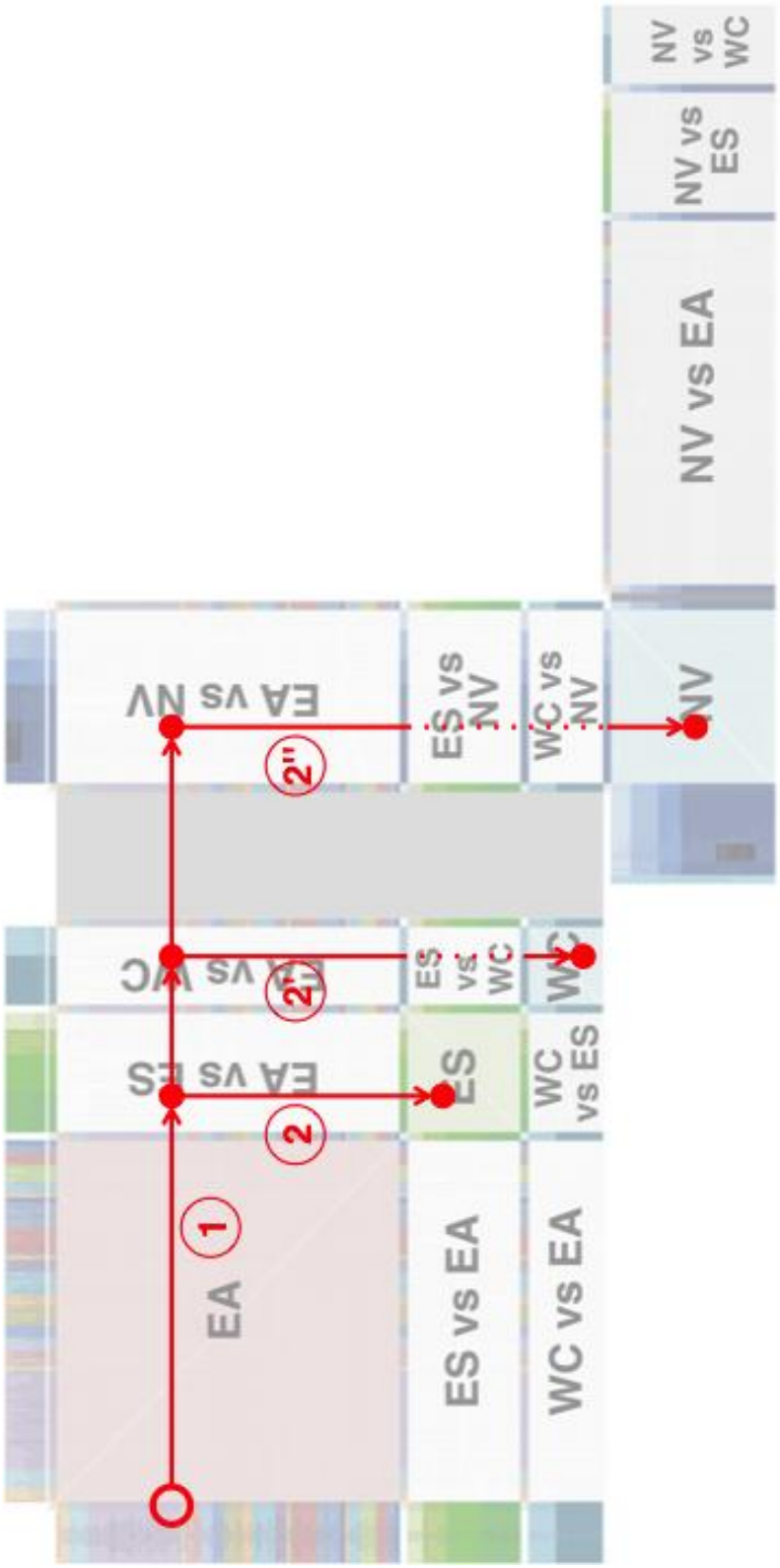


Figure 35 - 1st order path: EA → ES/WC/NV

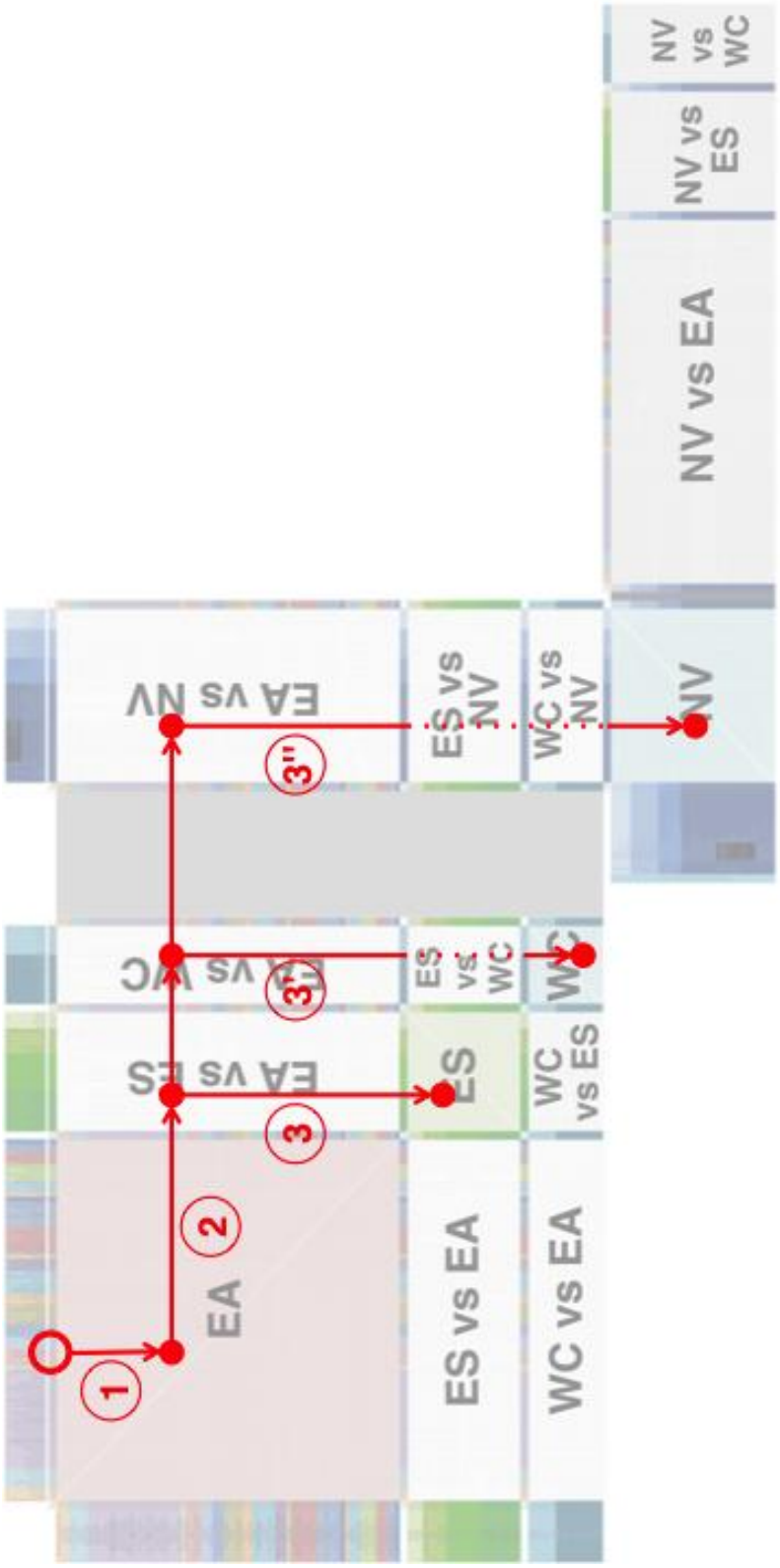


Figure 36 - 1st order path EA → ES/WC/NV, including the EAs on which the selected one depends

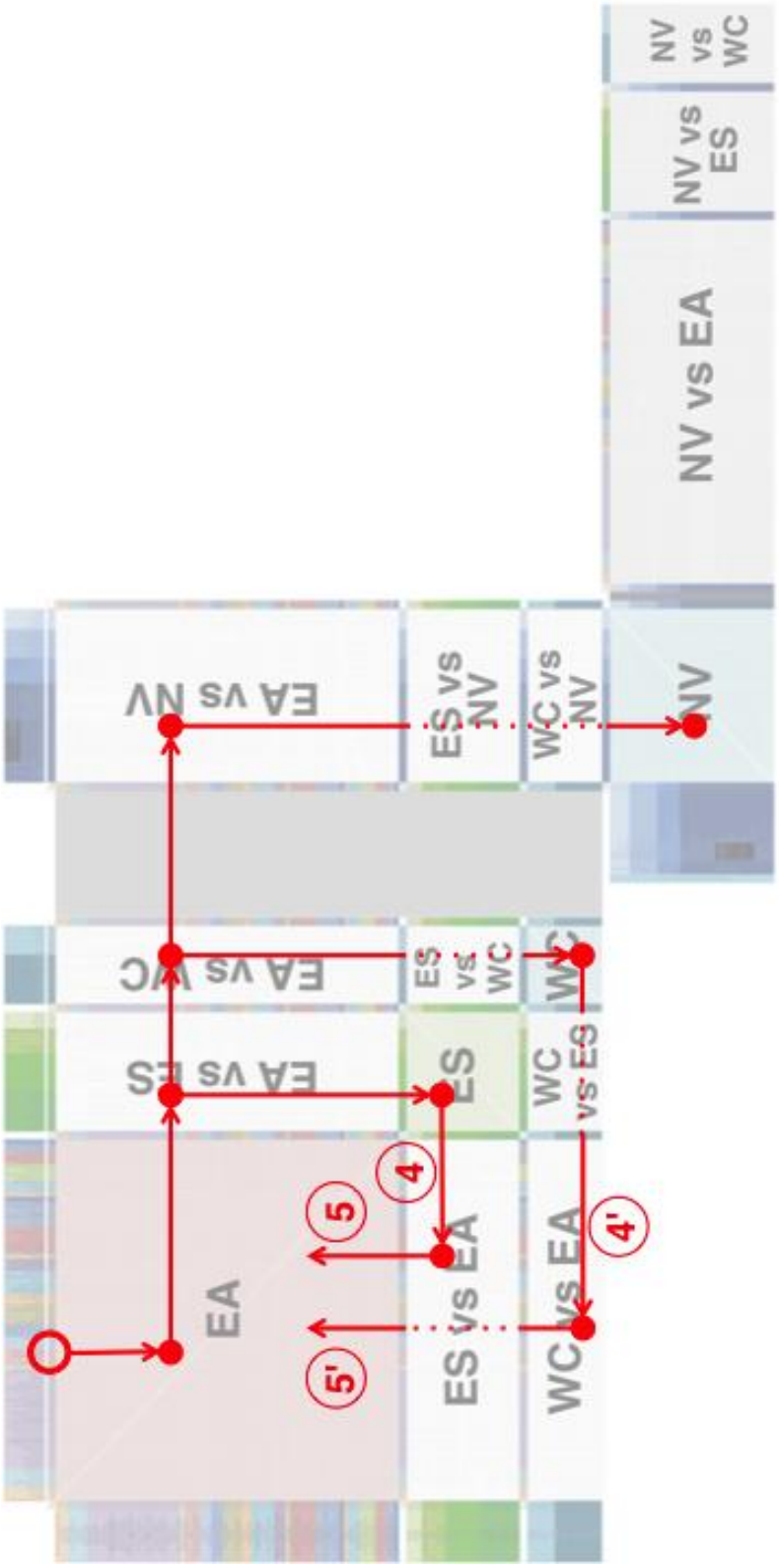


Figure 37 - 2nd order paths: EA → ES → EA and EA → WC → EA

3.3 Exclusion of stakeholders

When applied to specific studies, the *PoChASSy42* framework allows for the exclusion of the virtual stakeholders which are not present in the territory. The simpler case concerns the *Economic Activities*. In general, not all activities are present within a local environment, therefore its analysis is needed and the exclusion of the activities not present has to be done. Other virtual stakeholders may be also missing.

The exclusion can be done by putting 0 in all cells of the *Adjacency Matrix* connected with the missing stakeholders. The essential point, to avoid the *Reflexivity* problem (see section 1.3.2), is that each exclusion has to be justified in the Report on the pre-quantitative analysis.

3.4 An example on bridge construction

In order to provide examples on how to exclude *virtual stakeholders* or the related interactions within a study, three cases will be examined:

1. the construction of a bridge with pylons;
2. the construction of a cable-stayed bridge;
3. the non-construction of a bridge (i.e., the *business as usual* case).

In all the three cases, the NACE code related to the *Economic Activity* "Construction of bridges" is "F 42.13" which is included in Division F 42.

Following the 1st order path shown in Figure 35, the interactions which connect the selected NACE division to the ES, WC and NV sub-matrices are:

- *Ecosystem Services*
    - Nutrient cycling;
    - Primary production;
    - Soil Formation;
    - Biochemicals, natural medicines, and pharmaceuticals;
    - Fiber;
    - Genetic resources (Biodiversity);
    - Ornamental resources;

- Air quality regulation;
- Climate regulation;
- Erosion regulation;
- Natural hazard regulation;
- Water purification and waste treatment;
- Water regulation;
- Aesthetic values;
- Cultural diversity;
- Cultural heritage values;
- Educational values;
- Knowledge systems;
- Inspiration;
- Recreation and ecotourism;
- Sense of place;
- Spiritual and religious values
- Social relations.

- *Water Cycle* processes
  - Evapo-traspiration;
  - Infiltration;
  - Surface runoff;
  - Stream flow.

- *Normative Values*
  - Prohibition of slavery;
  - Right to movement and residence;
  - Right to leave and return;
  - Right to free choice of employment;
  - Right to just and favourable work condition;
  - Right to equal pay for equal work;
  - Right to rest and leisure;
  - Right to limitation of working hours;
  - Right to periodic paid holidays;

Many of the interactions with the *Ecosystem Services* and the *Water Cycle* processes are due both to the different typologies of construction, their related and effective extension on the land cover and the geographical place where the construction work must be realized. Such construction, if built on a coastal system (dunes), may affect the "Natural hazard regulation". Other works which, with their realization, generate an extensive land use change, such as the construction of a dam (F 42.91 Construction of water projects), may irreversibly affect water cycle processes and other services.

Not having a specific case study and given the impossibility to know which *Economic Activity* is active in the region, this example will be limited to:

- the exclusion of interactions which, even if derived from the selected NACE division code (F 42), are not due to the specific actions related to the construction of a bridge (e.g., the construction of a bridge, contrary to a dam, should not have such an extension to directly affect the land cover);
- the exclusion of the interactions which, due to the project features, cannot be physically present.

In order to understand which interactions are to be excluded, two typologies of bridges and their interaction with the other sub-matrices will be examined in the following.

The first typology is that of a bridge with pylons. An example of this kind is shown in Figure 38 - a. Its realization provides different job opportunities within the same NACE Division, and also in the Divisions which provide products and services useful to that *Economic Activity* as described in path 1 of Figure 36.

This is highlighted by the interaction with the *Normative Values*, which concern the right to a fair and regular work. The interaction with the *Normative Value* "Prohibition of slavery" is a possible condition which must be obviously avoided. If the monetary resources and the project execution time are appropriate with respect to both the number of employed workers and the number of working hours agreed with the trade unions, then the interactions with these *Normative Values* can be excluded. The interaction with the "Right to movement and residence" and the "Right to leave and return" cannot be excluded, being these *Normative Values* part of the motivations which could have led to the construction of the bridge.

Figure 38 - Example of a bridge with pylons (a) and a cable-stayed bridge (b) which connect the two sides of a valley

The construction of a bridge cannot concern the coastal ecosystem, for this reason the interaction with "Natural hazard regulation" can be excluded within the EAvsES matrix. On the contrary, the presence of pylons may affect the "Supporting" (including the

water cycle), "Provisioning" and "Regulating" *Ecosystem Services*, as well as the related "Cultural" services, possibly damaged by the impact on the landscape. It will be matter of the following quantitative stage to verify the entity of the impact toward these services.

The second typology is that of a cable-stayed bridge, an example of which is shown in Figure 38 - b. As it is possible to note, this kind of structure does not have any kind of impact on the land cover (for the part that concerns the bridge itself) because of the absence of pylons. As a consequence, all the interactions which have led to the "Supporting" (including the water cycle), "Provisioning" and "Regulating" services selection in the previous case can be excluded within the EAvsES matrix. For what concern the "Cultural" services, due to the impact of this construction on the landscape they must be included as virtual stakeholders. The *Normative Values* inclusion or exclusion follow the same motivation related to the first bridge typology.

Even in the *business as usual* case, *i.e.* the non-construction of that bridge, *PoChASSy42* can be consulted and the reasons are the following

The non-realization of the work does not generate impacts on the *Ecosystem Services*. The real impact this policy choice generates is on some *Normative Values* selected by the interactions described above: the realization of a bridge could represent, in particular geographical circumstances, the only way of communication with the outside world. Not building the bridge may cause the isolation of these countries. The non-construction is thus preventing the "right to movement" and "the right to leave and return", which are also connected to the:

- Right to Food;
- Right to Clothing;
- Right to Housing;
- Right to Medical care;
- Right to free education;
- Right freely to participate in the cultural life of the community;
- Right to enjoy the arts;
- Right to share in scientific advancement and its benefits.

The impact on the "Right to free choice of employment" may also be considered.

The consequences of these impacts can be spread and identified through consulting the NVvsEA, NVvsES and NVvsWC sub-matrices.

Another direct impact of *business as usual* case is the missing work opportunities, related both directly to the construction and indirectly to the other activities which provide products and services for the bridge construction (path 1 in Figure 36).

3.5 The *PoChASSy42 Adjacency Matrix*: tool

As it has been said, the whole *PoChASSy42 Adjacency Matrix* can be found at the web address specified in section 2.7. The Excel file contains the entire, not modifiable, matrix.

The present version of the tool allows for selecting an *Economic Activity* and performing the actions, programmed through the *VBA Macro*[14] language, corresponding to the 1st order path: EA → ES/WC/NV (Figure 35) and the 1st order path EA → ES/WC/NV, including the EAs on which the selected one depends (Figure 36).

When opening the file, the dialog shown in Figure 39 is displayed, which allows for selecting the starting *Economic Activity* and the action to be performed. At the right of the opening page, the user can exclude *Virtual Stakeholders* filling up the motivations (see Figure 40). The output of the Excel tool for the case of the bridge with pylons described in the previous section is shown in Figure 41.

At the end of the processing, the sheets "Activated ES", " Activated WC" and "Activated NV" will show the list of the *Ecosystem Services*, the *Water Cycle* processes and the *Normative Values* connected to the selected *Economic Activity*, respectively. When running the tool with the option "1st order EA with dependencies" the sheet "Activated EA" will contain all activated EAs, including those on which the selected one depends.

The full matrices can be examined by zooming in the resulting sheet ("PoChASSy42 working sheet"), or by looking at the "PoChASSy42 basic" sheet.

Further developments of the tool are foreseen to allow for the selection of any *Virtual Stakeholder* and for the identification of all 1st and 2nd order interactions.

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[14] The macro has been developed thanks to the precious help of Andrea Contin (Full Professor of Physics and Environmental Management) and Lucio Quadrani (PhD Physics), of the Environmental Management Research Group, Interdepartmental Centre for Research in Environmental Science (CIRSA), University of Bologna, Ravenna Campus.

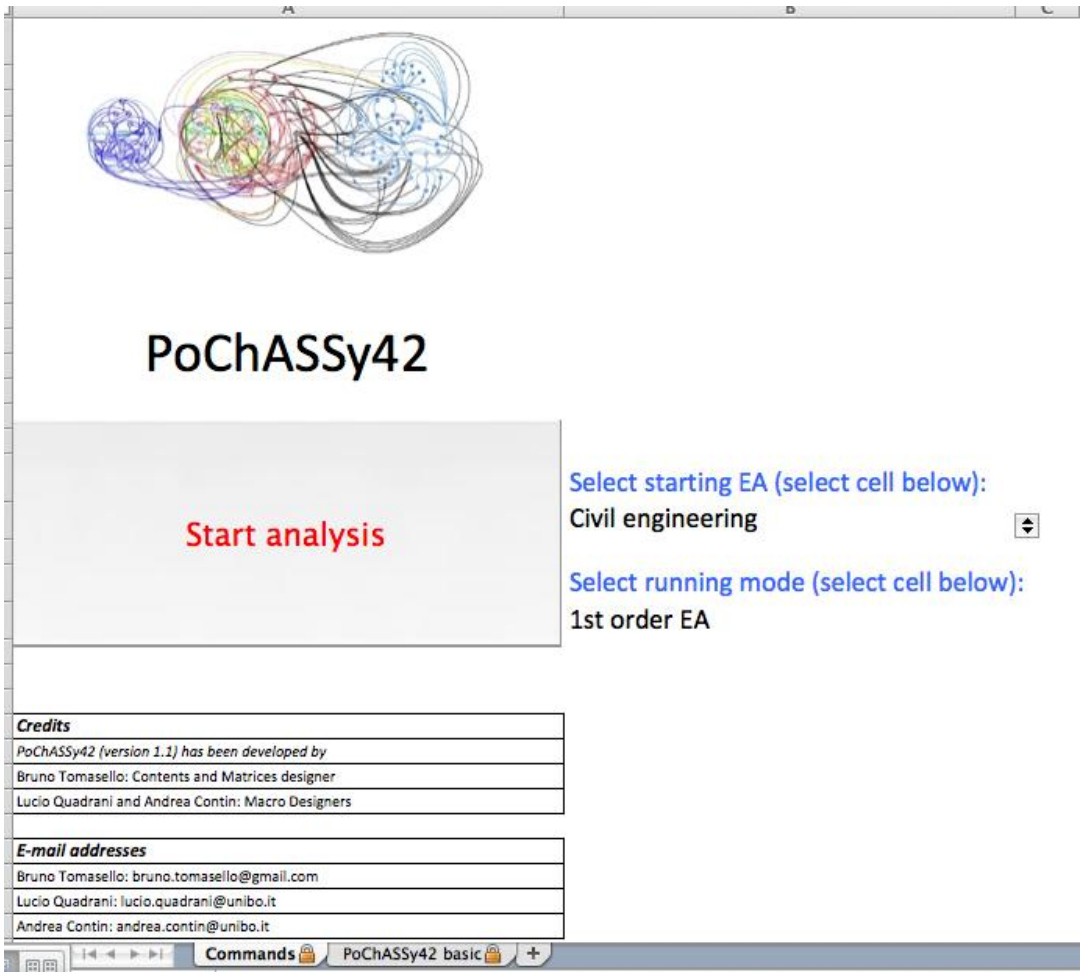

Figure 39 - Dialog box in the Excel file of the *PoChASSy42 Adjacency Matrix*.

Exclude virtual stakehoders which are not relevant

				Is it involved?		*Note
				YES	NO*	
Agriculture, forestry and fishing	Crop and animal production, hunting and related service activities	A	1	X		
	Forestry and logging	A	2	X		
	Fishing and aquaculture	A	3	X		
Mining and quarrying	Mining of coal and lignite	B	5	X		
	Extraction of crude petroleum and natural gas	B	6	X		
	Mining of metal ores	B	7	X		
	Other mining and quarrying	B	8	X		
	Mining support service activities	B	9	X		
Manufacturing	Manufacture of food products	C	10	X		
	Manufacture of beverages	C	11	X		
	Manufacture of tobacco products	C	12	X		
	Manufacture of textiles	C	13	X		
	Manufacture of wearing apparel	C	14	X		
	Manufacture of leather and related products	C	15	X		
	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	C	16	X		
	Manufacture of paper and paper products	C	17	X		
	Printing and reproduction of recorded media	C	18	X		
	Manufacture of coke and refined petroleum products	C	19	X		
	Manufacture of chemicals and chemical products	C	20	X		
	Manufacture of basic pharmaceutical products and pharmaceutical preparations	C	21	X		
	Manufacture of rubber and plastic products	C	22	X		
	Manufacture of other non-metallic mineral products	C	23	X		
	Manufacture of basic metals	C	24	X		
	Manufacture of fabricated metal products, except machinery and equipment	C	25	X		
	Manufacture of computer, electronic and optical products	C	26	X		
	Manufacture of electrical equipment	C	27	X		
	Manufacture of machinery and equipment n.e.c.	C	28	X		
	Manufacture of motor vehicles, trailers and semi-trailers	C	29	X		
	Manufacture of other transport equipment	C	30	X		
	Manufacture of furniture	C	31	X		

Figure 40 - Exclusion list.

Figure 41 - The output from the *PoChASSy42* Excel tool applied to the case of a bridge with pylons described in section 3.4. The red cells are the ESs, WCs and NVs connected to the starting *Economic Activity* derived from the 1st order path: EA → ES/WC/NV.

4. Discussion

"Freedom is participation"
La libertà - Giorgio Gaber

In this chapter an evaluation will be given of the developed methodology, through the assessment of its strength and weakness points, threats and opportunities and in view of the objectives declared in the Introduction.

4.1 *PoChASSy42* strengths

Participation is a fundamental process of human beings life within a community. The importance of the process is evidenced both by Ancient Greek philosophers (e.g., Aristotle, *Politics*) and by the study of human history. The elimination of the participatory process and therefore the impossibility for the people to manifest their needs to the proper authorities, has led to the realisation of this necessary process in anything but peaceful manner (*i.e.*, through rebellions).

As highlighted by the Post-normal science, the *extended peer review* (the participation "scientific" synonym) is the only way to deal with such a complex world. Policy choices, which affect the environment (as defined in this work), are characterized in the modern era by the highest uncertainty, given the involvement of an increasing number of stakeholders. As evidenced by the NACE classification constant upgrading (Table 4), the *Economic Activities* tend to increase in quality (the creation of new job form) and quantity (the increase in the global population and in the demand for jobs).

Precisely because of the modern era complexity, participation is a process hard to be put in practice, especially if decisions must be made in a short time or if the decision has already been taken *a priori*, regardless of the participatory process (*Perspectivity*).

One of the ways to deal with the necessity to collect information in parallel with the participatory process (analysed in the Introduction) is expert judgement, helped by the DPSIR framework for the organization of information, both elements of the decision making process which characterize *Decision Support Systems*. These processes can be

affected by four *side effects*: *Reflexivity*, *Reproducibility*, *Analyticity* and *Perspectivity* (see section 1.3.2).

The development by *PoChASSy42* of a full relational network between the anthropogenic interests and the ecosystem elements, makes it a natural antagonist of the expert knowledge-based tools. Why should *PoChASSy42* be preferable with respect to a widely accepted and still used path? A comparative assessment can be carried out with respect to the main side effect which concerns the pre-analytic stage: *Reflexivity* (Do I have the same values, goals, taboos - *i.e.* the problems perception - as the rest of the society?).

PoChASSy42 has been developed in order to establish a new paradigm aimed at the determination of environment observation rules. While in the expert knowledge-based tools, as it has been possible to see in section 1.3.2, the decision of "what to observe" is necessarily based on the observer's goals and beliefs, and acts as a filter between the observer and the external world, using the *PoChASSy42* framework the relations between *Virtual Stakeholders* is fixed. In standard Decision Support Systems the expert it is called to "fill" the *D - P - S - I* and *R* indicators with his knowledge (*e.g.*, risking "to solve a 200 pieces puzzle with only 150 pieces"). In *PoChASSy42* the expert is called to "exclude" the *Virtual Stakeholders* not present in the territory under analysis, amply justifying the exclusion through a local investigation and publishing a report available to the public which includes also the resulting *Narrative Structure*. The exclusion process occurs because in *PoChASSy42* all *Virtual Stakeholders* have been considered and put in relation with all the others. This situation does not describe a specific geographical reality but can be applied to all possible realities. This process is analogous to a marble statue carving as shown in Figure 42: removing excess marble (the *Virtual Stakeholders* not present in the territory under investigation), the sculptor (the expert) with his art (knowledge about the territory) manages to outline the shape of a woman (the case study) as close as possible to the reality, knowing that the amount of marble needed at the beginning cannot be less than that of the final creation (without applying a reductionist perception to a complex system).

Figure 42 - A sculptor carving a statue representation from the initial (on the left) to the final phase (on the right) (source: http://www.treccani.it/enciclopedia/scultura/)

Another *PoChASSy42* feature which can help to overcome the *Reflexivity* problem is to provide some information which do not necessarily belong (nor are requested) to an expert's cultural background or to the people in general:

- a way to describe the society through the *individual interests* (*Normative Values* – Table 3);
- the inclusion of the *Cultural and Amenity Services* which ecosystems are able to provide.

These two pieces of information are linked to each other, and this link spreads, through the various interactions, to the whole system.

An example is provided by the *Hajj* (Arabic: (حج, the annual Islamic pilgrimage to Mecca, and the *Umrah* (Arabic: عمرة), the pilgrimage to Mecca at other times of the year (Mamdouh, 1996). These pilgrimages are two fundamental pillars of the Muslim life as well as part of a religion which arose from that territory (in Mecca, town of the Arabian Peninsula) as the result of the Arabian people history since its origins (the *Cultural diversity* service). These cultural values have a feedback on the local economy as well. As reported by the online newspaper Arab News (2013) "Economists have estimated the Kingdom's revenues from *Hajj* and *Umrah* services in 2012 at more than SR 62 billion ($ 16.5 billion), 10 per cent up from 2011 figures. They also said that *Hajj* revenue accounted for three per cent of the country's gross domestic product (GDP)". Similar relations

between Cultural and Economic values, are also present (even if with less amplitude) in other cultural services such as *Recreation and Ecotourism* and *Cultural heritage*.

Cultural Service	***Description***
Cultural diversity	The diversity of ecosystems is one factor influencing the diversity of cultures
Spiritual and religious values	Many religions attach spiritual and religious values to ecosystems or their components.
Knowledge systems (traditional and formal)	Ecosystems influence the types of knowledge systems developed by different cultures
Educational values	Ecosystems and their components and processes provide the basis for both formal and informal education in many societies
Inspiration	Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising
Aesthetic values	Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, scenic drives, and the selection of housing locations
Social relations	Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies
Sense of place	Many people value the "sense of place" that is associated with recognized features of their environment, including aspects of the ecosystem
Cultural heritage values	Many societies place high value on the maintenance of either historically important landscapes ("cultural landscapes") or culturally significant species
Recreation and ecotourism	People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area

Table 12 - Cultural and Amenity Services provided by the ecosystem (MA, 2005). Extract from Table 9.

In this way, *PoChASSy42* gives a chance to reflect on the importance of certain aspect of the ecosystems that may be affected by superficiality in policy choices although supported by local regulations (e.g., building permits). A choice done for the benefit of a single individual could compromise the collective benefit of present and future generations, due to the missing of the ecosystem cultural benefits (and related economic benefits).

A further strength point of *PoChASSy42* resides in its ability to describe the complexity of the environmental system in a dynamic way. The methodology has been developed knowing that environment is in constant evolution. As it has been specify in section 3), the references used to build the *Adjacency Matrix* have been chosen for their credibility, the capability of the publishing institution to keep them up-to-date and their widespread availability. The second feature, in particular, is one of the fundamental reason which has led to the definition of the *Economic Activities* with the NACE classification and

of the *Ecosystem Services* with the Millennium Ecosystem Assessment: both Eurostat and UNEP plan to continue providing updated information in the future.

PoChASSy42 can be expanded to account for more and more accurate identification of stakeholders which otherwise may be excluded due to an out-dated tool. To include the evolution of the interests (individuals, collectives and ecosystem) is fundamental for its proper application and function. For these reason it is strongly recommended to:

- adapt the *Normative Values* to local culture: as specify in section 4.2.2, the use of UDHR *Normative Values* represents an example of how to define the Individual Interests; if the framework were to be used in a country where there is not a general agreement with the UDHR values, it would be appropriate to choose a set of *Normative Values* more consistent with local values, otherwise the acceptability of the policy choices could be hampered;
- follow the evolution of the *Economic Activities* through the upgrading of the classification system;
- follow the evolution of the scientific investigation on *Ecosystem Services*.

If this methodology were to be used in future, new interactions between *Virtual Stakeholders*, provided by different scientists all over the world and with an "open source" approach, would make it stronger and more reproducible. This is the only way to make expert knowledge an essential weapon for the battle against reductionism. A "collective thought source" can be developed into which each expert can pour fresh water or from which he can drink in order to compensate the thirst for knowledge, if it exists.

4.2 *PoChASSy42* weaknesses

From a technical point of view, *PoChASSy42* brings with it the typical weaknesses of a new methodology, which surely requires further and necessary developments as regards to the details of its materials and methods. Being aware of the limitations, discussed in the following, can help in making people understand its full potential and in making a better use of it.

In the following sections, two cornerstones of *PoChASSy42* are discussed in detail: the NACE classification of *Economic Activities* and the *Normative Values* derived by the UN Human Rights.

4.2.1 NACE classification: a good choice if at high resolution

The use of a systematic classification of the *Economic Activities* in order to describe the *Collective interests* is, from a conceptual point of view, one of the cornerstones of *PoChASSy42*. However, the use of the NACE system may result incomplete if applied in some parts of the World, *i.e.* far beyond of the European Union borders, The development of a population and its differentiation with respect to others is linked to the *Ecosystem Services* through, e.g. the Cultural Services and the local biodiversity, or inter-ecosystem diversity (Ferrari, 2001).

The reasons that led to the choice of NACE codes are:

- The provision of a familiar representation of the *Economic Activities*, as close as possible to those present in the European Union within which this thesis work has been developed.
- The necessity to identify the interactions between *Economic Activities* and the ecosystem in a known environment. Highly endemic *Economic Activities* present in other parts of the World suffer from a lack of knowledge just because of cultural distance.

The use of the NACE classification outside the European Union could lead to a lack of information (i.e., potential stakeholders not included in the *PoChASSy42* framework). A possible solution might be to use, for each case study, the *Economic Activities* classification system in force in the territory under analysis and then find possible interactions within the *PoChASSy42 Adjacency Matrix* according to the paradigm provided in this work.

Alternatively, the *International Standard Industrial Classification of All Economic Activities* (ISIC) *i.e.* the United Nations industry classification system developed by the United Nations Statistics Division (UN, 2008) could be used. As specified in the NACE Rev. 2 document: "NACE is derived from ISIC, in the sense that it is more detailed than

ISIC. ISIC and NACE have exactly the same items at the highest levels, where NACE is more detailed at lower levels." (Eurostat, 2008). The *Economic Activities* classification system defined in ISIC could be a good start point in order to satisfy the local diversity.

Once the *Economic Activities* classification system has been chosen, it is necessary to apply the hierarchical organization level more appropriate to the *PoChASSy42* scope. In this work, the NACE classification *Division* level has been selected. This choice allowed to find relevant interactions both among the *Economic Activities*, and with the *Ecosystem Services* (including the water cycle processes) and the *Normative Values*. However, in some cases this level of detail could create confusion in the allocation based on the *input/output* flows. Some *Divisions* are not so specific as in the case of Manufacturing, which is the *Section* with the largest number of *Divisions* (for example, *Section F - Constructions* is made up by different construction typologies and phases, as shown in Table 13).

In particular, *Division* "42" includes very different typologies of constructions and each one generates a different impact on the environment: a bridge and a tunnel, a road and a railway can have different interaction within the *PoChASSy42* framework as in the case of division "43" which goes from the Demolition phase to the Painting and glazing passing through the electrical, plumbing and other construction installation activities.

Division	*Group*	*Class*
41 - Construction of buildings	41.1 - Development of building projects	41.10 - Development of building projects
	41.2 - Construction of residential and non-residential buildings	41.20 - Construction of residential and non-residential buildings
42 - Civil engineering	42.1 - Construction of roads and railways	42.11 - Construction of roads and motorways
		42.12 - Construction of railways and underground railways
		42.13 - Construction of bridges and tunnels
	42.2 - Construction of utility projects	42.21 - Construction of utility projects for fluids
		42.22 - Construction of utility projects for electricity and telecommunications
	42.9 - Construction of other civil engineering projects	42.91 - Construction of water projects
		42.99 - Construction of other civil engineering projects n.e.c.
43 - Specialised construction activities	43.1 - Demolition and site preparation	43.11 - Demolition
		43.12 - Site preparation
		43.13 - Test drilling and boring
	43.2 - Electrical, plumbing and other construction installation activities	43.21 - Electrical installation
		43.22 - Plumbing, heat and air-conditioning installation
		43.29 - Other construction installation
	43.3 - Building completion and finishing	43.31 - Plastering
		43.32 - Joinery installation
		43.33 - Floor and wall covering
		43.34 - Painting and glazing
		43.39 - Other building completion and finishing
	43.9 - Other specialised construction activities	43.91 - Roofing activities
		43.99 - Other specialised construction activities n.e.c.

Table 13 - Divisions, Groups and Classes of the Constructions Section (F)

In *PoChASSy42* terms, this means that *Divisions* "42" and "43" are attributed all the possible interactions of their *Groups* and *Classes* in all the matrices which make up the general *Adjacency Matrix*, and this entails a significant loss of detail.

4.2.2 UNHR: not enough universal

The individual interests description in *PoChASSy42* is made according to the UDHR. This represents an example of how the framework can be applied. If the framework were to be used in the pre-analytic stage related to a case study in a country in which there is not a general agreement with the UDHR, a different set of values should be used in order to describe the individual interests of that society.

In other words, *PoChASSy42* is a set of rules, a conceptual model for the description of the *environment* in the pre-analytical stage. It is not a pre-packaged tool, like a dress to wear by a male without regard to size, colour or whether it is a female's dress. The intent is to reduce the problem of *Reflexivity* (the individual filters through which the reality is seen by the expert) but not to increase the *Perspectivity* (the arbitrary use of the expert's advise for political purposes).

4.3 *PoChASSy42* threats and the meaning of *42*

Transparency and communication are the two elements which stand at basis of the policy-making process as well as of the definition of politics itself, as discussed in the Introduction. Making public both the adjacent matrices and the resulting *Narrative Structure* is a fundamental part of the process.

Even if *PoChASSy42* provides a *Virtual Stakeholder* participation process, it does not want to replace real people participation: the intent is to reduce the errors, implicit in expert-knowledge based decision-making processes, and to make the results of a complex analysis of an equally complex system, communicable and understandable (through the adjacent matrix) as well as with an easy insight (through the *Narrative Structures*). To use the tool without communication and transparency represents its main threat.

The *PoChASSy42* methodology, based on a "justified elimination" of *Virtual Stakeholders*, adds a step which is not present in the stakeholders identification phase of expert knowledge-based frameworks. The absences must be justified and a mistake in this case should involve an error by excess (including more stakeholders than those who are actually present) and not by default (including less stakeholders than those who are actually present).

By knowing both the original matrix and the one derived by the case study (with justified exclusions) as well as its *Narrative Structure*, all citizens can control the survey work carried out, and are given the possibility of objecting to the fact that some *Virtual Stakeholder* is not present. But communication does not rule out an internal control, and makes it possible the intrusion of the *Perceptivity* effect: being the *PoChASSy42 Adjacency Matrix* made by 29,920 interaction, it would be very easy to change few numbers without anyone noticing. Given the chain of interactions between two stakeholders, the exclusion of one interaction leads to subsequent exclusions. In this way, undesired consequences can be turned down by the decision maker.

The importance of communication and transparency can be illustrated by the example shown in Figure 43, a generic school management where three different events happen:

- CASE 1 - A Substitute teacher at his first day of work doing the appeal in the classroom declare that all students are present. He does not know the number of students, not being supported by an attendance register (limited expert knowledge *i.e. Reflexivity*). In this case, absent students could be declared present and this could benefit their final judgment.
- CASE 2 - An ordinary teacher does the appeal with the support of the attendance register (complete expert knowledge). But being one of the students unruly and hated by the professors which secretly have decided to reject him, the teacher declare him absent (Perspectivity effect);
- CASE 3 - Everyday the school director, knowing that some teachers may act in the way described in CASE 2, pretends that all the teachers after the appeal deliver to him their attendance registers (communication and transparency) in order to personally compare their work with the "global enrolled student register" in its possession (this allows to limit the CASE 1 effects). Subsequently, by means of direct "class to class" control, the

director assesses whether the teachers have actually declared the truth or not (limiting the CASE 2 effects).

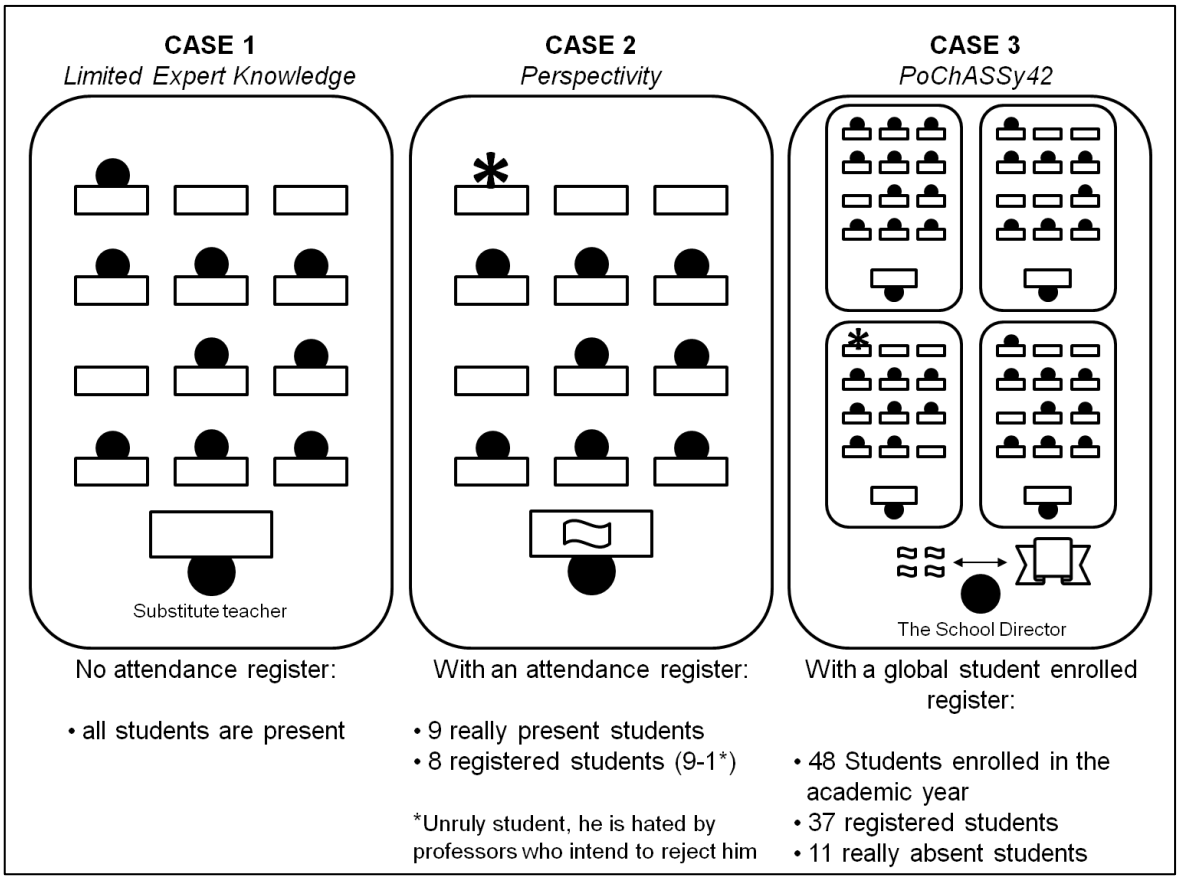

Figure 43 - The school management could provide an interesting analogy in order to understand differences between expert knowledge based framework and the *PoChASSy42*.

PoChASSy42 is the analogue of the "global enrolled student register" for the process of stakeholders identification. As in CASE 3, by using *PoChASSy42*, the partial expert knowledge effects can be limited (*Reflexivity*) but without the citizen control (analogue of the School director "class to class" control) on the communicated results there would be no remedy to the *Perspectivity* effects which characterize CASE 2.

PoChASSy42 supported by communication could be a good tool to contrast both *Reflexivity* and *Perspectivity* effects. In the challenge to the *Perspectivity* effect reside the meaning of the number *42* which is not only a tribute to the novel by Douglas Adams "The Hitchhiker's Guide to the Galaxy". As evidenced by the quote at the beginning of section 2.2, *42* is the "Answer to The Ultimate Question of Life, the Universe, and Everything" a very complex request. But a "request" is not a "question": a specific "request" can affect the entire analytical work that will tend to choose items that best meet the request (the *Perspectivity* effects). A specific "question" allows the analyst to query the complex

system totality (or the known part of it) providing a fairly complete information that can be helpful to an understanding of the system.

For this reason the number *42* has been put at the end of the first thing which the analyst reads, *i.e.* the name of the framework, so as to say:

> *"This is a Policy Choices Analysis and Synthesis System with all its rules. If you are affected by Perspectivity the answer for you is 42. If you are not satisfied of it, DON'T PANIC and please choose another methodology. So long and thanks for all the fish"*[15]

4.4 *PoChASSy42* framework future developments

On the basis of the weak points described above, the future development of *PoChASSy42* framework structure would be to increase the level of details in the identification of the *Virtual Stakeholders* which describe the *Collective interests*, trying to use the *Subcategories* hierarchical organization level. This is necessary in order to generate an univocal relation among the specific *Economic Activity* and the other *Virtual Stakeholders*, relation which is feasible also at the current framework detail level but less deducible: in order to understand it, it is necessary to investigate which *Subcategory*, included within the *Division* has generated that specific interaction and this requires the consultation of further bibliographical references.

As it has been said, this work wants to represent a first step, a new paradigm in order to describe the environment. More than a tool, *PoChASSy42* described in this work wants to be a set of rules on which to develop an even more complex tool.

Another development towards an increase in complexity without losing details would be to create an epistemological journal where to highlight the interactions between virtual stakeholders not included in the present scheme. The journal name could be *"The epistemology Agora"*. *Agora* is the term used in Ancient Greece to indicate the main square of the *polis* and it was the place where people created interpersonal relationships and took decisions. In this hypothetical journal, the epistemological complexity can provide the

[15] The sentences "DON'T PANIC" and "So long and thanks for all the fish" are both quotes from Adams, 1995.

vision of every perception which it is composed of, in order to discover (or strengthen the already existents) interactions between *Virtual Stakeholders*, allowing *PoChASSy42*, which at that point would become a global and open, but referenced, source, to tend even more to the description the environmental complexity but with a more and more solid methodological structure.

Another future development could be the creation of a website where policy makers can face with the *PoChASSy42* tool in order to be helped not by an expert with a limited knowledge, but by an expert community. The interface between policy maker and this tool may be supported by a user-friendly process in order to know at the beginning, by filling in a questionnaire and not through a request, the useful information for deleting the not present *Virtual Stakeholders*. At the end of this process, the result could be either the final matrix already compiled based on the answers as well as the resulting *Narrative Structure*. The policy maker, with these tools, can begin the participatory process by communicating, with transparency, the resulting stakeholders coming from the *analysis* and *synthesis*, always remembering that participation is the basis of a political process, and nothing can replace it. Not even *PoChASSy42*.

5. Conclusions

"Time is an illusion.
Lunchtime doubly so."
(The hitchhiker's guide to the galaxy - Adams 1995)

The management of natural resources is a task which politics carries on since the first historical communities were formed through the sharing of the same geographical area by a group of people. Ever since, the human evolution history has followed different paths, which in the majority of the cases (excluding some isolated community or lost tribes who live, by choice or by circumstance, without significant contact with global civilization) have led to an increasing system complexity and to the need for politics to deal with an even more increasing of both system uncertainty and decision stakes. Society needs are increasingly differentiated and more difficult to tackle. The interface between man and ecosystems has seen an increase in interconnections, not only concerning the biological and physiological needs, but also extending to culture, religion interests and to the most concrete impacts due to pollution or resources overexploitation.

The environmental sustainability of the policy choices is recent in human history. The necessity to consider all the consequences of economic growth on the environment and on the society, both now and in the future, must be an internationally shared task. In this challenge, politics calls for the help of sciences (economics in particular) in an attempt: i) to provide new methodologies able to deal with the sustainability of policy choices; and ii) to change the measurement index (the GDP) in order to demonstrate that the intentions to behave in a more sustainable exist. However, politics currently live the paradox where, to evaluate the performance of policy choices, it still uses an index considered wrong by the scientific community and by the politicians themselves.

The "expert" and the policy maker perceptions (*Reflexivity*), together with the possible corruption of *Perspectivity*, are the first sources of mistakes which affect the qualitative stage of the environmental accounting methodologies (also affected, in the quantitative stage, by other "side effect" such as *Reproducibility* and *Analyticity*). In particular, the *Reflexivity* effect finds its main source in the environment definition itself.

In order to reduce this chain of mistakes, and starting from a definition of the environment as *a set of interacting elements, including their interactions and the*

motivations behind these interactions, a new methodology has been developed within this work, which has the ambition to create a new paradigm for dealing with the description of a complex systems such as the environment: *PoChASSy42*.

This methodology is based on a different perception of the three sustainability pillars (environment, economics, society) both in their description and in their interactions. Until now, this task has been entrusted to experts which, thanks to their knowledge and with the help of causal frameworks (such as the DPSIR), describe these three compartments choosing the stakeholders that, according to their knowledge, could be involved in the policy choice.

PoChASSy42 provides a pre-built framework that describes the environment through all the possible interactions between the three compartments described as the spheres which enclose the:

- **Individuals Interests** - identified through the study of the Normative Values that have led to Universal Declaration of the Human Rights (UDHR) (UN, 1948);
- **Collective Interests** - identified through the *Economic Activities* classified according to the Nomenclature statistique des activités économiques dans la Communauté européenne (NACE) (Eurostat, 2008);
- ***Ecosystem Services*** - identified through the study of the Millennium Ecosystem Assessment (MA, 2005) and the Water Cycle (Evans and Perlman, 2005).

The elements which make up these spheres of interests are considered in this work as *virtual stakeholders, i.e.* the representatives of the existence, intentions, motivations and interests (where present) that make up the complex environmental system. The interactions among them exist because each *Virtual Stakeholder*, while trying to realize its target, depends on other *virtual stakeholders* (which, in their turn, want to realize their targets) and produces consequences to the other *Virtual Stakeholders*.

Both the *Virtual Stakeholders* and the possible interactions among them, are represented by *PoChASSy42* through the development of an *Adjacency Matrix* and a diagram inspired by the Lombardi *Narrative Structure*. Using these two tools, derived by the graph theory, the expert can be able to:

- find the involved matrix elements highlighted because of the interactions binding them together;
- simplify the system by deleting the *Virtual Stakeholders* which are not present in the local context, declaring the motivations of the deletion;
- create a *Narrative Structure* for the resulting *Virtual Stakeholders*.

The methodology developed in this work involves the drafting of a report which contains the results of the above steps because their transparent communication is a fundamental and critical step for its effectiveness. Only through communication it is possible to reduce the *Perspectivity* threats, while the reduction of the *Reflectivity* effect is the purpose of the methodology itself.

The *PoChASSy42* structure, at its present evolution stage, contains some critical issues that need to be investigated further, above all with regard to the level of detail of the *Economic Activities*.

Improper use should be avoided by using few clues:

- According to the Post-normal Science solution, the *virtual* participative process here proposed do not want to substitute the real citizens participation to a decision-making process (being it a right as well as a duty), but it wants to be a mean, useful to provide more awareness in the conversion processes of a citizen into a stakeholder.
- The *Normative Values*, which represent the individual interests, are a useful way to interpret society but, in order to not convert the expert into a fundamentalist, it is necessary to change them according to the local culture.
- The same applies to the *Economic Activities* description. The choice of a more appropriate classification in a given case study allows for a complete identification of the stakeholders.

The paradigm developed in this work is a first result and could represent the starting point for a global participation in the building of an epistemologically stronger *PoChASSy42* tool. The environmental description needs the perception of the full spectrum of elements (epistemological complexity). The various accounting methodologies, applied after *PoChSSy42*, should provide an almost complete and useful information to politics in the *Res Publica* management. In this way citizens will regain confidence in politics not

looking at it as a separated and elitist sphere but as something that involves them and listens to them. In this way *PoChASSy42* could be a useful interface between politicians and citizens which, for a moment, can switch roles mingling with each other. As it should be in reality.

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Appendix 1 - List of Publications

Okello, C., Tomasello, B., Greggio, N., Wambiji, N., & Antonellini, M. (2015). **Impact of Population Growth and Climate Change on the Freshwater Resources of Lamu Island, Kenya**. Water, 7(3), 1264-1290.

To be submitted:

Tomasello. B., Benini, L., Vogli, L., Contin, A. Supporting spatial conservation planning through conservation values based on threatened species distribution: the case of the Ural River Delta Reserve.

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Il più bello dei mari
è quello che non navigammo.
Il più bello dei nostri figli
non è ancora cresciuto.
I più belli dei nostri giorni
non li abbiamo ancora vissuti.
E le più belle parole
che vorrei dirti
non te l'ho ancora dette…

The most beautiful sea
hasn't been crossed yet.
The most beautiful child
hasn't grown up yet.
Our most beautiful day
we haven't seen yet.
And the most beautiful words
I wanted to tell you
I haven't said yet...

Nazim Hikmet